## APPENDIX A.  NRM Designation Letter and RNA Agreements

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**DEPARTMENT OF THE NAVY**
NAVAL AIR STATION WHIDBEY ISLAND
3730 NORTH CHARLES PORTER AVENUE
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N00/1848
20 Jan 22

From: Commanding Officer, Naval Air Station Whidbey Island
To: Mr. John Phillips, Biologist

Subj: APPOINTMENT AS INSTALLATION NATURAL RESOURCES MANAGER

Ref: (a) OPNAVINST 5090.1E
(b) OPNAV M-5090.1
(c) CNICINST 3700
(d) OPNAVINST 3750.21
(e) CNICINST 3750.1
(f) Migratory Bird Treaty Act
(g) Bald and Golden Eagle Protection Act

1. Per section 12-4.7(e) of references (a) and (b), you are appointed as the Installation Natural Resources Manager for Naval Air Station Whidbey Island Properties/Ranges and Naval Weapons Systems Training Facility Boardman effective on the date of this memorandum.

2. As the designated Installation Natural Resources Manager, you are required to comply with the provisions of references (a) and (b), along with all applicable laws and regulations that relate to the management of natural resources on the installation's properties and are delegated signature authority for routine staff level natural resource correspondence. As the primary advisor to the Commanding Officer (CO) on natural resource issues, you are required to ensure that the CO is informed of natural resource issues, conditions of natural resources, preparation and implementation of the Integrated Natural Resources Management Plan, and potential or actual conflicts between mission requirements and natural resources mandates. Additionally, you are responsible for the inherently governmental decisions made on behalf of the CO with regards to Sikes Act compliance.

3. Pursuant to your duties as Installation Natural Resources Manager you are delegated a sub-permittee and authorized agent with signature authority for the purposes of executing your duties under Section 4(g) of reference (c) to ensure the compliance of the Bird/Animal Aircraft Strike Hazard program with references (a) through (e) and all applicable state and federal natural resource laws and regulations including matters pertaining to the permitting requirements of reference (f) and/or reference (g).

4. This appointment shall remain in effect until specifically revoked by the installation CO.

E. M. HANKS

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COOPERATIVE MANAGEMENT AGREEMENT

between

U.S. Department of the Navy, Boardman,Oregon

and

The Nature Conservancy

## I. Purpose

This Cooperative Management Agreement is made by and between The Nature Conservancy, hereinafter called the Conservancy, and the U. S. Department of the Navy, hereinafter called the Navy. The purpose of this agreement is to define the cooperative arrangement between the Navy and the Conservancy in managing the Research Natural Area (RNA) at the Naval Weapons Systems Training Facility at Boardman, Oregon.

## II. Background

The Navy established The Boardman Research Natural Area on September 1, 1978 to preserve high-quality examples of Columbia River Basin grassland and steppe vegetation communities and associated wildlife. For the subsequent 10 years, The Nature Conservancy, under the auspices of the Northwest Interagency Research Natural Area Committee, has fenced and managed the area for the Navy. Many research projects have been undertaken on the RNA since its establishment. In 1987, the Conservancy proposed a boundary change to transfer a fair condition grassland site for an excellent quality shrub-steppe plant community and to include better examples of some of the other already protected communities.

## III. Authority

A. Office of the Chief of Naval Operations Instruction (OPNAVINST) 5090.1, 26 May 1983.

B. Naval Facilities Engineering Command (NAVFAC) P-73 Procedural Manual vol. 2, May 1987.

## IV. Provisions

A. The Conservancy will:

1. Establish permanent plots and monitor vegetation trend within the RNA.
2. Control noxious weeds within the RNA boundaries.

3. Encourage the use of the RNA for educational and research purposes.

4. Maintain the RNA fences.

B. The Navy will:

1. Review all Conservancy proposed management activities on the RNA.

2. Provide fire suppression on the RNA.

3. Control visitation on the RNA.

C. The Conservancy and the Navy mutually agree:

1. That nothing in this agreement shall limit or compromise the policies and authorities of the Navy or the Conservancy.

2. That this Cooperative Agreement shall become effective upon signing by the Navy and the Conservancy.

3. That amendments to this Cooperative Agreement may be proposed at any time by either party and shall become effective upon written approval of both parties.

4. That this agreement shall continue in full force until termination by mutual agreement or by either party. Termination shall require 30 days notice in writing to the other party of the intention to terminate upon a date indicated.

5. That the boundaries of the RNA shall be changed and that the new area should be fenced (See Exhibit A).

Department of the Navy
Western Division
Naval Facilities Engineering Command
P. O. Box 727
San Bruno, CA 94066-0720

[signature]
Manager, Natural Resources

3/7/88
Date

The Nature Conservancy
Oregon Field Office
1205 NW 25th Avenue
Portland, Oregon 97210

[signature]
Executive Director

2-12-88
Date

Boundaries of existing and proposed Boardman Research Natural Area (RNA)

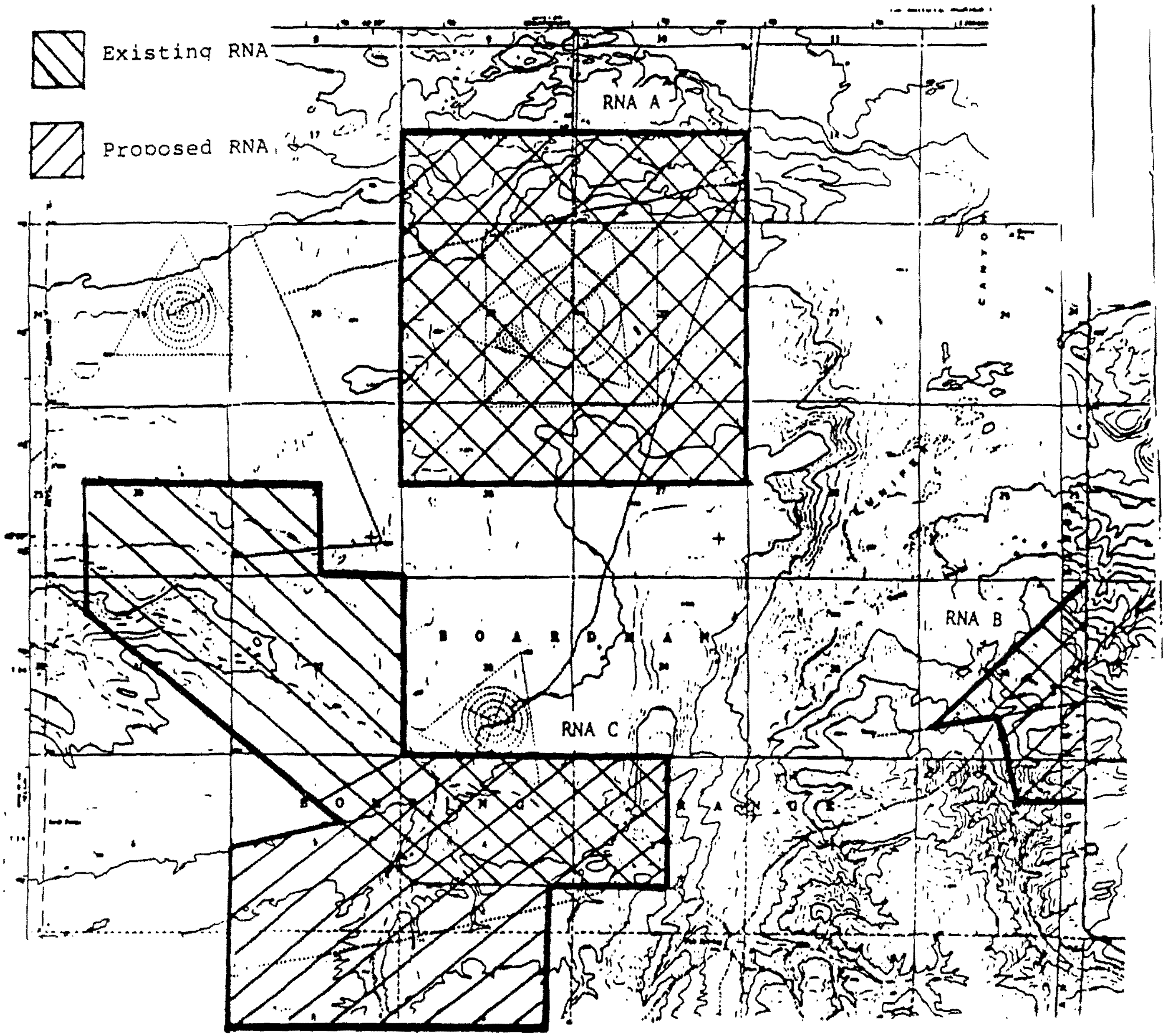


EXHIBIT A

Morrow County
T2N, R25E
T3N, R25E

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The Nature Conservancy
Protecting nature. Preserving life.™

The Nature Conservancy in Oregon
Columbia Basin Office
PO Box 314
The Dalles, OR 97058

tel (541) 298-1802
(541) 980-3633
fax (541) 298-1802

nature.org

April 18, 2012

John Phillips
Natural Resources Manager, N442
Environmental Division
Public Works Department
NAS Whidbey Island
1115 W. Lexington St., Bldg. 103
Oak Harbor, WA 98278-3800

**Re: Boardman NWSTF Integrated Natural Resources Management Plan**

Dear Mr. Phillips,

I am writing on behalf of The Nature Conservancy to offer our cooperation and support in implementing the 2012 Integrated Natural Resources Management Plan (INRMP) for the Naval Weapons Systems Training Facility (NWSTF) Boardman. As you know, The Nature Conservancy is a non-profit conservation organization whose mission is to conserve the lands and waters on which all life depends. The Conservancy has an organization-wide commitment to working with partners to accomplish this mission in a science-based, collaborative manner.

The Conservancy has worked closely with the Navy under a cooperative management agreement to co-manage three Research Natural Areas (RNAs) on the NWSTF since their designation in 1978. We also coordinate with the Navy on various natural resource issues, ranging from invasive species control to developing and conducting wildlife and habitat research and surveys within the RNAs and throughout the NWSTF. The Conservancy also manages the 22,642-acre Boardman Conservation Area (BCA) immediately to the west of the NWSTF.

We have reviewed the final 2012 INRMP and commit to follow and advance the goals of the plan in our management of the RNAs, under our current cooperative management agreement with the Navy, to protect the unique and irreplaceable native ecosystems represented on the installation while ensuring no net loss of the capability of the installation lands to support the Department of Defense mission.

Sincerely,

Leslie Nelson
Columbia Basin Project Manager
The Nature Conservancy

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RNA FILE

# ESTABLISHMENT REPORT

## RESEARCH NATURAL AREA

NAVAL WEAPONS SYSTEMS
TRAINING FACILITY
BOARDMAN, OREGON

243F:DCR:pr
11015
Ser 243F/222
1 Sep 1978

# ESTABLISHMENT REPORT

for

RESEARCH NATURAL AREA

at

NAVAL WEAPONS SYSTEMS TRAINING FACILITY, BOARDMAN, OREGON

(Controlled by: Naval Air Station, Whidbey Island, Oak Harbor, WA)

Prepared by:

Donald C. Rappel
Staff Forester
Seattle Branch, Western Division
Naval Facilities Engineering Command

Date: 1 September 1978

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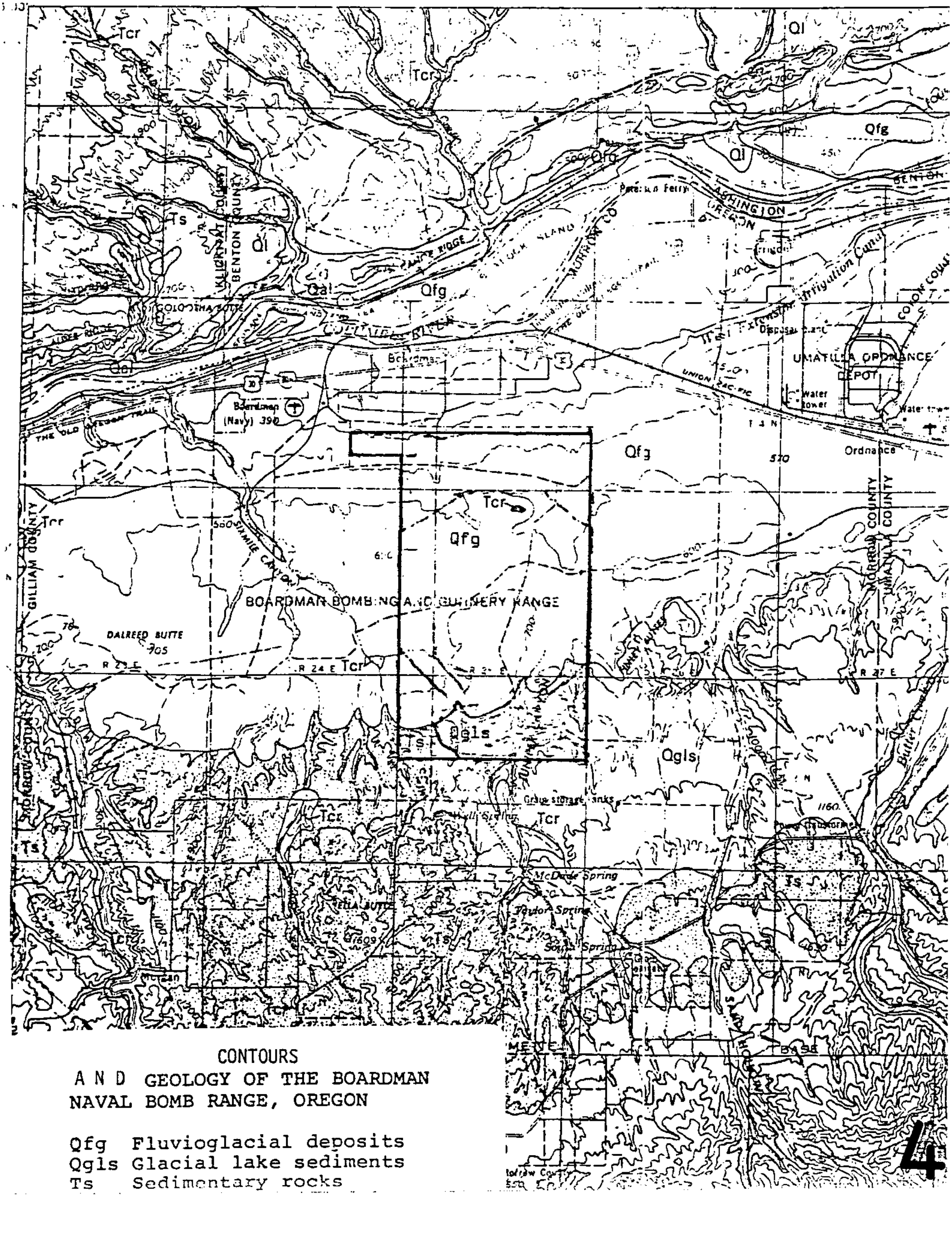
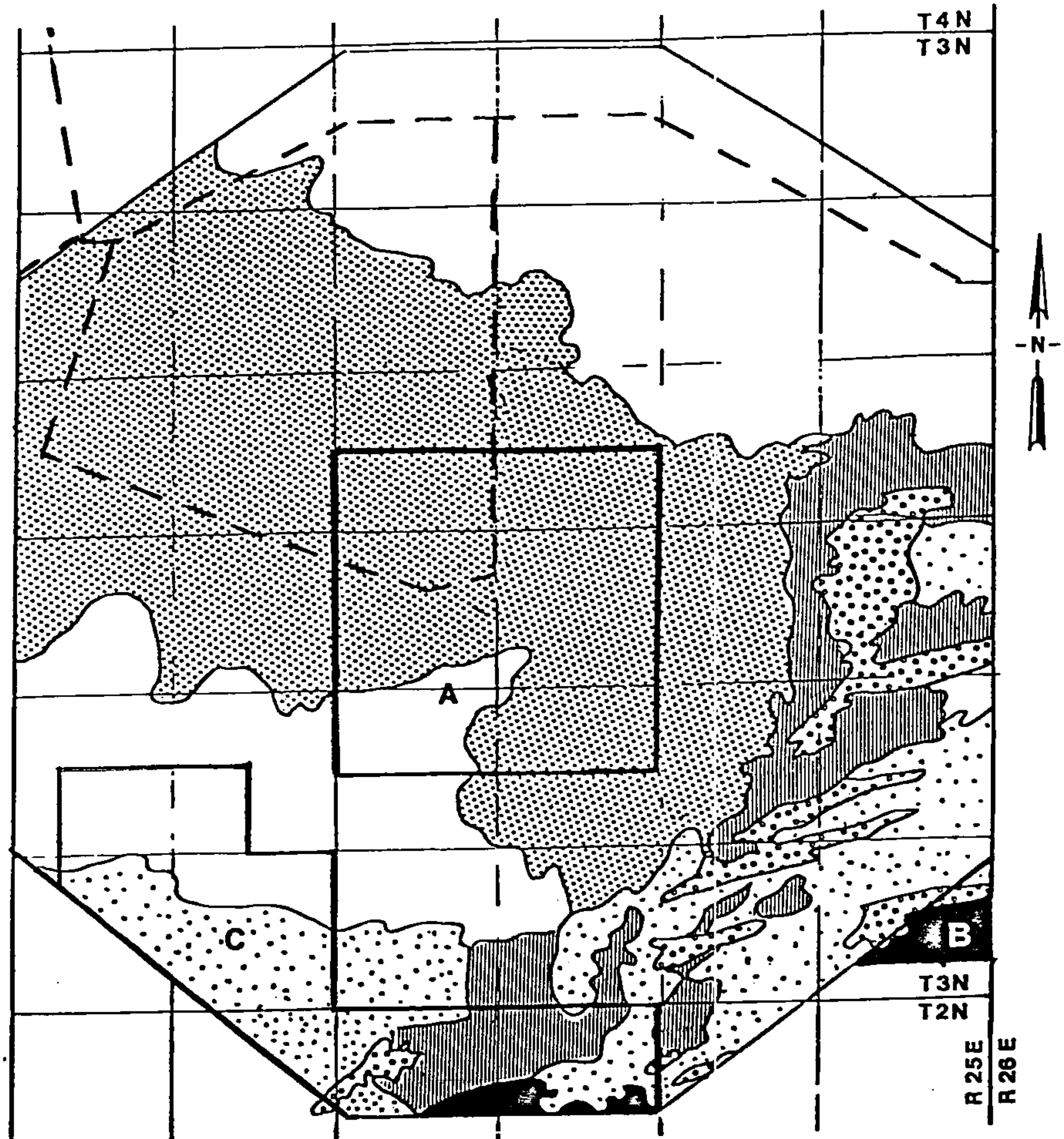
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY




CONTOURS
AND GEOLOGY OF THE BOARDMAN
NAVAL BOMB RANGE, OREGON

Qfg Fluvioglacial deposits
Qgls Glacial lake sediments
Ts Sedimentary rocks

SOIL MAP OF CENTRAL TARGET
OCTAGON




SOIL SERIES

| | | | |
|---|---|---|---|
| Dunes | Royal | — — ROADS | |
| Koehler | Warden | | |
| Quincy | Sagehill and Taunton | | |

SCALE: 1" = 1 MI.

PHOTO #1

False color infra-red satellite photo. Large octagonal target area of the Boardman Bombing Range is readily distinguished from the surrounding basin lands. Red circles are irrigated lands from 120 to 160 acres each. Non-irrigated agricultural development is mainly to the South and East of the Bombing Range. Since this photo was taken, irrigation circles have been developed up to the West boundary of the Boardman Bombing Range. The central bombing octagon stands out from space because it has never been plowed and has been free of grazing for nearly forty years.

PHOTO #2

The area left of the fence line is within the target octagon of the Bombing Range. This area has not been grazed and consists of bluebunch wheatgrass and Sandberg's bluegrass. It is within the proposed Research Natural Area "C". The area to the right of the fence line has been grazed and consists of cheatgrass and sagebrush.

2. - PHOTOGRAPHS

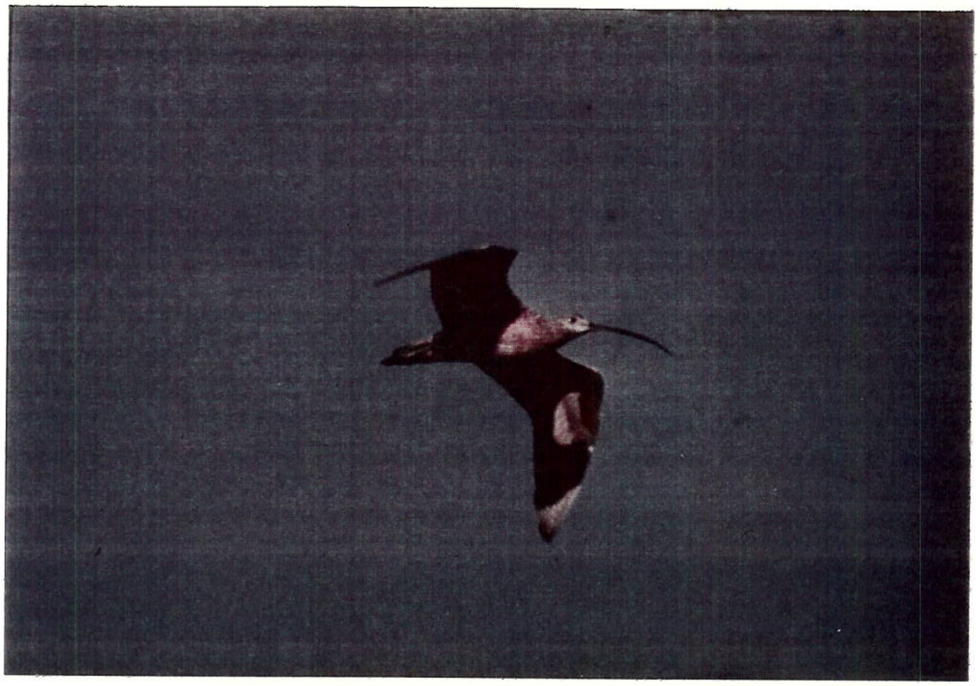


PHOTO #3
The Northern Long-billed curlew Numenius americanus parvus nest on the range and the proposed Research Natural Area. This bird, along with others listed in this report, are considered to be rare and will be protected if the Research Natural Area is established.

PHOTO #4
The undisturbed ground cover of the target area octagon shows lush growth of bluebunch wheatgrass, phlox and cover of cryptogam (mosses and lichens). This area is located in the proposed Research Natural Area "C".

2. - PHOTOGRAPHS

PHOTO #5
Agropyron dasytachyum-Stipa comata (downy wheatgrass-needlegrass) community on Sage hill and Taunton soils.

PHOTO #6
Stipa comata-Poa sandbergii (needlegrass-Sandberg's bluegrass) community on Koehler soil.

PHOTO #7
Agropyron spicatum-Poa sandbergii (bluebunch wheatgrass-Sandberg's bluegrass) community on Warden soil

PHOTO #8
Stipa comata-POA sandbergii (needlegrass-Sandberg's bluegrass) community on Quincy soil.

## 3. - DESIGNATION ORDER

By virtue of the authority vested in me by the Secretary of Defense under regulation 36 CFR 251.23, I hereby propose the Boardman Bombing Range Research Natural Area as an Ecological Reserve Area. The lands described in the attached report by Donald C. Rappel, Seattle Branch, Western Division, Naval Facilities Engineering Command, dated 1 Sep 1978, shall hereafter be administered as an ecological reserve area, subject to the said regulations and instructions thereunder.

| | |
|---|---|
| ____________ | ____________________ |
| Date | Commanding Officer |

# 4. - TEXT

## A. INTRODUCTION

The Naval Weapons Systems Training Facility at Boardman, Oregon is a component of the Naval Air Station, Whidbey Island, Oak Harbor, Washington. The Boardman Facility consists of 47,432.07 acres - see Map 1. This land was acquired by transfer from the Department of the Air Force on 22 November 1960. Of the 47,432.07 acres of land, 10,111.76 acres are Navy owned and 37,320.31 acres have been withdrawn from the public domain. The Facility is divided into six general areas:

| | |
|---|---|
| Administrative Area | 640 acres |
| North End | 9429 acres |
| Mobile Target | 1150 acres |
| Target Octagon | 20,994 acres |
| South End | 15,001 acres |
| Road Easement | 218 acres |

The North and South Areas have been outleased for livestock grazing since 1963. The remaining areas have not been grazed since acquisition of the range by the Navy Department. It is believed that these areas have not been grazed since the acquisition of the property by the Air Force Department in 1943.

In early 1975, the WESTNAVFACENGCOM Staff Forester took a group from the Oregon Natural Area Preserves Committee on a tour of the range. At that time no interest was expressed in preserving any of the range area.

In 1977 the grazing leases for the North and South ends expired and it was decided to include the Target Octagon in the new grazing leases.

After the new leases were advertised and awarded, the WESTDIV Staff Forester was contacted by the Oregon Natural Area Preserves Committee and the Nature Conservancy. As a result of this contact, this request for the establishment of the Research Natural Area is being made. The Research Natural Area being proposed consists of three areas:

Area "A" is 2,560 acres in size and is located within the ungrazed Target Octagon, as shown on Map 2. It is not included in the grazing lease and has been fenced by the lessee.

Area "B" is 196 acres in size and is located outside of but immediately adjacent to the Target Octagon as shown on Map 2. It is included in the grazing lease; however, no grazing will be done on the area since it is a dune stabilization area. It is fenced separately from the remaining grazing lease area.

Area "C" is 2,420 acres in size and is located within the ungrazed Target Octagon as shown on Map 2. It is included in the grazing lease and will be grazed if it is not established as a Research Natural Area. It is not separately fenced from the remaining grazing lease area.

All of the proposed Research Natural Areas are located on land which has been withdrawn from Public Domain.

B. JUSTIFICATION

In the Pacific Northwest (Oregon and Washington) a comprehensive system of Research Natural Area needs has been outlined in the publication "Research Natural Area Needs in the Pacific Northwest," U.S. Department of Agriculture, Forest Service Pacific Northwest Forest and Range Experiment Station General Technical Report PNW-38 1975. See Appendix I. The Boardman sites are the only areas that can adequately fill a number of these needs as described in the sections on the Washington and Oregon portions of the Columbia Basin physiographic provinces. The Boardman Bombing Range contains the only known high quality examples of flood deposit (sandy soil) shrub and bunchgrass communities remaining in Oregon or Washington.

The proposed Research Natural Area on the Boardman Bombing Range would protect high quality examples of the following Research Natural Area cells or needs:

1. Stipa comata - Poa sandberii (Needle and thread grass - Sandberg's bluegrass) on a range of soil types. See Photos 6 and 8.
2. Agropyron spicatum - Poa sandbergii (Bluebunch wheatgrass - Sandberg's bluegrass) See Photo 1.
3. Artemisia tridentata - Stipa comata (Big sagebrush - Needle and thread grass)
4. Columbia River sand dunes in various stages of stabilization.
5. Agropyron dasystachyum - Stipa comata (Downy wheatgrass - Needle and thread grass) While this community is not described as a need, it is the best habitat for the Washington ground squirrel. See Photo 5.

The following species of flora and fauna are of concern:

Astragalus succumbens - Crouching or columbia milk - vetch.

Numenius americanus parvus - Northern long-billed curlew.

Speotyto cunicularia hypugasa - Western burrowing owl.

Buteo regalis - ferruginous hawk.

Buteo swainsoni - Swainson's hawk.

Aquila chrysaetos - Golden eagle.

Spermophilus washingtoni - Washington ground squirrel.

## C. PRINCIPAL DISTINGUISHING FEATURES

As discussed in Section 4B, quality representatives of Columbia Basin ecosystems are now quite rare. The Boardman Bombing Range contains the last high-quality representative of the native shrub-steppe vegetation that formerly covered millions of acres of the central Columbia Basin. In the remainder of the basin, the native ecosystems have been substantially altered by decades of grazing and, more recently, by irrigated and non-irrigated agriculture.

Beyond this general distinguishing feature, the spectrum of sandy soils and sandy soil ecosystems is well represented. A number of species of concern are represented.

At present, research on the long-billed Curlew by the U.S. Fish and Wildlife Service is in progress, permanent vegetation transects have been emplaced, and preliminary investigations of the Washington ground squirrel population has been made.

The extraordinary cryptogam (mosses and lichens) cover in the *Agropyron spicatum-Poa sandbergii* community of RNA "C" is of great interest - see Photo 4. The proposed Research Natural Area holds an irreplaceable opportunity to study the effects of this cover on a variety of ecosystem characteristics, such as nitrogen fixation, erosion control, moisture relationships, and control of invasion by weedy, exotic species. High cryptogam cover is invariably accompanied by almost complete absence of the typical weedy anruals such as Bromus techtorum-cheatgrass, Erodium cicutarium-storksbill alfilaria, and Sisymbrium altissimum-Tumble mustard.

In the proposed Research Natural Area "B", grazing occurred up to about three years ago. Cryptogam cover is much lower in this area and weedy species are much more abundant. At the same time, the cover of Agropyron and Poa is comparable to Area "C".

D. LOCATION (See Map 1)

1. The Northern boundary of the Naval Weapons Systems Training Facility is located two miles due South of the town of Boardman, Oregon and Interstate Highway 80 N. The Research Natural Areas are located as shown on Map 2.

2. The Research Natural Area is located at 45°41'05" Longitude and 119°42'33" Latitude.

3. The legal description of the Research Natural Area is as follows:

Area "A" - S 1/2 Sec 15, S 1/2 Sec 16, Sec 21, Sec 22 N 1/2 Sec 27, N 1/2 Sec 28, all in T. 3 N., R. 25 E., Willamette Meridian

Area "B" - Beginning at the Northeast Corner of Section 36, T. 3 N., R. 25 E., Willamette Meridian, thence Southwesterly along the existing Target Area fence for a distance of 6487 feet to its intersection with the South boundary fence of the dune stabilization area, thence Easterly along the existing South boundary fence for a distance of 4978 feet to its intersection with the Facility's boundary fence, thence North along the boundary fence for a distance of 3470 feet to the Point of Beginning.

Area "C" - Beginning at the Northeast corner of Section 3 T. 2 N. R. 25 E., Willamette Meridian, thence due South 3922 feet to the intersection of the Target Area Fence, thence due East along the existing fence for a distance of 9806 feet to the angle point in the Target Fence, thence Northwesterly along the existing fence for a distance of 13,064 feet, thence due North 3960 feet, thence due East 6600 feet thence due South 2640 feet thence due East 2640 feet thence due South 5280 feet thence due East 10,560 feet to the Point of Beginning.

4. Total Acreage of Area - The Research Natural Area is composed of three separate areas, all within the boundaries of the Naval Weapons Systems Training Facility, Boardman, Oregon.

| | | |
|---|---|---|
| Area "A" | | 2,560 acres |
| Area "B" | | 196 acres |
| Area "C" | | 2,420 acres |
| | Total acreage | 5,176 acres |

5. Access Routes - The following access routes may be used to reach the Research Natural Areas:

Area "A" - From the town of Boardman 3.75 miles East along Interstate Highway 80 N. to the Boardman Junction, then South along the Boardman-Heppner County Road for 5.5 miles to the road to Tower #5, then Westerly past Tower 5 along the unpaved Target Area Perimeter Road for 3.1 miles to the Mobile Target Control Tower, then South along the unpaved road immediately East of the Tower for 2 miles to the North Boundary of Area "A".

Area "B" - From the town of Boardman, 3.75 miles East along Interstate Highway 80 N. to the Boardman Junction, then South along the Boardman-Heppner County Road for 9 miles. Area "B" is adjacent to the road on the West side. An unpaved road is located along the South Boundary of the Area.

Area "C" - From the town of Boardman 3.75 miles East along Interstate Highway 80 N. to the Boardman Junction, then South along the Boardman-Heppner County Road for 9.5 miles then Westerly on unpaved road along the South Boundary of Area "B" for 0.5 mi. to "Y" in road, then Southwesterly along the left fork of the "Y" for 2 miles to Tub Springs, then Northwesterly 0.5 mi. to the Target Area Boundary fence and the South Boundary of Area "C". A road follows the Target Area Fence West and Northwest to the West Boundary of the Facility.
(See Map 2 for above routes.)

E. AREA BY GENERAL COVER TYPE.

Of the 5175 acres within the proposed Research Natural Area, approximately 4825 acres are taken up by the sandy soil flood deposits and associated vegetation. These deposits support a general cover type of needle and thread grass, bearded wheatgrass and sagebrush communities of undetermined individual extent. The remaining 350 acres are a lacustrine terrace sediment which supports a Bluebunch wheatgrass - Sandberg's bluegrass community.

F. PHYSICAL AND CLIMATIC CONDITIONS.

The site consists of a moderate series of ravines. The largest and most obvious of these is referred to as Juniper Canyon. Although referred to as "canyons", they are not in the true serse in that the contours of the surrounding area are composed of brcad flat plateaus with rounded hillsides dropping into the valleys at moderate slopes. Larger valleys are generally flat across the bottom for several hundred feet and the drainage channel in most areas is undefined.

Contours of the site rise gently from approximately 400 feet elevation (MSL) at the North end to 900 feet elevation at the South end.

Climatological Data has been obtained from the following three stations:

1. Heppner, Oregon Weather Station located 40 miles south of Boardman.
2. Hermiston, Oregon Weather Station located 24 miles east of Boardman.
3. Pendleton, Oregon Weather Station located 44 miles east of Boardman.

Table I lists the elevations, length of records and monthly precipitation. Since the Hermiston station is at 624 foot elevation, its records are most similar to conditions on the facility.

Table 2 lists temperature extremes and Table 3 lists average days of High and Low temperatures.

TABLE 1

Average Days of High and Low Temperature Extremes

Based on Mid-Columbia U.S. Weather Stations

| Number of days in which Temperature is equal or Greater than the Following Average...... | | Number of Days in Which Temperature is below Freezing...... | |
|---|---|---|---|
| Average Temp. | Number of days greater than average | Degrees below freezing | Number of days given low temp. |
| 65° F | 186 days | 32° or less | 112 |
| 70 | 161 | 20° " " | 27 |
| 75 | 135 | 10 " " | 9 |
| 80 | 104 | 0 " " | 3 |
| 85 | 74 | | |
| 90 | 47 | | |
| 95 | 24 | | |
| 100 | 8 | | |

# TABLE II

## Temperature Extremes, Mid-Columbia U.S. Weather Stations

| | Heppner 1938-1967 Elev. 1978' MSL | | Hermiston 1942-1971 Elev. 624 MSL | | Pendleton 1928-1971 Elev. 1482 MSL | |
|---|---|---|---|---|---|---|
| | Record High | Record Low | Record High | Record Low | Record High | Record Low |
| Jan. | 70° F. | -19° F | 72°F | -35°F | 67°F | -22° |
| Feb. | 72° | -21° | 71° | -29° | 66° | -18° |
| Mar. | 78° | -6 ° | 84° | 6° | 79° | 10° |
| Apr. | 92° | 9 ° | 96° | 14° | 89° | 18° |
| May | 100° | 21 ° | 102° | 22° | 99° | 25° |
| June | 105 | 32° | 108° | 33° | 108° | 36° |
| July | 108 | 36° | 112° | 38° | 110° | 42° |
| Aug. | 110 | 35° | 113° | 35° | 113° | 41° |
| Sept | 99 | 19° | 102° | 21° | 102° | 30° |
| ct. | 89 | 10° | 92° | 6° | 86° | 11° |
| Nov. | 80 | -8° | 79° | -12° | 74° | -6° |
| Dec. | 75 | -18° | 70° | -37° | 67° | -12° |

Note: For additional data, refer to Umatilla Weather Station for records.

TABLE III

Monthly Mean Precipitation at Mid-Columbia U.S. Weather Stations

| | Heppner 1938-1967 Elev. 1978' MSL | Hermiston 1942-1971 Elev. 624' MSL | Pendleton 1928-1971 Elev. 1482' MSL |
|---|---|---|---|
| Jan. | 1.29 inches | 1.22 inches | 1.42 inches |
| Feb. | 1.16 | 0.82 | 1.18 |
| Mar. | 1.28 | 0.73 | 1.20 |
| Apr. | 1.27 | 0.57 | 1.09 |
| May | 1.42 | 0.72 | 1.12 |
| June | 1.30 | 0.73 | 1.17 |
| July | 0.40 | 0.20 | 0.22 |
| Aug. | 0.49 | 0.18 | 0.28 |
| Sept. | 0.76 | 0.46 | 0.63 |
| Oct. | 1.27 | 0.86 | 1.18 |
| Nov. | 1.55 | 1.18 | 1.40 |
| Dec. | 1.47 | 1.24 | 1.49 |
| Annual Average | 13.66 | 8.91 | 12.38 |
| Highest Annual Ave. on Record | 19.23 (1942) | 14.00 (1957) | 17.73 (1942) |
| Lowest Annual Ave. on Record | 7.81 (1939) | 4.43 (1967) | 6.77 (1967) |

## G. DESCRIPTION OF ECOLOGICAL VALUES.

### 1. Flora

The only species of concern is Astragulas succumbens - Crouching or Columbia milk-vetch. The plant communities which would be protected by the establishment of the Research Natural Area are listed in section 4 B. The following is a list of common species found on the area:

Chrysothamnus nauseosus - Gray Rabbitbrush

Chrysothamnus viscidiflorus - Green Rabbitbrush

Purshia tridentata - Antelope Bitterbrush

Agropyron spicatum - Bluebunch Wheatgrass

Stipa comata - Needle and thread grass

Oryzopsis hymenoides - Indian Rice grass

Agropyron dasystachyum - Thickspike Wheatgrass

Festuca idahoensis - Idaho fescue

Poa sandbergii - Sandberg's bluegrass

Agropyron cristatum - Crested wheatgrass

Bromus tectorum - Cheatgrass

Phlox longifolia - Phlox

Erodium cicutarium - Storksbill alfilaria or crane's bill

Descurainia pinnata - Tansymustard

Astragalus purshii - Pursh's milk-vetch

Salsola kali - Russian thistle

Sisymbrium altissimum - ~~Tuble~~ tumble mustard or Jim Hill mustard

Achillea millefolium - Western yarrow

Erigeron linearis - Fleabane

Zygadenosus venosus - Deathcamas

Psoralea lanceolata - Lanceleaf scurfpea

Balsamorhiza spp. - Balsamroot
Cymopterus terebinthinus - Turpentine cympterus
Hieracium spp. - Hawkweed
Draba verna - spring whitlow grass
Lomatium macrocarpum - Long-fruited parsley
Holosteum umbellatum - holosteum
Fritillaria pudica - Yellowbell
Phacelia linearis - thread-leaf phacelia
Delphinium spp. - Larkspur
Layia glandulosa - tidy tips
Oenothera spp. - Primrose
Aster canescens - hoary aster
Lomatium cous - Biscuitroot
Amsinckia lycopsioides - tarweed fiddleneck
Juniperus occidentalis - Western Juniper
Opuntia polycantha - prickly pear
Wyethia amplexicalis - Smooth mule ears
Sitanion hystrix - squirrel tail grass
Verbascum thapsus - Mullein

Artemesia tridentata - Big Sagebrush

Madia glomerata - Tarweed

References:

Daubenmire, R. 1970. Steppe Vegetation of Washington
Wash. Agric. Exp't Station Tech. Bulletin 62

Franklin, J.F. and C.T. Dyrness 1973.
Natural Vegetation of Oregon and Washington.
USDA For. Ser. Gen. Tech. Rep't PNW-8
Pac. N.W. For & Range Exp't Sta. Portland, OR

Nature Conservancy Transect plots inventoried April 1978

Gibbs, Jacy USDA Soil Conservation Service,
Range Inventory June 1977

2. Fauna

The species of concern are listed in Section 4B. The raptors feed on the small mammals of the proposed Research Natural Area while nesting in nearby areas. Long-billed curlews nest in the grassland communities throughout the bombing range including the proposed RNA. See photo 3. The population of the Washington Ground Squirrel is the first one found in Oregon for over 30 years.

The following is a list of common species found on the area:

Odocoileus hemionus - Mule deer

Sylvilagus nuttallii - Cottontail rabbit

Lepus californicus - Blacktail jackrabbit

Phasianus colchicus - Ring-necked pheasant

Centrocercus urophasianus - Sage grouse

Lophortyx californicus - California quail

Zenaidura macroura - Mourning dove

Canis latrans - Coyote

Taxidea taxus - Badger

Lynx rufus - Bobcat

Perognathus parvus - Great Basin pocket mouse

Peromyscus maniculatus - Deer mouse

Sturnella neglecta - Western meadowlark

Pica pica - Black-billed magpie

Sturnus vulgaris - Starling

Charadrius vociferus - Killdeer

Circus cyaneus - Marsh hawk

Falco sparverios - Sparrow hawk

Pituophis melanoleucus - Yellow-bellied racer

References:

1. Federal Research Natural Areas in Oregon and Washington. A guidebook for Scientists and Educators. USDA For. Ser. Pac. N.W. Forest & Range Exp. Sta. Portland, OR 1972

2. Personal Observations by D. Rappel over the period 1966 to present.

3. Geology

The majority of the proposed Research Natural Area is underlain by quaternary flood deposits from one or more episodes of the Missoula or Spokane floods. A small section of the site is underlain by old quaternary terrace deposits that are lacustrine in origin. These deposits are overlain by a mantle of loess. See map 4 for locations and contours. The Warden soil series marks the extent of these deposits on the proposed Research Natural Area. See map 3 for soil types.

4. Soils

Six soils series are represented on the proposed Research Natural Area. Five of these are flood deposit soils and increase in sandiness from top to bottom.

Royal fine sandy loam

Taunton fine sandy loam

Sagehill fine sandy loam

Koehler loamy sand

Quincy fine sand

The sixth soil series is the Warden silt loam developed in lacustrine terrace sediments. These soils are shown on map 3. U.S. Soil Conservation Service descriptions of these soils are included as Appendix IV.

H. IMPACTS AND POSSIBLE CONFLICTS

1. Cultural Value - The establishment of the proposed Research Natural Area does not involve any lands which are of known cultural or historic value. A 7-mile segment of the Oregon Trail lays 2 to 4 miles South of Area "C". It has been nominated for designation as a National Historic Site. Neither the Research Natural Areas or the access routes to them will impact on the Oregon Trail.

2. Mineral Value - There are no known mineral deposits located within the proposed Research Natural Areas or for that matter anywhere on the entire Facility. Mineral development, especially within the Target Octagon, would not be compatible with the military use of the area.

3. Grazing - Area "A" was not included in the grazing lease - is separately fenced, and there is no impact or conflict with grazing values. Area "B" was included in the grazing lease; however, it is an area of active blowsand and is of no value for grazing. Sand stabilization efforts are being made which preclude the grazing of livestock in Area "B". This Area is separately fenced from the rest of the grazing area. Area "C" is part of the grazing lease, and is only partially fenced. If the Research Natural Area is approved, approximately 7 miles of fence must be constructed. The estimated cost of the required fencing is $24,000. The Oregon Natural Area Preserves Committee and the Nature Conservancy will pay the cost of the fencing. The Navy is presently receiving $12.11 per AUM ( Animal Unit Month). The withdrawal of Area "C" from the grazing lease will result in an annual loss in revenue to the Navy of

approximately $2400. The present grazing lessee has verbally agreed to the withdrawal of Area "C" from his grazing lease.

4. Watershed Value - Due to the relatively high porosity of the soil, the short duration of most rainstorms, and the relatively flat topography of the Research Natural Areas, there are no watershed values involved. Since the proposed research will be non-destructive in nature, there will be no change in surface runoff.

5. Recreational Value - There will be no impacts or conflicts with the recreational value since the entire facility is closed to the general public.

6. Wildlife Preserve - The establishment of the Research Natural Area would not impact or conflict with the wildlife population on the Facility. A number of rare and threatened species either breed on the Facility or breed nearby, and forage over the Facility. These include the prairie falcon, Swainson's hawk, Ferruginous hawk, burrowing owl, long-billed Curlew and the Washington ground squirrel. The Washington ground squirrel population is the only viable one known in Oregon and Area "C" will preserve their habitat.

7. Roads and Trails - Areas "B" and "C" contain no maintained roads or trails; however, Area "C" does have some abandoned roads within its boundaries. These are remnants of the Air Force's use of the Facility and are not used by the Navy. Area "A" is the main Target Area and several maintained roads are contained within it. These are necessary for the maintenance of the main Target and for unexploded ordnance disposal. These roads will continue to be used if the area becomes a Research Natural Area.

I. ADMINISTRATION RECORDS AND PROTECTION

The Commanding Officer, Naval Air Station, Whidbey Island (Oak Harbor, Washington) is the administrator and protector of the Research Natural Area at the Naval Weapons Systems Training Facility at Boardman, Oregon.

The Officer in Charge (OIC) of the Naval Weapons Systems Training Facility, Boardman, Oregon is responsible for coordinating access to the Research Natural Area with the scheduled military use of the Facility. Access will not be granted during periods of military use of the Target Area.

The principal contact for approval and coordination of research on the Natural Area is the Staff Forester, Western Division, Naval Facilities Engineering Command, Seattle Branch Office, Building 5B, Naval Support Activity, Seattle, WA 98115. Research requests will be forwarded to the Pacific Northwest Federal Research Natural Areas Committee for technical approval. Final approval of proposed research will be made by the Commanding Officer, Naval Air Station, Whidbey Island.

Scientists who wish to use the Research Natural Area must abide by the requirements listed in Appendices 2 and 3 of this report.

# 5. - APPENDICES

## APPENDIX I

## RESEARCH NATURAL AREAS - PURPOSE, SELECTION AND MANAGEMENT

### Purposes of the System

The land management agencies have been actively developing a national system of Research Natural Areas (RNA's) since 1927. This system has grown to the current 389 areas covering 4.4 million acres in 46 states and one territory. Each area is administered by one of eight cooperating agencies: Forest Service in the Department of Agriculture; Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service and National Park Service in the Department of the Interior; Air Force in the Department of Defense; Energy Research and Development Administration; and the Tennessee Valley Authority.

From the inception of the program there have been two primary purposes for developing a comprehensive and representative system of Research Natural Areas:

1. To preserve a representative array of all significant natural ecosystems and their inherent processes as baseline areas. This action provides a potential range of diversity, including common, rare, and endangered species or disjunct populations.

2. To obtain through scientific education and research, information about natural system components, inherent processes, and comparisons with representative manipulated systems.

The system provides several specific advantages to the nation's scientific community which have not usually been available, namely:

1. The potential use of an area that has had minimal human interference and has a reasonable assurance of long-term existence.

2. The potential availability of diverse or multiple data sets for analysis of factor interrelationships or temporal sequences.

3. The potential association with scientists of different disciplines leading toward scientific discoveries unlikely to occur without such association.

These values not only assist the investigator and science, but also provide the administering agencies with an information base with which to optimize their resource management decisions.

Interrelated with system preservation and the intrinsic scientific information are the numerous future options the system provides to society, especially with respect to genetic and land resource potential.

## Recommendation, Selection, and Establishment

The Research Natural Area designation is used by the Federal land administering agencies to establish areas on which natural features and processes are preserved with minimal human intervention for research and educational purposes. This designation differs from other classifications such as wilderness sanctuary, refuge, or preserve, in that the latter designations often have broader use-management objectives than the preservation/scientific applications of the RNA system.

As initially conceived by the system founders, an RNA should contain an exemplary tract of vegetation along with its major supporting factors. In recent years, however, the range of features designated has expanded to include: typical or unusual floristic and/or faunistic assemblages, characteristic or unusual geologic, pedologic, or aquatic features; or characteristic or unusual processes. At the time of designation, significant effort is expended to assure that adequate conditions are provided to insure longevity of the feature. Presently, a designated area may range in size from a few to several thousand acres and may possess one or more features of interest.

A point which should be documented is that the Research Natural Area system receives no special legislative protection. The additional protection afforded the areas is derived only from the individual agencies which designate them.

Each participating agency has a different procedure leading to the designation of an RNA. In general, the on-site staff inventories the land resources to identify potential sites. Each area recommended by the inventory is documented by an agency-provided establishment report which details the features and proposed management plan. Upon administrative approval, the site becomes an agency-recognized RNA. In some agencies, the establishment process includes a detailed withdrawal procedure; this administrative recognition is the strongest action available to insure the protection and management of the RNA.

Should a particular feature be identified that has not received designation, documentation supporting the feature may be submitted to the area manager as a recommendation for review and consideration. Proposing new sites for designation can encourage growth of the national system and also precipitate review of the existing RNA's.

## Management and General Use

All agencies employ a similar set of regulations to insure the protection of the educational and scientific values in their management and use. The Committee has developed a set of standards and policy guidelines to provide greater uniformity in system definitions, objectives, classification, selection, use, management and administrative policies. The underlying emphasis in RNA management is on preserving and protecting the features of each area by controlling any disruptive use, encroachment, and development.

An activity such as logging, grazing, burning or restocking is prohibited unless it replaces natural processes and thus contributes to the protection and preservation of the designated feature. Such a practice is invoked only after thorough research and testing indicate that it adequately or favorably benefits the feature. In such an instance, a portion of the tract is left untreated as a control to justify the practice.

Picnicking, camping, swimming, hiking, and gathering of rocks, plants, nuts, or berries are generally discouraged, and in some cases are prohibited if serious impairment is anticipated. Hunting, fishing, and trapping of fur-bearing animals are also not encouraged, but are permitted subject to State regulation except on restricted lands such as those within National Parks.

No agency has purposely encouraged public use of RNA's through publicity or recreational development. However, some peripheral ature trails and interpretive signs have been established and more can be anticipated as these undisturbed sites become subject to increased public attention.

## Scientific Use

Scientific use of RNA's by responsible scientists and educators is encouraged, providing their activities will not impair or threaten the features of the area. The limitations on use vary with the particular tract, its features, and the managing agency's regulations. An agency may place increased restrictions on some areas or portions of areas that it deems fragile or hazardous.

Research activities must be essentially non-destructive in character. Felling of trees and tree ring analyses, manipulative studies requiring extensive community floor modification, and extensive soil excavation are generally not allowed. Collection of plant and animal specimens should be restricted to the minimum necessary for providing vouchers and other research needs. In no case should specimens be collected to a degree that significantly reduces species population levels. The collection should be carried out in accordance with applicable Federal and State agency regulations and the specimens should be deposited in some public holding institution.

Within these guidelines, the appropriate uses of RNA's are determined on a case-by-case basis by the administering agency.

## APPENDIX III

## REQUIREMENTS FOR SUBMISSION OF RESEARCH PROPOSALS

Proposals for use of the Boardman Research Natural Area will provide as a minimum, the following:

1. Name, address and telephone number of researcher.
2. Qualifications and/or educational background.
3. Sponsoring agency or institution.
4. Detailed description of research proposed:
    - A. Purpose of research
    - B. Methods to be used.
    - C. Expected results.
    - D. Duration.
    - E. Anticipated schedule of on-the-ground use of the area.
    - F. Disposition of collected materials, if any.

# APPENDIX II

## REGULATIONS COVERING USE OF BOARDMAN RESEARCH NATURAL AREAS

1. Approval of proposed research must be obtained from the Navy prior to using the area.
2. Proposed research must be essentially non-destructive.
3. Collection of plant and animal specimens will be restricted to a minimum and such collections must be deposited in a public holding institution.
4. A cooperative agreement between the Navy and the researcher must be entered in to prior to use of the area.
5. Researcher must obtain approval from the OIC NWSTF Boardman for access to the area prior to each use.
6. Periodic reports on the progress of the research and copies of published research results must be provided to the Navy.
7. Specific research must be compatible with the preservation of the ecosystem and maintenance of its processes.
8. Non-idigenous or exotic plant and animal species will not normally be introduced into the area.
9. Permanent structures will not be constructed within the Area. Minimal temporary research facilities may be approved by the Navy.
10. No interference with normal cycles and fluctuations of wildlife populations will be allowed.
11. Predator control will not be allowed within the Area without specific approval of the Navy.
12. No camping is allowed on the Area or the Navy Facility.
13. No services or support will be provided by the Navy.

Established Series
Rev. ARH/JJR
12/73

# TAUNTON SERIES

The Taunton series is a member of the coarse-loamy, mixed, mesic family of Xerollic Durorthids. Typically, Taunton soils have light brownish gray fine sandy loam Ap horizons, pale brown fine sandy loam B2 horizons, pale brown gravelly fine sandy loam Cca horizons, and a white strongly cemented duripan at depth of about 24 inches.

Typifying Pedon: Taunton fine sandy loam - cultivated
(Colors are for dry soil unless otherwise noted.)

Ap 0-5"--Light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable, nonsticky, nonplastic; common roots; moderately alkaline (pH 8.0); abrupt smooth boundary. (3 to 8 inches thick)

B2 5-18"--Pale brown (10YR 6/3) fine sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, very friable, nonsticky, nonplastic; common roots; few very fine tubular pores; moderately alkaline (pH 8.0); clear wavy boundary. (4 to 14 inches thick)

C1ca 18-24"--Pale brown (10YR 6/3) gravelly fine sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; common roots; few very fine tubular pores; 20 percent gravel-size fragments which are lime-silica cemented; strongly effervescent; strongly alkaline (pH 8.6); abrupt smooth boundary. (3 to 20 inches thick)

IC2casim 24"--White (10YR 9/2) strongly cemented duripan; upper surface has thin smooth laminar cap; laminar cap and matrix are violently effervescent.

Type Location: Adams County, Washington; 250 feet south and 50 feet east of the center of the northwest 1/4 sec. 16, T.15N., R.28E., WM.

Range in Characteristics: Solum thickness ranges from 10 to 20 inches. Depth to the duripan ranges from 20 to 40 inches. Taunton soils are usually dry in all parts between depths of 8 and 24 inches or the top of the duripan if shallower. The mean annual soil temperature at depth of 20 inches or the surface of the duripan if shallower ranges from 50 to 56 degrees F. The Ap or A1 horizon has value of 5 or 6 dry and chroma of 2 or 3 dry or moist. It is fine sandy loam or loamy fine sand. This horizon has weak granular or subangular structure. The B2 horizon has value of 6 or 7 dry, 4 or 5 moist and chroma of 2 or 3 dry or moist. The C1ca horizon has the same color range as the B2 horizon. It contains 5 to 35 percent gravel-size lime-silica fragments.

Competing Series and their Differentiae: These are the Babcock, Burke, Crooked, Koehler, Prineville, and Royal series. Babcock and Burke soils have loam and silt loam control sections. Crooked soils are somewhat poorly drained and commonly have a high water table. Koehler soils have sandy control sections. Prineville soils are mildly alkaline above the duripan and have 5 to 25 percent sand-size pumice. Royal soils lack a duripan.

Setting: Taunton soils are on nearly level to sloping old high terrace tops and mesa-like areas between coulees, at elevations of 900 to 1,300 feet. They formed in old alluvium that has been reworked by wind. These soils occur in an arid climate with hot dry summers and cool moist winters. The mean annual precipitation ranges from 6 to 9 inches. The mean January temperature is 29 degrees F. The mean July temperature is 71 degrees F. The mean annual temperature is 50 degrees F. The frost-free season is 170 to 210 days.

Principal Associated Soils: These are the Wiehl soils and the competing Royal soils. Wiehl soils lack a duripan.

Drainage and Permeability: Somewhat excessively drained; slow runoff; moderately rapid permeability above the pan and very slow within the pan.

Use and Vegetation: Range and irrigated crops. Native vegetation is bluebunch wheatgrass, Sandberg bluegrass, buckwheat, rabbitbrush, and sagebrush.

Distribution and Extent: South-central Washington and north-central Oregon. Series is of moderate extent.

Series Established: Walla Walla County, Washington, 1960.

Remarks: Taunton soils were formerly classified as Sierozems.

National Cooperative Soil Survey
U. S. A.

Established Series
Rev. ARH
10/71

# ROYAL SERIES

The Royal Series is a member of the coarse-loamy, mixed, mesic family of Xerollic Camborthids. Typically, Royal soils have light brownish gray fine sandy loam A1 horizons, and pale brown fine sandy loam B2 horizons over pale brown light gray, light brownish gray, and gray stratified fine sandy loam and loamy fine sand C horizons.

Typifying Pedon: Royal fine sandy loam - grassland
(Colors are for dry soil unless otherwise noted.)

A1 0-5"--Light brownish gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable, nonsticky, nonplastic; many roots; mildly alkaline (pH 7.6); abrupt smooth boundary. (3 to 6 inches thick)

B2 5-15"--Pale brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) moist; weak medium prismatic structure; soft, very friable, nonsticky, nonplastic; common roots; few very fine tubular pores; mildly alkaline (pH 7.8); clear wavy boundary. (6 to 18 inches thick)

C1ca 15-30"--Very pale brown (10YR 7/3) fine sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; common roots; few very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary. (10 to 25 inches thick)

C2 30-40"--Light gray (10YR 7/2) loamy fine sand, grayish brown (10YR 5/2) moist; massive; soft, very friable, nonsticky, nonplastic; few roots; few very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary. (6 to 12 inches thick)

C3 40-46"--Light brownish gray (10YR 6/2) fine sandy loam, dark brown (10YR 4/3) moist; massive; soft, very friable, nonsticky, nonplastic; few roots; few fine tubular pores; strongly effervescent; moderately alkaline (pH 8.4); abrupt wavy boundary. (6 to 12 inches thick)

C4 46-57"--Gray (10YR 6/1) loamy fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose; nonsticky, nonplastic; few roots; interstitial pores; strongly effervescent; strongly alkaline (pH 8.6); abrupt wavy boundary. (6 to 12 inches thick)

C5 57-70"--Light gray (10YR 7/2) fine sandy loam, dark brown (10YR 4/3) moist; massive; slightly hard, very friable, nonsticky, nonplastic; few roots; few very fine tubular pores; strongly effervescent; strongly alkaline (pH 8.7).

Type Location: Franklin County, Washington; Farm Unit 126 of Irrigation Block 16; 1,400 feet north and 200 feet west of southeast corner of sec. 28, T.11N., R.29E., WM.

Range in Characteristics: Solum thickness and depth to lime are 10 to 24 inches. The 10- to 40-inch control section averages sandy loam. Some pedons contain small pockets or thin strata of silt loam or very fine sandy loam. The soils are usually dry in all parts between depths of 8 and 24 inches. The mean annual soil temperature at a depth of 20 inches ranges from 50° to 56°F. The A1 horizon has value of 4 or 5 moist, and chroma of 2 or 3 dry or moist. It is fine sandy loam, loamy fine sand, or loamy sand. The B2 horizon has value of 6 or 7 dry and 4 or 5 moist, and chroma of 2 or 3 dry or moist. It is fine sandy loam or borderline fine sandy loam-loamy fine sand. The C horizon has value of 6 or 7 dry and 4 or 5 moist, and chroma of 1 through 3 dry or moist. It is stratified fine sandy loam and loamy fine sand.

Competing Series and their Differentiae: These are the Adkins, Cleman, Clems, Crestline, Deschutes, Ephrata, Prosser, Scooteney, Timmerman, and Wiehl series. Adkins soils are uniform fine sandy loam and lack lime above depth of 30 inches. Cleman soils are noncalcareous in all parts. Clems soils are noncalcareous to depths of 45 to about 60 inches. Crestline soils have gravelly textures in the lower part of the control section and have heavy sandy loam B horizons. Deschutes and Prosser soils have bedrock at depths of less than 40 inches. Ephrata soils have contrasting textures within the control section. Scooteney soils have more than 35 percent coarse fragments in the lower part of the control section. Timmerman soils have sandy control sections. Wiehl soils have a paralithic contact at depths of less than 40 inches.

Setting: Royal soils are on nearly level to gently sloping footslopes and terraces at elevations of 700 to 1,100 feet. They formed in wind modified glacio-fluvial sediments. These soils are in an arid climate with hot dry summers and cool moist winters. The mean annual precipitation is 6 to 9 inches. The mean January temperature is 27°F. The mean July temperature is 71°F. The mean annual temperature is 50°F. The frost-free season is 150 to 210 days.

Principal Associated Soils: These are the Taunton soils and the competing Wiehl soils. Taunton soils have a duripan at depths of less than 40 inches.

Drainage and Permeability: Well-drained; slow and medium runoff; moderately rapid permeability.

Use and Vegetation: Irrigated cropland and range. Native vegetation is needle-and-thread grass, bluebunch wheatgrass, Indian ricegrass, and big sagebrush.

Distribution and Extent: South-central Washington and north-central Oregon. Series is of moderate extent.

Series Established: Franklin County, Washington, 1971.

Remarks: Royal soils were classified as Sierozems.

Additional Data: S61 Wash, 11-13 (107) Riverside Lab. Nos. 61204-61210, and S61 Wash, 11-4 (1-6) Riverside Lab. Nos. 61211-61216.

National Cooperative Soil Survey
U. S. A.

Established Series
Rev. ARH
10/71

# KOEHLER SERIES

The Koehler series is a member of the sandy, mixed, mesic family of Xerollic Durorthids. Typically, Doehler soils have coarse textured horizons over an indurated duripan at dpeth of about 2 1/2 feet.

Typifying Pedon: Koehler loamy sand - grassland
(Colors are for dry soil unless otherwise noted.)

A1 0-4"--Grayish brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky, nonplastic; many roots; mildly alkaline (pH 7.8); clear wavy boundary. (2 to 5 inches thick)

C1 4-12"--Light brownish gray (10YR 6/2) loamy sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky, nonplastic; common roots; moderately alkaline (pH 7.9); slight effervescence with dilute HCL; clear wavy boudary. (2 to 15 inches thick)

C2ca 12-25"--Light brownish gray (10YR) loamy fine sand, dark grayish brown (10YR 4/2) moist; single grained; soft, very friable, nonsticky, nonplastic; few roots; 10 percent lime-silica duripan fragments; moderately alkaline (pH 8.2); violent effervescence with dilute HCL; abrupt wavy boundary. (10 to 15 inches thick)

C3casi 25-31"--Light gray (10YR 7/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; massive; very friable, nonsticky, nonplastic; few matted roots; 70 percent lime-silica duripan fragments; moderately alkaline (pH 8.2); violent effervescence with dilute HCL; abrupt wavy boundary. (0 to 6 inches thick)

C4casim 31"--Indurated lime-silica cemented duripan.

Type Location: Benton County, Washington; 75 feet east of intersection of Umatilla Road and PSH #8, in the NW1/4 SW1/4 sec. 32, T.6N., R.28E., WM.

Range in Characteristics: Depth to the duripan ranges from 14 to 40 inches. The soils are usually dry between depths of 12 and 35 inches or to the duripan if shallower. The mean annual soil temperature at depth of 20 inches or at the top of the duripan if shallower is 50° to 56° F. After the upper 7 inches are mixed the soil is calcareous in all parts. The A1 horizon has value of 5 or 6 dry and 3 or 4 moist. It is loamy sand, loamy fine sand, or fine sand. The C and Cca horizons have value of 6 through 8 dry and 3 through 5 moist, and chroma of 2 dry or moist. They are loamy sand, loamy fine sand, or fine sand. Thin sandy loam lenses occur immediately above the duripan in some pedons.

Competing Series and their Differentiae: These are the Babcock, Prineville, Quincy, Taunton, and Winchester series. Babcock soils have medium textured control sections above the duripan. Prineville soils are mildly alkaline above the duripan and have 5 to 25 percent sand-size pumice in the control section. Quincy and Winchester soils lack a duripan within a depth of 40 inches. Taunton soils have moderately coarse texture in the control section.

Setting: Koehler soils are on nearly level to sloping terraces, at elevations of 300 to 1,000 feet. They formed in alluvial and colluvial materials mantled with eolian sand. Koehler soils occur in an arid climate with hot dry summers and cool moist winters. The mean annual precipitation is 6 to 8 inches. Mean July temperature is 76° F. The mean January temperature is 50° F. The mean annual temperature is 53° F. The frost-free season is 150 to 210 days.

Principal Associated Soils: These are the Burbank and Finley soils and the competing Quincy and Winchester soils. None of these have a duripan.

Drainage and Permeability: Somewhat excessively drained; slow runoff; rapid permeability above the duripan and very slow within the duripan.

Use and Vegetation: Native range. Vegetation is needle-and-thread grass, Indian ricegrass, cheatgrass, hop sage, rabbitbrush, and big sagebrush.

Distribution and Extent: South-central Washington and north-central Oregon. Series is of moderate extent.

Series Established: Franklin County, Washington, 1914.

Remarks: Koehler soils were formerly classified as Regosols.

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U. S. A.

# WARDEN SERIES

The Warden series is a member of the coarse-silty, mixed, mesic family of Xerollic Camborthids. Typically, Warden soils have light brownish gray very fine sandy loam Ap horizons, pale brown very fine sandy loam B2 horizons, pale brown and light gray silt loam and very fine sandy loam C horizons.

Typifying Pedon: Warden very fine sandy loam - cultivated
(Colors are for dry soil unless otherwise stated.)

Ap 0-6"--Light brownish gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable, nonsticky, nonplastic; many fine roots; mildly alkaline (pH 7.8); abrupt smooth boundary. (3 to 6 inches thick)

B2 6-19"--Pale brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak medium subangular blocky structure; soft, very friable, nonsticky, nonplastic; common fine roots; common very fine tubular pores; mildly alkaline (pH 7.8); abrupt smooth boundary. (11 to 24 inches thick)

IIC1ca 19-40"--Pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive but irregularly finely laminated; hard, firm, slightly sticky, slightly plastic; common fine roots; many very fine tubular pores; violently effervescent; moderately alkaline (pH 8.4); clear wavy boundary. (15 to 30 inches thick)

IIIC2 40-54"--Pale (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, very friable, nonsticky, nonplastic; common fine roots; common very fine tubular pores; violently effervescent; strongly alkaline (pH 8.6); clear wavy boundary. (8 to 20 inches thick)

IVC3 54-60"--Light gray (10YR 7/2) silt loam, light brownish gray (10YR 6/2) moist; massive; hard, firm, slightly sticky, slightly plastic; few roots; few very fine tubular pores; violently effervescent; strongly alkaline (pH 8.5).

Type Location: Adams County, Washington; 100 feet south and 500 feet east of northwest corner sec. 19, T.16N., R.29E., W.M.

Range in Characteristics: Thickness of solum and depth to lime range from 15 to 30 inches. Mean annual soil temperature ranges from 50° to 55° F. These soils are continuously dry in all parts between 4 and 12 inches from about May 1 to October 1. Colors are in 10YR or 2.5Y hue. The solum is neutral to mildly alkaline (pH 6.8 to 7.8). The Ap horizon has value of 5 or 6 dry, and chroma of 2 or 3. It has weak granular or subangular blocky structure. The B2 horizon has value of 5 or 6 dry, and chroma of 2 or 3. It is silt loam or very fine sandy loam and has weak subangular blocky or prismatic structure. The C horizon has value of 4 or 5 moist and 6 or 7 dry, and chroma of 2 or 3. It is stratified silt loam and very fine sandy loam in that portion within the control section, but may be sandy loam or loamy sand below the control section. Vertical or diagonal clastic dikes occur within the C horizon of some pedons.

Competing Series and their Differentiae: These are the Sagemoor, Shano, and Stingal series. Sagemoor soils have laminated, slowly permeable, calcareous sediments at depths of 15 to 30 inches. Shano soils have uniform nonstratified silt loam control sections. Stingal soils are calcareous in all parts.

Setting: Warden soils are on nearly level to gently sloping terraces at elevations of 500 to 1200 feet. These soils formed in lacustrine sediments with a loess mantle. Warden soils occur in an arid climate having an annual precipitation of 6 to 9 inches, with warm dry summers and cool moist winters; average January temperature is 27° F.; average July temperature is 71° F.; mean annual temperature is 50° F.; and frost-free season is 136 to 160 days.

Principal Associated Soils: These are the competing Sagemoor and Shano soils.

Warden Series



Drainage and Permeability: Well-drained; slow to medium runoff; moderate permeability.

Use and Vegetation: Dryland wheat and rye; range, and irrigated crops. Native vegetation is bluebunch wheatgrass, Sandberg bluegrass, needle-and-thread grass, and big sagebrush.

Distribution and Extent: South-central Washington. Series is of moderate extent.

Series Established: Columbia Basin Area (Reconnaissance), Washington, 1929.

Remarks: These soils were formerly classified as Sierozems.

Supporting Data: S61 Wash-13-11-(1-5):Riverside Lab Nos.61331-61336, S61 Wash 13-12-(1-7):Riverside Lab Nos.61337-61343, S61 Wash13-13-(1-7):Riverside Lab Nos.61344-61350.

National Cooperative Soil Survey
U. S. A.

Established Series
Rev. ARH
8/70 8/75

# QUINCY SERIES

The Quincy series is a member of the mixed, nonacid, mesic family of ~~Typic~~ Xeric Torripsamments. Typically, these soils are deep fine sands that range in color from grayish brown to pale brown and are noncalcareous or nearly so in the upper 20 inches.

Typifying Pedon: Quincy fine sand - grassland
(Colors are for dry soil unless otherwise stated.)

C1 0-15"--Grayish brown (10YR 5/2) fine sand, dark brown (10YR 3/3) moist; structureless, single grain; loose many roots; moderately alkaline (pH 8.0); clear wavy boundary. (5 to 20 inches thick)

C2 15-60"--Grayish brown (10YR 5/2) fine sand, dark brown (10YR 3/3) moist; structureless, single grain; loose common roots; slight effervescence; moderately alkaline (pH 8.2).

Type Location: Adams County, Washington; 100 feet north and 530 feet west of south quarter corner sec. 28, T.15N., R.29E., W.M.

Range in Characteristics: At a depth of 20 inches the mean annual soil temperature ranges from 47° to 59° F., and the mean summer temperature ranges from 66° to 78° F. These soils are usually dry in all parts between 7 and 20 inches. The surface soils have hues of 7.5YR, 10YR, or 2.5Y, and values of 4 through 7 dry and 3 through 5 moist, and chromas of 2 or 3. Organic matter content of the surface horizons when mixed to 7 inches is commonly very low and is everywhere less than 1 percent. Colors of the subsoil and substratum are similar to those of the surface soil, the difference is less than 1 unit of value. Texture of the 10- to 40-inch control section ranges from sand to loamy fine sand. Less than 75 percent of the sand is of the very coarse, coarse, and medium size classes if the clay content is less than 5 percent. If the clay content exceeds 5 percent more than 75 percent of the sand fraction can be in the very coarse, coarse, and medium size classes. In the upper 20 inches these soils are usually free of lime, except for small particles brought up by insects and animals; but the matrix below 20 inches may be slightly calcareous. Reaction in the upper 20 inches is slightly acid to moderately alkaline, and below 20 inches it is neutral to moderately alkaline. Some pedons have unconforming materials, including bedrock, at depths below 40 inches. Depth to bedrock is commonly greater than 60 inches.

Competing Series and their Differentiae: These are the Hezel, Koehler, Preston, Sheppard, Tipperary, and Winchester series. Hezel soils have medium and moderately coarse textured strata in the lower part of the control section. Koehler soils are calcareous and have a lime-silica cemented duripan. Preston soils have A1 horizons that are darker than the C horizon by at least one unit of value and they are not usually dry. Sheppard soils have 2.5YR thru 7.5YR hues and have chromas of 4 to 6 inclusive. Tipperary soils have Cca horizons. Winchester soils have textures in the control section of sand or loamy sand. More than 75 percent of the sand fraction is in the very coarse, coarse, and medium size classes, and clay content is less than 5 percent.

Setting: Quincy soils are on level to rolling uplands and terraces having a ridged, hummocky, or duny microrelief. Many of the low rounded ridges are narrow and long. The soil formed in sands from mixed sources. Elevations range from 400 to 4,500 feet. The climate is arid or semiarid and summers are dry. Average annual precipitation is 6 to 12 inches, and the average freeze-free season is 100 to 180 days.

Principal Associated Soils: These are the Burbank, Cencove, ~~Taunton~~, Esquatzel, Feltham, Hezel, Taunton and Warden soils. ~~are in the general area.~~ Burbank soils are loamy-skeletal. Taunton soils have petrocalcic horizons and coarse-loamy texture. Hezel and Warden soils have medium textured control sections. Feltham soils are [illegible] part. Hezel soils are [illegible] Cencove soils coarse-loamy in the upper part.

Drainage and Permeability: Excessively or somewhat excessively drained. Runoff is very slow, and permeability is very rapid or rapid.

Use and Vegetation: Native rangeland and irrigated cropland. Irrigated areas are in hay, pasture, small grains, grapes and deciduous fruits. The natural vegetation is needle-and-thread grass, thickspike wheatgrass, Indian ricegrass, rabbitbrush, horsebrush, [illegible] saltbush and Russian thistle.

Distribution and Extent: California, Idaho, Nevada, Oregon, ~~Utah~~ and Washington. Soils [illegible] extensive.

Series Established: Grant County, Washington, 1911.

Remarks: The Quinby soils were formerly classified as Regosols.

National Cooperative Soil Survey
U. S. A.

WA0178

# S O I L   S U R V E Y   I N T E R P R E T A T I O N S

M RA(S): 7, 11
DLG.LWR, 7-75
XEROLLIC CAMBORTHIDS, COARSE-LOAMY, MIXED, MESIC

SAGEHILL SERIES

THE SAGEHILL SERIES CONSIST OF WELL-DRAINED SOILS FORMED IN WIND-MODIFIED GLACIO-FLUVIAL SEDIMENTS. IT IS FOUND ON NEARLY LEVEL TO GENTLY SLOPING FOOTSLOPES AND TERRACES. THE VEGETATION IS MAINLY GRASSES AND SHRUBS. M.A.P. IS 6 TO 9 INCHES. M.A.A.T. IS ABOUT 50 F. AND THE F.F.S. IS 150 TO 210 DAYS. TYPICALLY, THE SURFACE AND SUBSOIL ARE BROWN, VERY FINE SANDY LOAM, ABOUT 19 INCHES THICK. THE SUBSTRATUM LAYERS ARE LIGHT BROWNISH-GRAY AND PALE BROWN VERY FINE SANDY LOAM AND SILT LOAM EXTENDING TO 60 INCHES. SLOPES RANGE FROM 0 TO 35 PERCENT.

## ESTIMATED SOIL PROPERTIES (A)

| DEPTH (IN.) | USDA TEXTURE | UNIFIED | AASHTO | FRACT >3 IN (PCT) | PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4 | 10 | 40 | 200 | LIQUID LIMIT | PLAS-TICITY INDEX |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-8 | VFSL, FSL | ML, SM | A-4 | 0-5 | 95-100 | 95-100 | 80-95 | 45-60 | 15-25 | NP-5 |
| 8-19 | VFSL | ML, SM | A-4 | 0-5 | 95-100 | 95-100 | 80-95 | 45-60 | 15-25 | NP-5 |
| 19-60 | VFSL, SIL | ML | A-4 | 0-5 | 95-100 | 95-100 | 80-95 | 50-65 | 15-25 | NP-5 |

| DEPTH (IN.) | PERMEABILITY (IN/HR) | AVAILABLE WATER CAPACITY (IN/IN) | SOIL REACTION (PH) | SALINITY (MMHOS/CM) | SHRINK-SWELL POTENTIAL | CORROSIVITY STEEL | CORROSIVITY CONCRETE | EROSION FACTORS K | EROSION FACTORS T | WIND EROD. GROUP |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-8 | 2.0-6.0 | 0.20-0.23 | 7.4-8.4 | - | LOW | MODERATE | LOW | .49 | 5 | 3 |
| 8-19 | 2.0-6.0 | 0.20-0.23 | 7.4-8.4 | - | LOW | MODERATE | LOW | .55 | | |
| 19-60 | 0.6-2.0 | 0.20-0.25 | 7.9-9.0 | - | LOW | HIGH | LOW | .55 | | |

| FLOODING FREQUENCY | FLOODING DURATION | FLOODING MONTHS | HIGH WATER TABLE DEPTH (FT) | HIGH WATER TABLE KIND | HIGH WATER TABLE MONTHS | CEMENTED PAN DEPTH (IN) | CEMENTED PAN HARDNESS | BEDROCK DEPTH (IN) | BEDROCK HARDNESS | SUBSIDENCE INIT. (IN) | SUBSIDENCE TOTAL (IN) | HYD GRP | POTENT'L FROST ACTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NONE | | | >6.0 | | | - | | >60 | | - | | B | MODERATE |

## SANITARY FACILITIES

| | |
|---|---|
| SEPTIC TANK ABSORPTION FIELDS | 0-8%: SLIGHT<br>8-15%: MODERATE-SLOPE<br>15+%: SEVERE-SLOPE |
| SEWAGE LAGOON AREAS | 0-2%: MODERATE-SEEPAGE<br>2-7%: MODERATE-SLOPE,SEEPAGE<br>7+%: SEVERE-SLOPE |
| SANITARY LANDFILL (TRENCH) | 0-15%: SLIGHT<br>15-25%: MODERATE-SLOPE<br>25+%: SEVERE-SLOPE |
| SANITARY LANDFILL (AREA) | 0-8%: SLIGHT<br>8-15%: MODERATE-SLOPE<br>15+%: SEVERE-SLOPE |
| DAILY COVER FOR LANDFILL | 0-8%: GOOD<br>8-15%: FAIR-SLOPE<br>15+%: POOR-SLOPE |

## COMMUNITY DEVELOPMENT

| | |
|---|---|
| SHALLOW EXCAVATIONS | 0-8%: SLIGHT<br>8-15%: MODERATE-SLOPE<br>15+%: SEVERE-SLOPE |
| DWELLINGS WITHOUT BASEMENTS | 0-8%: MODERATE-FROST ACTION,LOW STRENGTH<br>8-15%: MODERATE-SLOPE,FROST ACTION, LOW STRENGTH<br>15+%: SEVERE-SLOPE |
| DWELLINGS WITH BASEMENTS | 0-8%: MODERATE-LOW STRENGTH<br>8-15%: MODERATE-SLOPE,LOW STRENGTH<br>15+%: SEVERE-SLOPE |
| SMALL COMMERCIAL BUILDINGS | 0-4%: MODERATE-FROST ACTION,LOW STRENGTH<br>4-8%: MODERATE-SLOPE,FROST ACTION, LOW STRENGTH<br>8+%: SEVERE-SLOPE |
| LOCAL ROADS AND STREETS | 0-8%: MODERATE-FROST ACTION,LOW STRENGTH<br>8-15%: MODERATE-SLOPE,FROST ACTION, LOW STRENGTH<br>15+%: SEVERE-SLOPE |
| LAWNS, LANDSCAPING AND GOLF FAIRWAYS | |

## SOURCE MATERIAL

| | |
|---|---|
| ROADFILL | 0-15%: FAIR-FROST ACTION,LOW STRENGTH<br>15-25%: FAIR-SLOPE,FROST ACTION,LOW STRENGTH<br>25+%: POOR-SLOPE |
| SAND | UNSUITED |
| GRAVEL | UNSUITED |
| TOPSOIL | 0-8%: GOOD<br>8-15%: FAIR-SLOPE<br>15+%: POOR-SLOPE |

## WATER MANAGEMENT

| | |
|---|---|
| POND RESERVOIR AREA | 0-2%: SEEPAGE<br>2+%: SLOPE,SEEPAGE |
| EMBANKMENTS DIKES AND LEVEES | PIPING,LOW STRENGTH,HARD TO PACK |
| EXCAVATED PONDS AQUIFIER FED | DEEP TO WATER |
| DRAINAGE | 0-2%: FAVORABLE<br>2+%: SLOPE |
| IRRIGATION | 0-2%: FAVORABLE<br>2+%: SLOPE |
| TERRACES AND DIVERSIONS | 0-8%: ERODES EASILY,PIPING<br>8+%: SLOPE,ERODES EASILY,PIPING |
| GRASSED WATERWAYS | |

## REGIONAL INTERPRETATIONS

| | |
|---|---|
| | |

## RECREATION

| | | | |
|---|---|---|---|
| CAMP AREAS | 0-8%: SLIGHT<br>8-15%: MODERATE-SLOPE<br>15+%: SEVERE-SLOPE | PLAYGROUNDS | 0-2%: SLIGHT<br>2-6%: MODERATE-SLOPE<br>6+%: SEVERE-SLOPE |
| PICNIC AREAS | 0-8%: SLIGHT<br>8-15%: MODERATE-SLOPE<br>15+%: SEVERE-SLOPE | PATHS AND TRAILS | 0-15%: SLIGHT<br>15-25%: MODERATE-SLOPE<br>25+%: SEVERE-SLOPE |

## CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

| CLASS-DETERMINING PHASE | CAPABILITY | | ALFALFA HAY (TONS) | | BEANS, OTHER DRY (CU) | | CORN (BU) | | PASTURE (AUM) | | PEAS, DRY (LBS) | | POTATOES, IRISH (CWT) | | SUGAR BEETS (TONS) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. | NIRR | IRR. |
| 0-2% | 4C | 2S | | 8 | | 40 | | 125 | | 24 | | 2700 | | 500 | | 30 |
| 2-5% | 4C | 2E | | 8 | | 40 | | 125 | | 24· | | 2400 | | 460 | | 30 |
| 5-10% | 4E | 3E | | 7 | | 30 | | 105 | | 21 | | 2200 | | 360 | | 25 |
| 10-25% | 4E | 4E | | 6 | | | | | | 18 | | | | | | |
| 25+% | 6E | 6E | | | | | | | | | | | | | | |

## WOODLAND SUITABILITY

| CLASS-DETERMINING PHASE | ORD SYM | MANAGEMENT PROBLEMS: EROSION HAZARD | EQUIP. LIMIT | SEEDLING MORT'Y. | WINDTH. HAZARD | PLANT COMPET. | POTENTIAL PRODUCTIVITY: IMPORTANT TREES | SITE INDX | TREES TO PLANT |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NONE | | |

## WINDBREAKS

| CLASS-DETERMIN'G PHASE | SPECIES | HT | SPECIES | HT | SPECIES | HT | SPECIES | HT |
|---|---|---|---|---|---|---|---|---|
| | NONE | | | | | | | |

## WILDLIFE HABITAT SUITABILITY

| CLASS-DETERMINING PHASE | POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED | GRASS & LEGUME | WILD HERB. | HARDWD TREES | CONIFER PLANTS | SHRUBS | WETLAND PLANTS | SHALLOW WATER | POTENTIAL AS HABITAT FOR: OPENLD WILDLF | WOODLD WILDLF | WETLAND WILDLF | RANGELD WILDLF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-2% IRR | GOOD | GOOD | GOOD | - | - | GOOD | GOOD | FAIR | GOOD | - | FAIR | GOOD |
| 2-5% IRR | GOOD | GOOD | GOOD | - | - | GOOD | POOR | V. POOR | GOOD | - | V. POOR | GOOD |
| 5+% IRR | FAIR | GOOD | GOOD | - | - | GOOD | V. POOR | V. POOR | GOOD | - | V. POOR | GOOD |
| NIRR | V. POOR | V. POOR | GOOD | - | - | GOOD | V. POOR | V. POOR | POOR | - | V. POOR | GOOD |

## POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

| COMMON PLANT NAME | PLANT SYMBOL (NLSPN) | PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| POTENTIAL PRODUCTION (LBS./AC. DRY WT): FAVORABLE YEARS | | | | | | |
| NORMAL YEARS | | | | | | |
| UNFAVORABLE YEARS | | | | | | |

FOOTNOTES

* ESTIMATE BASED ON TEST DATA FROM TWO PEDONS FROM FRANKLIN COUNTY.

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DEPARTMENT OF THE NAVY
WESTERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
SAN BRUNO, CALIFORNIA 94066

IN REPLY REFER TO:

243:MMB:po
RESEARCH NATURAL AREA
BOARDMAN
8 FEB 1979

FIRST ENDORSEMENT on NAVFACENGCOM ltr of 24 Jan 1979

From: Commanding Officer, Western Division, Naval Facilities Engineering Command
To: Commanding Officer, Naval Air Station, Whidbey Island

Subj: Research Natural Area, Naval Weapons Systems Training Facility, Boardman, Oregon; establishment of

1. Original letter not received. Copy of letter is forwarded concurring with approval for establishment of subject research natural area.

2. The subject area contains the last high-quality examples of the native shrub-steppe vegetation that formerly covered millions of acres of the central Columbia Basin. In the remainder of the basin the native ecosystems have been substantially altered by decades of grazing and, more recently, by irrigated and non-irrigated agriculture. In addition, the spectrum of sandy soils and sandy soil ecosystems is present and a number of plant and wildlife species of concern are represented.

3. It is understood that the fencing required to protect the subject area is being provided by the Pacific Northwest Branch of Nature Conservancy. This Command is initiating action to amend the affected grazing outleasing to exclude the subject area from the lease.

A. W. COLLINS
By direction

Copy to:
NAVFACENGCOM (Code 2042)
WESTNAVFACENGCOMBRO SEATTLE (Code 243F)
DASD (MRA&L)
CNO (Op-45)

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332

IN REPLY REFER TO

24 JAN 1979

From: Commander, Naval Facilities Engineering Command
To: Commanding Officer, Naval Air Station, Whidby Island, WA.
Via: Commanding Officer, Western Division, Naval Facilities Engineering Command

Subj: Research Natural Area, NWSTF, Boardman, Oregon; establishment of

Ref: (a) NAS, Whidby Is. ltr Ser 3738 to CNO (Op-45) of 22 Sept 78
(b) CNO ltr Ser 453/722365 to COMNAVFACENGCOMHQ of 02 Nov 78
(c) COMNAVFACENGCOMHQ ltr Code 20R to CNO (Op-45) of 3 Jan 79

1. The designation of certain areas of NWSTF, Boardman Range as Research Natural areas submitted by reference (a), has been approved by reference (b) and concurred in by reference (c). Therefore, the designation is now official and requires no further approval action.

2. As a follow-up, a copy of the establishment Report is being forwarded to the Federal Committee on Ecological Reserves with the request that the area be made a part of the National system of Natural and experimental areas for environmental and ecological research and listed in the "Directory of Research Natural areas on Federal Lands".

HR Richard

H. R. RICHARD
By direction

Copy to:
DASD (MRA&L)
CNO (Op-45)

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA 22332

IN REPLY REFER TO

Mike Walt

From: Commander, Naval Facilities Engineering Command
To: Chief of Naval Operations (OP-45)

Subj: Research Natural Areas, Naval Weapons Systems Training Facility, Boardman, Oregon

Ref: (a) CNO ltr Ser 453/722365 of 2 Nov 1978

1. As requested by reference (a) this Command concurs with the designation of portions of subject property as a Research Natural Area provided the Navy reserves the right to disestablish the area in the event that there is an operational or other requirement for its use at a future date. The Navy should further reserve the right to report as excess, transfer, convey, donate, exchange, outgrant or otherwise dispose of all or any portion of the property at which time it may also be disestablished as a Research Natural Area.

F. S. STERNS
Deputy Assistant Commander
for Real Estate

Copy to:
OASN(MRA&L) (CAPT Macdonald)
NAVMAT (044)
NAVAIRSYSCOM (AIR 01B)
~~WESTNAVFACENGCOM~~ (24)
NAS Whidbey Is.

Reply Due
Copy in Reading File

| CODE | INITIAL & DATE |
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DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D.C. 20350

Dir, Seattle Brand

IN REPLY REFER TO
Ser 453/722365
02 NOV 1978

From: Chief of Naval Operations
To: Commander, Naval Facilities Engineering Command

Subj: Research Natural Areas, Naval Weapons System Training Facility (NWSTF) Boardman, Oregon

Ref: (a) NAS Whidbey Island ltr PWEC:psw ser 3738 of 22 Sep 1978
(b) OPNAVINST 6240.3E

1. By reference (a) a nomination for a portion of NAS Whidbey Island lands was proposed as a Research Natural Area in accordance with reference (b). Accordingly, it is requested that subject designation be concurred with and that coordination be accomplished with the Federal Committee on Ecological Reserves as also stipulated in reference (b).

B. F. Montoya

R. F. Montoya
By direction

Copy to:
CHNAVMAT (MAT 044)
NAVAIRSYSCOM (AIR 01B)
COMNAVFACENGCOM (FAC 204)
WESTNAVFACENGCOM ✓
CO NAS WHIDBEY ISLAND

Copy In Reading File ✓

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PWEC:psw
11011
Ser [illegible]8
SEP [illegible] 1979

From: Commanding Officer, Naval Air Station, Whidbey Island
To: Chief of Naval Operations, Washington, D.C. (OP-45)

Subj: Research Natural Area, Naval Weapons System Training Facility (NWSTF) Boardman, Oregon; establishment of

Ref: (a) OPNAVINST 6240.3E, Environmental Protection Manual

Encl: (1) Establishment Report, Research Natural Area, Naval Weapons Systems Training Facility, Boardman, Oregon (3 copies)

1. Enclosure (1), prepared by the Western Division, Naval Facilities Engineering Command, has been signed and is forwarded for final approval in accordance with reference (a). The portion of land designated in enclosure (1) is considered an Experimental Ecological Reserve Area as defined in Chapter 10, Part 5 of reference (a).

J. M. SEELY

Copy to: (w/o encl)
WESTNAVFACENGCOM
Seattle Branch, WESTDIV
COMMATVAQWINGPAC

243F:DCR:pr
11015
Ser 243F/230
1 Sep 1978

From: Commanding Officer, Western Division, Naval Facilities Engineering Command
To: Commanding Officer, Naval Air Station, Whidbey Island

Subj: Research Natural Area, Naval Weapons System Training Facility, Boardman, Oregon; establishment of

Ref: (a) Meeting w/CO NAS Whidbey Is, 1300 14 Jun 78
(b) OPNAVINST 6240.3E of 5 Jul 77 (Part 5)

Encl: (1) Establishment Report for Research Natural Area at NWSTF Boardman, OR (4 copies)

1. As a result of reference (a) and in accordance with reference (b), enclosure (1) has been prepared and is forwarded for your approval.

2. Page 3-1 requires the signature of the Commanding Officer, NAS Whidbey Island. Reference (b) requires forwarding of three copies of enclosure (1) to CNO (OP-45) for final approval. The extra copy is for your records.

3. The proposed Research Natural Areas must be fenced prior to grazing season. Since grazing season begins on or about 1 Nov 78, it is requested that enclosure (1) be forwarded as soon as possible so that fencing can begin as soon as approval is received.

DONALD C. RAPPEL
By direction

Copy to:
WESTNAVFACENGCOM (243)
Dir, Nature Conservancy, NW Office
Portland

Mailed 9/1/78 pr

# BOARDMAN RESEARCH NATURAL AREA

*Suppleınent No. 17*[1]

*Molly Morton Mayt1'eld and Janet K.ielmyr*[2]

The Research Natural Area described in this supplement is administered by the Commanding Officer, Naval Air Station, Whidbey Island (Oak Harbor, Wash.). The Officer in Charge of the Naval Weapons Systems Training Facility, Boardman, Oreg., is responsible for coordinating access to the Research N atural Area for scientific and educational uses vvith scheduled military use of the facility. Scientists interested in using this Research Natural Area should prepare a written proposal that explains the nature, purpose, and duration of the proposed activities. The request should be addressed to the Staff Forester, Western Division, Naval Facilities Engineering Command (Building 138, Room 215, Naval Station, Seattle, Wash. 98115). Requests to do research that is controversial or destructive in nature will be forwarded to the Pacific Northwest Federal Research Natural Areas Committee for its advice on the appropriateness of the particular research. Approval for any use of the area will be made by the Commanding Officer, Naval Air Station, Whidbey Island. For brief observational visits, permission may be obtained from the Officer in Charge at the Naval Facility, Boardman, Oreg.

The Boardman Research Natural Area is a part of a Federal system of RNA's established for research and educational purposes. In these areas, natural features are preserved for scientific purposes and natural processes are allowed to dominate. Their main purposes are to provide:

1. Baseline areas against which effects of human activities can be measured.
2. Sites for study of natural processes in undisturbed ecosystems; and
3. Gene pool preserves of organisms, especially rare and endangered types.

The Federal system is outlined in "A Directory of the Research Natural Areas on Federal Lands of the United States of America.":J Of the 96 Federal Natural Research Areas established in Oregon and Washington, 45 are described in "Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and Educators" (see footnote 1). Supplements to the guidebook describe additions to the system.

The guiding principle in management of Research Natural Areas is to prevent unnatural encroachments or activities that directly or indirectly modify ecological processes. Logging and uncontrolled grazing are not allowed, for example, nor is public use that might impair scientific or educational values. Management practices necessary for maintenance of the ecosystems may be allowed.

Federal Research Natural Areas provide a unique system of publicly owned and protected examples of undisturbed ecosystems where scientists can conduct research with minimal interference and reasonable assurance that investments in long-term studies will not be lost to logging, land development, or similar activities. In return, a scientist wishing to use a Research Natural Area is obligated to:

1. Obtain permission from the appropriate administering agency before using the area;4

'Supplement No. 17 to "Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and Educators." by .Jcrry F. Franklin. Frederick C. Hall. C. T. Dyrness. imd Chris Maser (Pacific Northwest Forest and Range Experiment Station 1 ~J72). The guidebook is available from the Superintendent of Documents. U.S. Government Printing Office. Washington, D.C. 20402: stock number 001-001-00225-9.

'Molly Morton Mayfield is a consulting biologist. P.O. Box 8457. Fort Collins. Colo .. 80525 . .Janet Kjelmyr is a graduate student in ecology at the University of New Mexico. Albuquerque. 87131.

:lFederal Committee on Ecological Reserves. A directory of the Research Natural Areas on Federal lands of the United States of America. Washington. D.C.: U.S. Department of Agriculture. Forest Service; 1977.

"Six agencies cooperatc in this program in the Pacific Northwest: U.S. Department of Agriculture-Forest Service: U.S. Department of the I nterior- Bureau of Land Management. Fish and Wildlife Service. and National Park Service; the U.S. Department of Energy; and the U.S. Department of Defense.

2. Abide by the administering agency's regulations governing use. including specific limitations on the type of research. sampling methods. and other procedures: and
3. Inform the administering agency on progress of the research. published results. and disposition of collected materials.

The purposes of these limitations are to:

1. Insure that the scientific and educational values of the tract are not impaired:
2. Accumulate a documented body of knowledge about the tract: and
3. Avoid confl ict between stud ies.

Research must be essentially nondestructive: destructive analysis of vegetation is generally not allowed. nor are studies requiring extensive mod ification of the forest floor or extensive excavation of soil. Collection of plant and animal specimens should be restricted to the minimum necessary to provide voucher specimens. Under no circumstances may collecting significantly reduce population levels of species. Collecting must also be carried out in accordance with applicable State and Federal agency regulations. Within these broad guidelines. appropriate uses of Research Natural Areas are determined by the administering agency.

Native Columbia Basin bunchgrass communities on a mosaic of sandy flood-deposit and loamy lakebed-deposit soils with abundant dry prairie wildlife species.

The Boardman Research Natural Area (RNA) was established September 1, 1978, to preserve high-quality examples of Columbia River basin steppe vegetation communities and associated wildlife. The RNA has never been plowed and has not been grazed since 1948.[5] Throughout much of the rest of the basin, however, such native communities have been sig-nificantly chang-ed by gTazing- and agTiculture.

Sandy flood-deposit and silt loam lakebed soils support bunchgrass communities over most of the Research Natural Area; dominant species include *Aql'OPYl'on spicotum. Af/l'l!}J?lnm dasytach?lllm. Stipu COll/atu, andPou sandhel'r/ii.* [li] Portions of the RN A are devoid of veg-etation where sand has formed into dunes or sandblows. A fragile cryptogam (moss and lichen) ground cover is associated with the bunchgrass communities on certain soil types.

Short-eared owls, long-eared owls, burrowing owls, Svvainson's hawks, and ferrug-inous hawks nest in the vicinity of the RNA. Longbilled curlews nest in large numbers on the RN A and in surround ing- areas, and the Washington ground squirrel, whose range appears to be diminishing in the Columbia Basin, has a thriving population in the RNA.7

The Boardman RN A is in Morrow County, north-central Oregon, and within the boundaries of the U.S. Naval Weapons Systems Training Facility, hereafter called the Bombing- Range (fig. BD-l). The RN A is composed of three separate areas that total 2 mJ5 ha (5.176 acres). RNA "A" located in the center of the Bombing Range, is 1 086 ha (2,560 acres); RN A "B," along the eastern boundary, is 79 ha (196 acres); and RNA *"C,"* to the southwest, is 980 ha (2,420 acres). The three sections are located in T. 2 and 8 N., R. 25 E., Willamette meridian (lat. 45°42' N., long.119°42'W.). The entire Bombing Range and RN A's A B, and C are fenced.

## Access and Accommodations

To reach the RN A travel west from Boardman along Interstate 84 for 7.2 km (4.5 mi) to the Tower Road exit. Travel south on Tower Road for 1.6 km (1.0 mi), turn left onto a gravel road, and continue southeast for 1.4 km (0.9 mi) to the administration headquarters. The northern boundary of the Naval Bombing Range is :3.2 km (2 mi) south of Boardman, Oreg., and Interstate 84 (fig. BD-2). All visitors must contact the Officer in Charge prior to their visit and check in on arrival at the headquarters for clearance to enter the RNA.

RN A's A, B, and C may be reached either from headquarters or from the east side()f th~ Bombing Range, via Highway 780, through locked gates. M ileag-es and routes are indicated in figure BD-2. A more detailed map of the area and complete directions can be obtained at headquarters when checking in.

Overnight camping is prohibited in the Bombing Range. Camping facilities and commercial accommodations are available in Board m an.

## Envi ronment

The Boardman RNA is part of the Umatilla Plateau in the central Columbia River basin. Most of the soils and topography are products of one or more episodes of the late-Pleistocene Missoula floods. Waters of Montana's glacial Lake Missoula poured from periodically retreating ice dams southwesterly into the Columbia Basin. At Wallula Gap, on the OregonWashington border, the floodwaters were impeded and reached a depth of 244 m (800 ft) (Bretz 1969). South of Wallula Gap, where the

"Much of the baekground information is derived from the "Establishment Report for the Boardman R('spareh Natural Area." by Donald C. Happel (1978) on file at The Nature Conservaney. 12:34 N.W. 25th. Portland. Oreg. 97210.

I;Common names and scienti fie names of vascu lar plants are listed in table BD-1.

7S<sub></sub>ientifie names of birds and mammals are listed in tables BD-4 and BD-5. respectively.

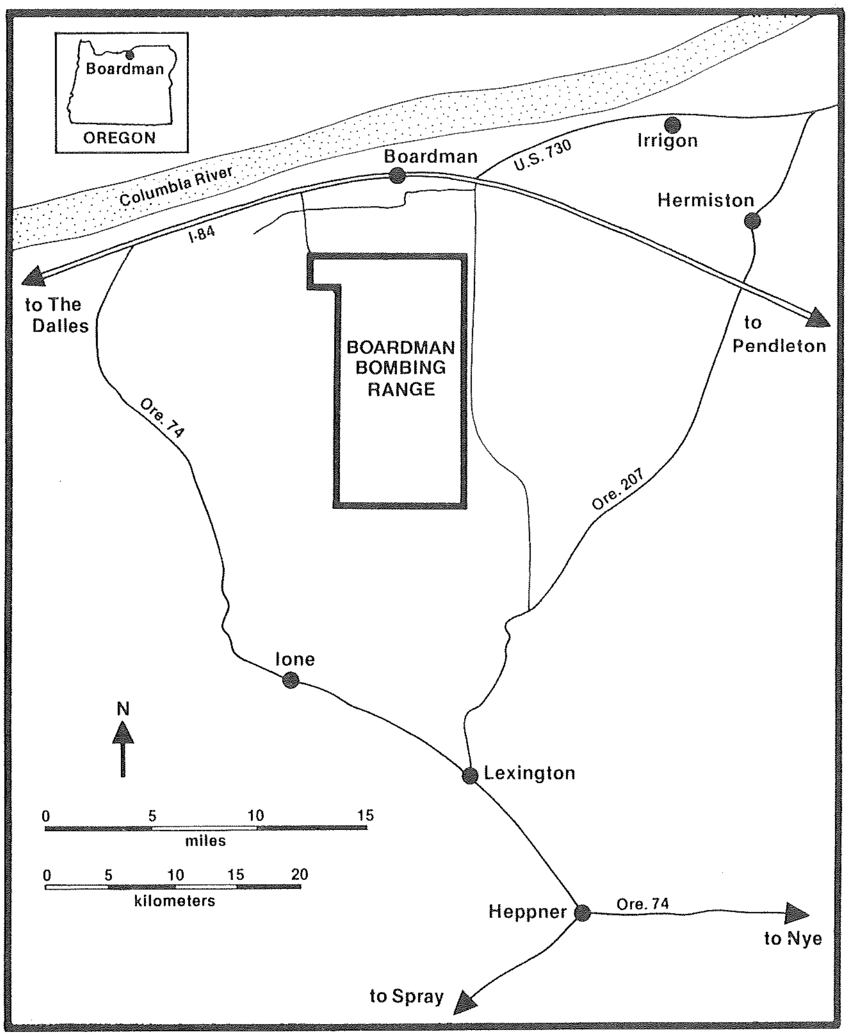


*Figure BD-1.—Location of the Boardman Bombing Range, south of Boardman, Morrow County, Oregon.*

Columbia's channel turns west, floodwaters spilled south onto the Umatilla Plateau where soils and huge ice-rafted erratics were deposited. Most of the Boardman RN A is underlain by these flood deposits over which a variety of sandy soils differing in texture, depth, and other characteristics have formed. Portions of RNA's Band C to the south and east are underlain by older Pleistocene lake deposits over which loamy soils have formed.

The contours of the Boardman Bombing Range rise gently from 122 m (400 ft) in elevation at the northern boundary to 274 m (900 ft) at the southern. The RNA consists of broad, flat plateau (2- to 5-percent slopes) changing in the south to rounded hillsides that drop into valleys at moderate slopes (5 to 12 percent). These valleys, generally broad and flat across the bottom, are dry most of the year because of the high porosity of the sandy soils and the short duration of rainstorms.

Juniper Canyon, in the eastern part of the Bombing Range (fig. BD-2), has more broken topography with deeper canyons and steeper slopes. Nearby Juniper Canyon provides nesting habitat for many avian species that use the RN A.

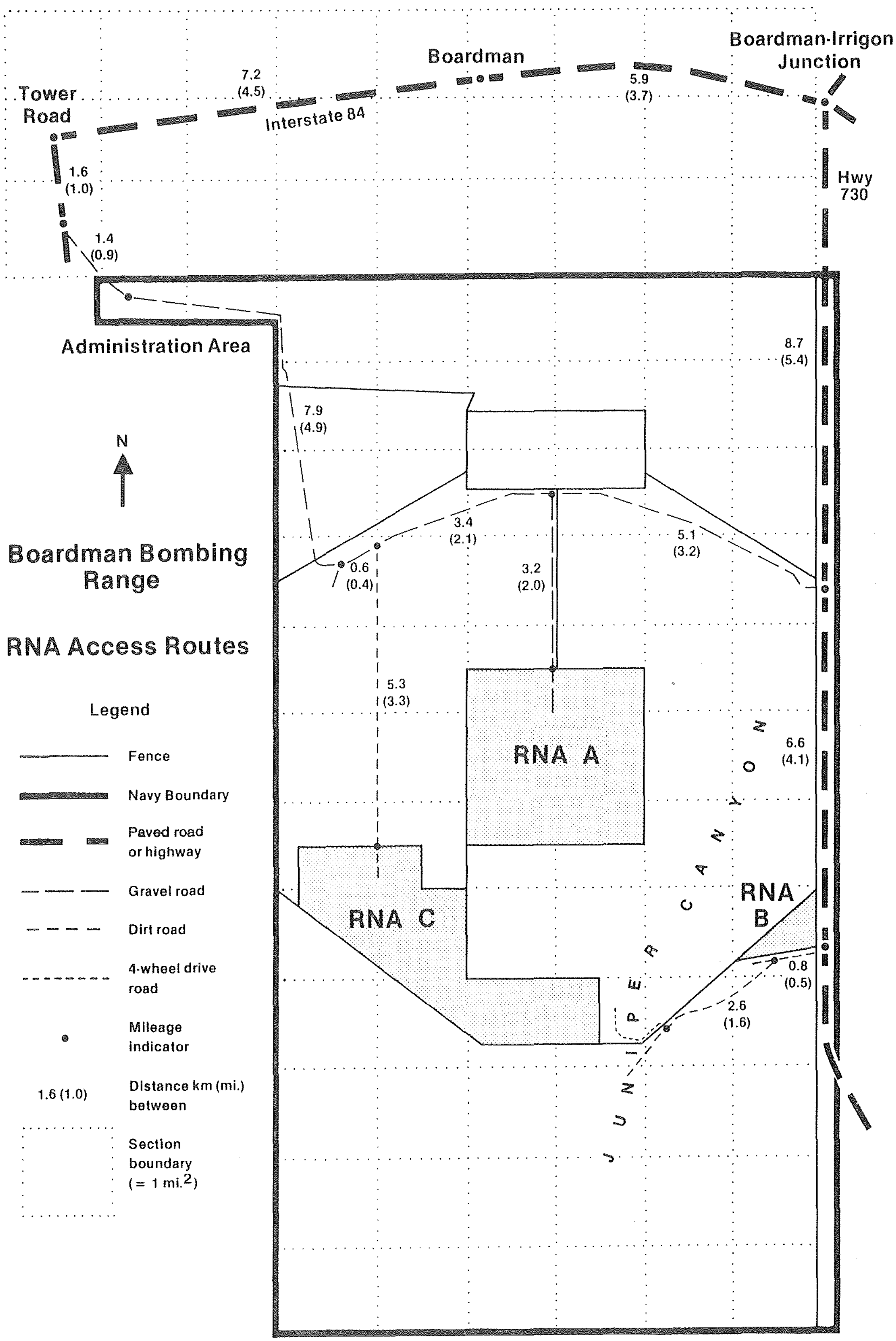


*Figure BD-2.—Access routes to the Boardman Research Natural Area.*

## Climate

The climate of the Boardman RNA is semiarid with low precipitation, hot and dry summers, and relatively cold winters. The climate is similar to that of Hermiston, Oreg., 38.4 km (24 mi) to the east.

The following climatic data for the period 1942-1971 are from the U.S. Weather Station, at Hermiston:

| | | |
|---|---|---|
| Mean annual temperature | 11.6 °C | (52.8 °F) |
| Mean January temperature | -0.1 °C | (31.8 °F) |
| Mean July temperature | 22.6 °C | (72.7 °F) |
| Mean January minimum temperature | -4.6 °C | (23.7 °F) |
| Mean July maximum temperature | 30.8 °C | (87.5 °F) |
| Mean annual precipitation (Rain+snow moisture) | 22.6 cm | (8.9 in) |
| Mean annual snowfall (Depth) | 22.6 cm | (8.9 in) |

The mean annual precipitation for the period was 22.6 cm (8.9 in). Most of the precipitation (68 percent) occurs from October through March with November, December, and January being the wettest months. There are an average of 46 days annually with temperatures in excess of 32.2 °C (90 OF), and an average of 113 days annually with temperatures below 0 °C (32 OF). The maximum temperature recorded during this period was 45°C (113 OF) in August 1961; the minimum recorded was -38°C (-37 OF) in December 1919.

Southwesterly winds prevail most ofthe year. Wind records for 1942-1972 from the weather station in Pendleton, Oregon [74 km (46 mi) to the east of the RN A ] show an average annual wind speed of 14.8 km/h (9.3 mi/h). March through July is the windiest period with velocities averaging 16.2 km/h (10.1 mi/h).

## Soils

The soils of the Boardman Bombing Range have been mapped by the U.S. Soil Conservation Service. Six soil types are present on the RNA (fig. BD-3 and table BD-l). Five types (Quincy, Koehler, Sagehill, Taunton, and Royal) are products of the late-Pleistocene Missoula floods. These flood-deposit soils cover approximately 93 percent of the RNA and range from fine sands to fine sandy loams.

The Quincy fine sands or loamy fine sands and the Koehler loamy sands are mildly alkaline and highly permeable. The former, classified as Xeric Torripsamments, are formed in mixed sands and occur on RNA A, extending south into RNA C. The latter, Xerollic Durorthids, are formed in alluvial and colluvial materials mantled with eolian sand and are present on RN A A.

The Sagehill and Taunton fine sandy loams, classified as Xerollic Camborthids and Xerollic Durorthids, respectively, are found intermixed on RN A C. The Royal loamy fine sand or fine sandy loam soils are grouped with the Xerollic Camborthids and are present on RNA C. These three soil types are formed in windlaid materials, are mildly alkaline, and are moderately well-drained.

The sixth soil type (Warden), adjacent to the southern extremity of the soils deposited by the Missoula flood, is a very fine sandy loam or silt loam. The Warden soils are unique among the soil types of the RNA in that they are older, lacustrine-deposit soils. They are mildly alkaline, moderately well-drained sandy loams over silt loams, and formed in wind-laid sands and silts over calcareous lacustrine silts. They are classified as Xerollic Camborthids.

Wind erosion can be severe, particularly on the highly permeable Quincy and Koehler sandy soils, because of the region's low precipitation and high-velocity winds. Vulnerability to wind erosion is reduced in undisturbed areas where a thin surface crust has formed over the soils. Wind erosion is greatly diminished where there is a well-established cryptogam or moss and lichen ground cover. Cryptogam cover is most notable on Warden soils of RNAC.

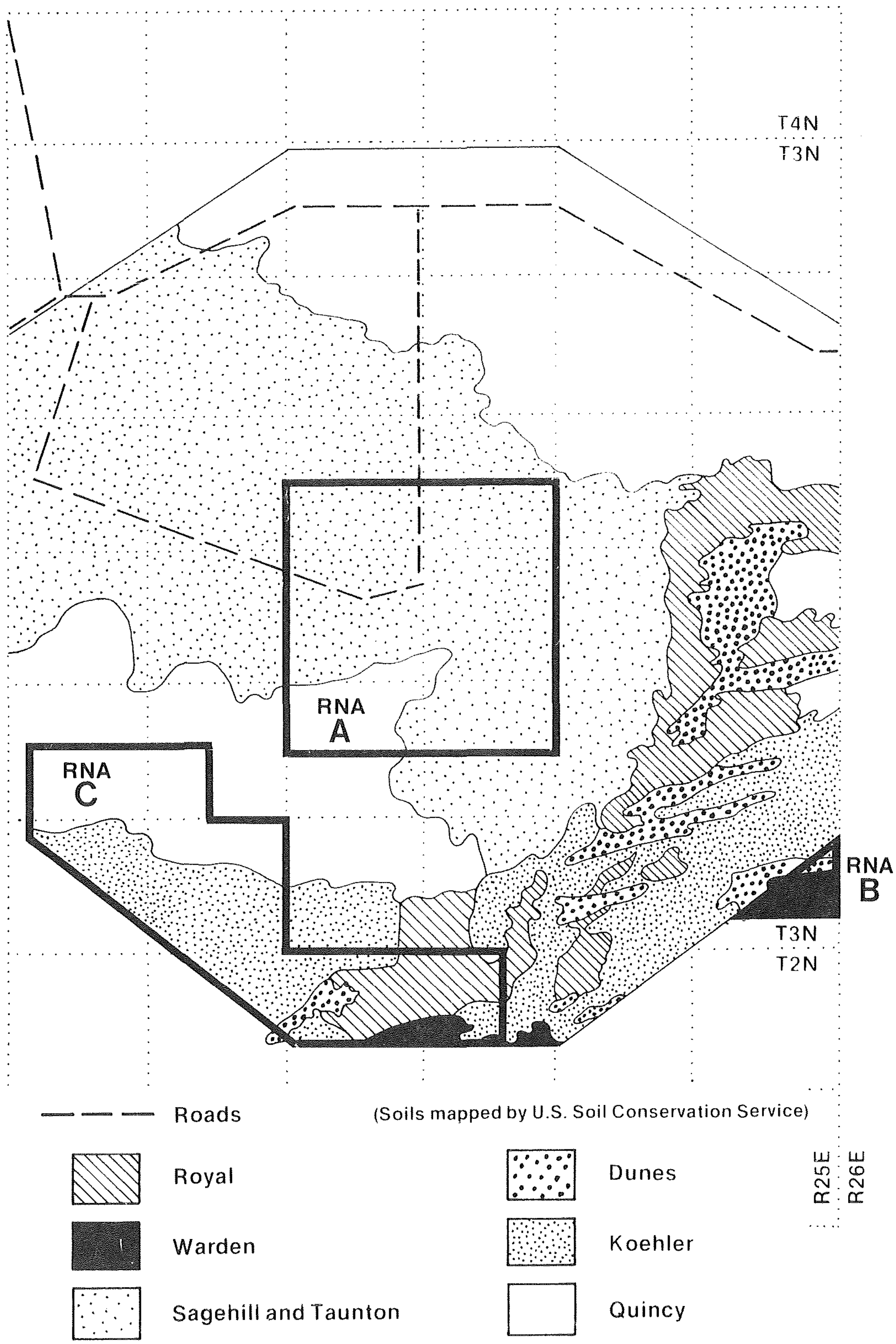


*Figure BD-3.—Soils of the Boardman Research Natural Area.*

**Table BD-1—General plant community-soil type associations found in the Boardman Research Natural Area**

| Soil type | Plant community |
|---|---|
| Warden | *Agropyron spicatum-Poa sandbergii* |
| Royal | *Agropyron spicatum-Poa sandbergii* |
| Sagehill and Taunton mosaic | *Agropyron dasytachyum-Stipa comata and Stipa comata-Poa sandbergii* |
| Koehler | *Stipa comata-Poa sandbergii* |
| Quincy | *Stipa comata-Poa sandbergii* |

Unstable sand in the form of dunes or sandblows extends across portions of the Bombing Range and is present in RNA's Band C (fig. BD-3). These blows are thought to be accumulations of riverbed sand that originated from the shores of the Columbia River southwest of Boardman, *Oreg.,* and were spread by the prevailing southwesterly winds. In portions of RNA C, the blown sand has become stabilized, and a hummocky terrain has resulted. In one part of RNA B, efforts to stabilize the sandblows were undertaken in 1972 and 1973.[8] Test plots were treated with a variety of stabilizers, such as shredded bark and papermill sludge, and were seeded with cereal rye. At present, the sand blows are largely stabilized.

## Biota

### Vegetation

The Boardman RNA is located in the central Columbia Basin region, which is classified as a sagebrush steppe (Daubenmire 1970, Franklin and Dyrness 1973, Kuchler 1965, Poulton 1955). Despite these classifications, *A rteJn1',';1'a triden/ata* is conspicuously absent from most of the RN A, and the perennial bunchgrass species *Agropyron spicatum, Agropyron dasytachyuTt1, Stipa com ata,* and *Poa s01I.dbergh'* are dominantsY

Variations in plant community structure are associated with changes in soils (fig, BD-3 and table BD-1) and topography. In general, on the five sandy, flood-deposit soils (Quincy, Kuchler, Sagehill, Taunton, and Royal) that cover most of the RN A, *St?'pa cmnata, Poo sandbergi1',* and *Agropynm dasytachyum* dominate, Their representation and coverage vary among the soil types. On the older Warden lakebed soils, represented only on the southern fringe of RN A's Band C, *Agropyron spicatum* and *Poa sondbergi?'* are the dominant species. The few concentrations of *Artemisia tridentata* are found in RN A's Band C on a variety of soils where the topography is more broken. Other shrub species found in the RNA are *Pursh1'a tridentata,* widely scattered on the northern portion of RN A A, and *Chrysotlwmnus nauseosus* and C. */!?'sc1'd1j7orus,* both represented in all RNA sections. A list of known shrubs, grasses, and forbs for the RN A is shown in Table BD-2.

8Ward, George D" and others, 1974. "Engineering study and field demonstration trials for sand dune stabilization, U,S. Naval Bombing Range, Boardman. Oregon." Unpublished report to the Naval Facilities Engineering Command, Bldg. 138, [loom 215, Naval Station, Seattle, Wash. 98115.

9Much of the information on plant representation and coverage is derived from field notes of preliminary investigations conducted by William N. Copeland, on file at The Nature Conservancy office. 1234 N.W. 25th. Portland, Oreg. 97210.

**Table BD-2—Plants found in the Boardman Research Natural Area[1] [2]**

| Family | Scientific name | Common name |
|---|---|---|
| SANTALACEAE | *Comandra umbellata* | Bastard toad-flax |
| POLYGONACEAE | *Eriogonum* sp. | Buckwheat |
| CHENOPODIACEAE | *Salsola kali* | Russian thistle |
| CARYOPHYLLACEAE | *Holosteum umbellatum* | Jagged chickweed |
| RANUNCULACEAE | *Delphinium nuttallianum* | Upland larkspur |
| CRUCIFERAE | *Descurainia pinnata* | Western tansymustard |
| | *Draba verna* | Spring whitlow-grass |
| | *Erysimum asperum* | Rough wallflower |
| | *Sisymbrium altissimum* | Jim Hill mustard |
| SAXIFRAGACEAE | *Lithophragma bulbifera* | Prairiestar |
| ROSACEAE | *Purshia tridentata* | Antelope bitter-brush |
| LEGUMINOSAE | *Astragalus purshii* | Pursh's milk-vetch |
| | *Astragalus sclerocarpus* | Stalked-pod milk-vetch |
| | *Astragalus succumbens* | Crouching milk-vetch |
| | *Psoralea lanceolata* | Lance-leaf surf-pea |
| GERANIACEAE | *Erodium cicutarium* | Stork's-bill |
| CACTACEAE | *Opuntia polyacantha* | Starvation cholla |
| ONAGRACEAE | *Oenothera pallida* | Pale evening-primrose |
| UMBELLIFERAE | *Cymopterus terebinthinus* | Turpentine cymopterus |
| | *Lomatium cous* | Cous biscuit-root |
| | *Lomatium macrocarpum* | Large-fruited desert-parsley |
| POLEMONIACEAE | *Gilia minutiflora* | Small-flowered gilia |
| | *Microsteris gracilis* | Pink microsteris |
| | *Phlox longifolia* | Long-leaf phlox |
| HYDROPHYLLACEAE | *Phacelia linearis* | Threadleaf phacelia |
| BORAGINACEAE | *Amsinckia lycopsoides* | Tarweed fiddleneck |
| | *Cryptantha* sp. | Cryptantha |
| SCROPHULARIACEAE | *Penstemon acuminatus* | Sand-dune penstemon |
| | *Verbascum thapsus* | Common mullein |

**Table BD-2—Plants found in the Boardman Research Natural Area[1] [2]—Continued**

| Family | Scientific name | Common name |
|---|---|---|
| PLANTAGINACEAE | *Plantago patagonica* | Indian-wheat |
| COMPOSITAE | *Achillea millefolium* | Common yarrow |
| | *Antennaria dimorpha* | Low pussytoes |
| | *Artemisia tridentata* | Big sage |
| | *Balsamorhiza careyana* | Carey's balsamroot |
| | *Chaenactis douglasii* var. *achilleaefolia* | Hoary chaenactis |
| | *Chrysothamnus nauseosus* | Gray rabbitbrush |
| | *Chrysothamnus viscidiflorus* | Green rabbitbrush |
| | *Crocidium multicaule* | Spring-gold |
| | *Erigeron filifolius* var. *filifolius*[3] | Thread-leaf fleabane |
| | *Erigeron linearis* | Line-leaf fleabane |
| | *Gutierrezia sarothrae* | Snakeweed |
| | *Hemizonia pungens* var. *septentrionalis* | Common spikeweed |
| | *Hieracium* sp. | Hawkweed |
| | *Madia glomerata* | Cluster tarweed |
| | *Tragopogon dubius* | Yellow salsify |
| | *Wyethia amplexicaulis* | Northern mule ears |
| GRAMINEAE | *Agropyron cristatum* | Crested wheatgrass |
| | *Agropyron dasytachyum* | Downy wheatgrass |
| | *Agropyron spicatum* | Bluebunch wheatgrass |
| | *Bromus tectorum* | Cheat grass |
| | *Elymus mollis*[3] | Dune wildrye |
| | *Festuca bromoides* | Barren fescue |
| | *Festuca idahoensis* | Idaho fescue |
| | *Oryzopsis hymenoides* | Indian ricegrass |
| | *Poa sandbergii* | Sandberg's bluegrass |
| | *Sitanion hystrix* | Bottlebrush squirreltail |
| | *Stipa comata* | Needle-and-thread grass |
| LILIACEAE | *Brodiaea douglasii* | Douglas' brodiaea |
| | *Calochortus macrocarpus* | Sagebrush mariposa |
| | *Fritillaria pudica* | Yellowbell |
| | *Zigadenus venenosus* | Meadow death-camas |

[1]Information supplied by William N. Copeland, consulting ecologist, Portland, Oreg.; Alan Copsey, Department of Biology, University of Oregon, Eugene; Donald C. Rappel, staff forester, Naval Facilities Engineering Command, Seattle, Wash.; and the authors.

[2]Nomenclature follows Hitchcock and Cronquist (1973).

[3]Species are tentatively identified for the RNA.

One of the most striking characteristics associated with the *Agropyron spica.turn-Poo sandber'g?:1:* community on Warden soils of RNA's Band C is the fragile and colorful cryptogam (moss and lichen) ground cover, Cryptogam cover is unusually high for the area and is believed to playa role in nitrogen fixation, erosion control, and moisture relationships, Because of the dense ground cover of cryptogams there is a nearly complete absence of weedy grasses and forbs such as *Bmmus tectorum, Erolhum c1'cutorium, S1'symbn'um alh's.(!l:murn,* and *Am.'J/:nckia lycopsoides,* A list of moss and lichen species on the Bombing Range is in table BD-3.

RNA A.-RNA A is composed oftwo sandy soil types, Koehler and Quincy, both of which support a *Sh:pa. coma.ta-Poa sandbe1'gi1:* community and differ primarily in the cover ofthe dominant grasses, On the Koehler loamy sands, which extend over all but the southwestern quarter of RN A A (fig, BD-3), cover of *S. comata.* is relatively high, at 25 to 30 percent (fig. BD-4), *Poa sandbe1'gi1'* is less prevalent, with a cover of 10 percent. *Bnnnus tectorum* is distributed in patches with cover averaging 20 percent. Other grasses such as *Agropyron s7n'cahlm, Agropyron dasytochyum, Oryzopsis hymenm'des,* and *Festuca* sp. are each present with a cover of less than 5 percent. The shrubs *Chrysothamn/us nauseosus* and *Chl7/sothamnU8 Vi8Cid1;t70r'l/.S* both show a low cover of 1 percent, and *Purs/n'a tn:dentata* occurs only as scattered individuals.

Within the southwestern quarter of RNA A, on sandier Quincy loamy fine sands, *Stipo comata* has a lower cover of 10 percent, and *Poa sandbm'gi1:* cover is higher at 12 to 15 percent. *Bnnnus tectorum* is present in local concentrations with a cover of 15 percent. The four other grass species listed above are again present with cover of less than 5 percent. *Ch1'Y8othamnlUi nOU8e0811S* and *Chrysothll'lnnus /J1'scidiflorus* have slightly higher cover values, 2 to 3 percent and 1 to 2 percent, respectively.

Cryptogam cover on both Koehler and Quincy soils is low, at 1 percent.

**Table BD-3—Mosses and lichens found in the Boardman Bombing Range**[1]

| Mosses | Lichens |
|---|---|
| *Aloina pilifera* | *Acarospora schleicheri* |
| *Bryum* sp. | *Dermatocarpon hepaticum* |
| *Ceratodon purpureus* | *Diploschistes scruposa* |
| *Didymodon australasii* | *Lecanora muralis* |
| *Didymodon brachyphyllus* | *Leptogium byssinum* |
| *Encalypta* cf. *rhaptocarpa* | *Polychidium albociliatum* |
| *Funaria hygrometrica* | *Psora luridella* |
| *Grimmia montana* | |
| *Phascum cuspidatum* | |
| *Pseudocrossidium revolutum* | |
| *Pterygoneurum ovatum* | |
| *Tortula brevipes* | |
| *Tortula princeps* | |
| *Tortula ruralis* | |

[1]Based on information compiled by John A. Christy; on file at The Nature Conservancy, 1234 N.W. 25th, Portland, Oreg. 97210.

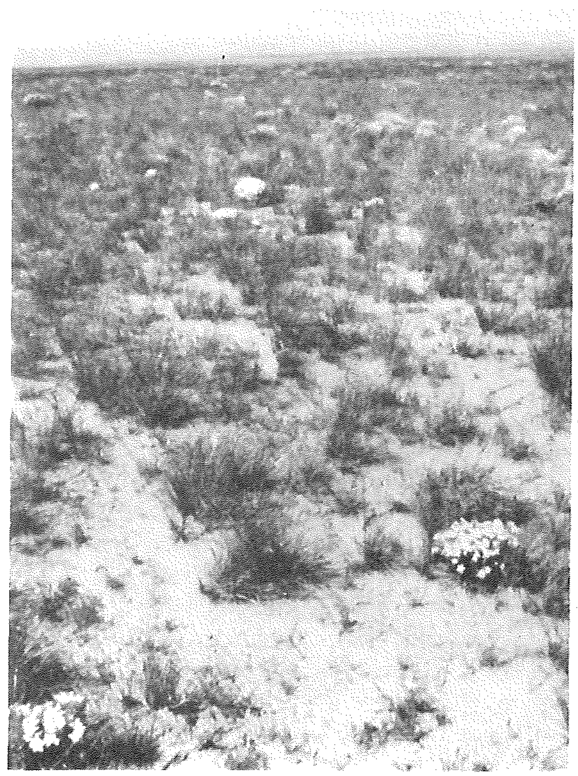

*Figure BD-4.*—Stipa comata-Poa sandbergii *community on Koehler soils, RNA A.*

Common forbs within *RNAAareHolosteum. umbellatum., Draba verna, Astragalus sclero-carpus, Cym.opterus terebintJn:nus, Phlox longifolia, Achillea m.Wefolium., Antennan:a dim.orpha, Crocid1:Um. m.ult1:caule, Gut1:errez1:a sarothrae,* and *Fritilleria PUd1:ca.*

RNA B.-RNA B, the smallest of the RNA sections, contains a wide range of soil types and vegetation from sandblow areas dominated by weedy species to a relatively undisturbed *Agropyron spicatum.-Poa sandbergii* community on Warden very fine sandy loam or silt loam soils.

Within the sandblows, vegetation cover ranges from 5 to 50 percent. Where cover is low, *Salsola kali* and *Chrysotham.nus nauseo*sus are the primary species. On older, more stabilized surfaces where cover is higher, additional species include *Brom.us tectorum., Sisym.b1'ium. altissim.um., Descurain1:a pinnata,* and *Hieracium.* sp. Along the sandblow margins, additional species include *Chrysotham.nus viscid1florus, Gutierrezia sarothrae,* and scattered *A rtem.isia tridentata* and *Secale cereale.* The *Secale* was seeded during a 19721973 effort to stabilize the dunes, and only dispersed individuals now remain.

Undisturbed areas of Warden and Sagehill-Taunton soils in RNA B support a community of *Agropyron spicatum.-Poa sandbergii-Stipa com.ata* with coverage of 20 to 25 percent, 10 to 15 percent, and 15 to 20 percent, respectively. *Brom.us tectorum.* is present in scattered patches. Cryptogam cover is relatively high at 10 to 15 percent.

Common forbs in RNA B include *Holosteum. um.bellatum., Astragalus purshii, Lom.atium. m.acrocarpum., Phlox longifolia,* and *A ntennaria dim.orpha.*

RNA C.-RNA C contains a mosaic of soil types and a corresponding mixture of plant communities. The northwestern portion of RNA C, composed of sandy Quincy soils, has little or no slope. It supports a *Stipa com.ataPoa sandberg1:1:* community similar to the one described for Quincy soils on RN A A.

In the southwestern portion of RN A C, topography ranges from flat in the west to hummocky and gently rolling in the east, and the soils are Sagehill and Taunton fine sandy loams. There is a mixture of two bunchgrass communities: an *Agropyron da.sytachyum.St1:pa cornata.* community with cover values of 10 to 15 percent and 1 percent, respectively, and a *Stipa com.ata.-Poa sa.ndbergi1:* community with cover of 15 percent and 8 percent, respectively. *Poa. sandbe1'g1:i* is present in the former with cover of 1 percent. In both communities, shrub cover is low, at2 percent, with equal distribution of *Chrysotham.nus nauseo*sus and *C. ViSC1:d1/lorus.* Cryptogam cover is 1 percent. An area of *Artem.isia tn:dentata* occurs in the rolling, southeastern part of this section of RN A C and is associated with a variety of grasses and forbs.

Another tract of Sagehill-Taunton soils occurs along the rolling eastern margin of RN A C, and the bunchgrass community is similar to the one described above. *A rtem.1:sia. tn:denta.ta* is present along hillsides and in bottoms.

In the central portion of RN A C, on Royal fine sandy loam soils, is a community of *Agropyron sp1:catum.* and *Poa. sandbergii* (cover values 15 to 20 percent and 10 to 15 percent, respectively). *St1:pa com.ata* is present at 5 percent cover. The slopes range from 2 to 5 percent, and *Brom.us tectorum.* occurs along hillsides and bottoms. *Ch1'ysotham.n1k'l natlseosus* and *A rtem.1:sia tn:dentata,* with an estimated cover of 15 to 20 percent, are distributed in concentrated patches throughout this community.

Along the southern edge of RN A C, flanking the southernmost extension of flood-deposit soils on the RN A, is a rolling area of Warden very fine sandy loams and silt loams on slopes of 3 to 12 percent. These lakebed-deposit soils support an *Agropyron spicatum.-Poa sandbergii* community with its associated cryptogam ground cover (fig. BD-5). Cover values are 25 percent for *Agropyron spicatum.* and 20 percent for *Poa sandbergii. Stipa com.ata* is present in localized sandier areas. Cryptogam cover is high, estimated at 45 percent, making this community quite different from the RNA communities present on flood-deposit soils. Throughout much of this community, where cryptogam cover is well-established, cover of weedy grasses and forbs is low. Scattered patches, where weedy species such as *Brom.us tectorum., Descurainia pinnata,* and *Erod1:um. c1:cutarium.* replace the cryptogam as dominants, indicate areas of past disturbance. On

*Figure BD-5.*—Agropyron spicatum-Poa sandbergii *community on Warden soils, RNA C.*

the Warden soils described earlier in RNA B, cryptogam cover is lower, at 10 to 15 percent, reflecting past disturbance by grazing which occurred intermittently until 1975, The plant communities on Warden soils that extend south of the boundaries of RN A's Band C have been heavily grazed since 1963. They show a prominence of weedy species and very little cryptogam ground cover.

On Warden soils in RNA C, *Artemisia tridentata* is largely restricted to draws or to slopes associated with *Brorr/lis tecton/ili.*

Associated forbs within RN A C include *Holosteumumbellatum, DI'01>a nenla. Astrago/us purshii, Lorrwtium cow';, Phlo:r lonqifolia, Ach·illeam.illefoliuru, Balsomorhiza careyono, Eriqeron* and *sonithrae.*

## Fauna

Although the Boardman RNA is limited in diversity of habitat, the bunchgrass communities and associated shrubs provide valuable foraging and nesting sites for many species of animals. Bird, mammal, amphibian, and reptile species observed in the Bombing Range and the RN A are summarized in tables BD-4, BD-5, and BD-6. Those species observed in the Bombing Range but not in the RNA are footnoted.

Bird species that are year-round residents of the Bombing Range include raptors such as the Northern harrier, American kestrel, golden eagle, long-eared owl, and short-eared owl. Other resident species include gray partridge, horned lark, black-billed magpie, common raven, sage sparrow, and western meadowlark.

A notable spring migrant to the RNA is the long-billed curlew; notable because the RNA su pports one of the highest densities of breedi ng curlews in North America (Pam push 1980). Other spring and summer residents include the turkey vulture, common nighthawk, loggerhead shrike, vesper sparrow, and savannah sparrow. The rough-legged hawk is a common winter resident.

Mammals commonly found in the RNA include the Ord kangaroo rat, Great Basin pocket mouse, and deer mouse. Common lagomorphs include Nuttall's cottontail and the black-tailed jackrabbit. Badger, long-tailed weasel, coyote, and an occasional bobcat are the local mammalian predators.

Species of concern [10] known or expected to use the RNA (tables BD-4 and BD-5) include Swainson's and ferruginous hawks, which nest in Juniper Canyon and utilize portions of the RNA as their home range.[11] Burrowing owls nest in cheat grass and bitter brush habitat types on the Bombing Range,12 and northern

JOSpecies of concern are species considered rare, threatened, or endangered-either in Oregon or throughout their range-by the authorities cited in tables B-4 and B-5.

llUnpublished data on competitive interactions among rap tors in the grassland region of North America. Personal communication from Stewart W . .Janes, Department of Biology, University of California at Los Angeles, Los Angeles 90024.

12Personal communication regarding the ecology of the burrowing owl in the Columbia Basin from Gregory A. Green, Department of Fisheries and Wildl ife, Oregon State University. Corvallis ~l73:31.

## Table BD-4—Birds found in the Boardman Research Natural Area[1] [2]

| Order | Scientific name | Common name |
|---|---|---|
| ANSERIFORMES | *Branta canadensis*[3] | Canada goose |
| | *Anas crecca*[3] | Green-winged teal |
| | *Anas platyrhynchos*[3] | Mallard |
| FALCONIFORMES | *Cathartes aura* | Turkey vulture |
| | *Haliaeetus leucocephalus alascanus*[3] [5] [6] [7] | Northern bald eagle |
| | *Circus cyaneus* | Northern harrier |
| | *Buteo swainsoni*[5] | Swainson's hawk |
| | *Buteo jamaicensis* | Red-tailed hawk |
| | *Buteo regalis*[5] | Ferruginous hawk |
| | *Buteo lagopus* | Rough-legged hawk |
| | *Aquila chrysaetos* | Golden eagle |
| | *Falco sparverius* | American kestrel |
| | *Falco mexicanus*[5] | Prairie falcon |
| GALLIFORMES | *Perdix perdix* | Gray partridge |
| | *Alectoris chukar* | Chukar |
| | *Phasianus colchicus* | Ring-necked pheasant |
| | *Callipepla californica* | California quail |
| CHARADRIIFORMES | *Charadrius vociferus* | Killdeer |
| | *Numenius americanus* | Long-billed curlew |
| | *Larus delawarensis* | Ring-billed gull |
| COLUMBIFORMES | *Zenaida macroura* | Mourning dove |
| STRINGIFORMES | *Athene cunicularia*[3] [4] | Burrowing owl |
| | *Asio otus* | Long-eared owl |
| | *Asio flammeus* | Short-eared owl |
| CAPRIMULGIFORMES | *Chordeiles minor* | Common nighthawk |
| PASSERIFORMES | *Sayornis saya* | Say's phoebe |
| | *Eremophila alpestris* | Horned lark |
| | *Pica pica* | Black-billed magpie |
| | *Corvus brachyrhynchos* | American crow |
| | *Corvus corax* | Common raven |
| | *Sialia currucoides* | Mountain bluebird |
| | *Turdus migratorius* | American robin |
| | *Anthus spinoletta* | Water pipet |
| | *Lanius excubitor* | Northern shrike |
| | *Lanius ludovicianus* | Loggerhead shrike |
| | *Sturnus vulgaris* | European starling |
| | *Pooecetes gramineus* | Vesper sparrow |

Table BD-4—Birds found in the Boardman Research Natural Area[1] [2]—Continued

| Order | Scientific name | Common name |
|---|---|---|
| | *Chondestes grammacus* | Lark sparrow |
| | *Amphispiza belli* | Sage sparrow |
| | *Passerculus sandwichensis* | Savannah sparrow |
| | *Ammodramus savannarum*[5] | Grasshopper sparrow |
| | *Zonotrichia leucophrys* | White-crowned sparrow |
| | *Sturnella neglecta* | Western meadowlark |

lBirds listed are believed to use the Natural Area at some time of the year. Information supplied by: Charles Bruce (Corvallis) and Ronald Rohweder (La Grande), Oregon Department ofFish and Wildlife; Stewart W. Janes. Department of Biology, University of California, Los Angeles:
Donald C. Rappe!, staff forester, Naval Facilities Engineering Command, Seattle, Wash.; and the authors. All species have been verified by sighting or sound. Species of concern are footnoted.

~Nomenclature follows Eisenmann and others (1982).

;JSpecies is documented for the Bombing Range but not for the RNA itself.

IDyrness and others (1975).

;'Marshall (1969).

tilJ.S. Department of the Interior, Fish and Wildlife Service (1982).

~()I'eg'()n Department of Fish and Wildlife (1978).

**Table BD-5—Mammals found in the Boardman Research Natural Area[1] [2]**

| Order | Scientific name | Common name |
|---|---|---|
| LAGOMORPHA | *Lepus californicus* | Black-tailed jackrabbit |
| | *Sylvilagus nuttalli* | Nuttall's cottontail |
| RODENTIA | *Spermophilus washingtoni*[3] | Washington ground squirrel |
| | *Thomomys talpoides* | Northern pocket gopher |
| | *Dipodomys ordii* | Ord kangaroo rat |
| | *Perognathus parvus* | Great Basin pocket mouse |
| | *Onychomys leucogaster*[4] | Northern grasshopper mouse |
| | *Peromyscus maniculatus* | Deer mouse |
| | *Erethizon dorsatum* | Porcupine |
| CARNIVORA | *Canis latrans* | Coyote |
| | *Mustela frenata* | Long-tailed weasel |
| | *Taxidea taxus* | Badger |
| | *Lynx rufus* | Bobcat |
| ARTIODACTYLA | *Odocoileus hemionus* | Mule deer |

lMammals listed are believed to use the Natural Area at some time of the year. Information supplied by Charles Bruce (Corvallis) and Ronald Rohweder (La Grande), Oregon Department of Fish and Wildlife; Donald C. Rappel, staff forester, Naval Facilities Engineering Command, Seattle, Wash.; B. J. Verts, Department of Fisheries and Wildlife, Oregon State University; and the authors. All species have been verified by sighting, sound, or sign. Species of concern are footnoted.

2Honaki and others (1982).

aOlterman and Verts (1972).

4Dyrness and others (1975).

Table BD-6—Amphibians and reptiles found in the Boardman Research Natural Area[1] [2]

| Order | Scientific name | Common name |
|---|---|---|
| ANURA | *Scaphiopus intermontanus* | Great Basin spadefoot toad |
| SQUAMATA | *Sceloperus graciosus* | Sagebrush lizard |
| | *Uta stansburiana* | Side-blotched lizard |
| | *Phrynosoma douglassi* | Short-horned lizard |
| | *Coluber constrictor* | Yellow-bellied racer |
| | *Pituophis melanoleucus* | Gopher snake |
| | *Crotalus viridis* | Western rattlesnake |

lAmphibians and reptiles listed are believed to use the Natural Area at some time of the year. Information supplied by Charles Bruce (Corvallis) and Ronald Rohweder (La Grande), Oregon Department of Fish and Wildlife; and from personal observations by the authors. All species have been verified by sighting.

2Nomenclature follows Stebbins (l96G).

bald eagles have been observed at its northern end.!:' Breeding pairs of grasshopper sparrows, about whose status in Oregon little is known, have been observed in the RNA (Janes 1983). Mammal species of note include the locally rare northern grasshopper mouse and the Washington ground squirrel (fig. BD-G), which is abundant in RNA C despite a reduced range in the Columbia Basin,14

## History of Disturbance

The Boardman Bombing Range was acquired by the Department of the Air Force in 1943 and, through subsequent transfer, by the Department of the Navy in 19GO. One-third of the Bombing Range is now owned by the Navy and two-thirds by the Department of the Interior Bureau of Land Management.

From 1943 to 1963 no livestock grazing occurred on the Bombing Range. Since 19fiB the northern and southern ends of the range, outside the central fenced octagon (refer to fig.

':lPersonal eommunieation from Donald C. Rappel. Staff Forester. Western Division. Naval Faeilities Engineering Command. Bldg. 1;i8. Room 215. Naval Station, Seattle. Wash. 98115.

"'Carlson, Leif: Geoff Geupel; and othersHJ80. "Geo· graphie range, habitat requirements and a preliminary population study of *8)!1'i'i1lojihi/IIs 11'(IS/iill!/tOIli."* Unpublished report, on file at The Nature Conservaney, 1284 N.W. 25th, Portland, Oreg. 97210.

*Figure BD-6.—Washington ground squirrel in RNA C.*

BD-2), have been leased by ranchers for grazing cattle and sheep. After the three RNA sections were established and fenced in 1978, the central octagon was opened for gTazing. RN A's A and C have not been grazed since the original acquisition of the Bombing Range by the Air Force in 1948. Grazing occurred in RNA B until 1975.

RN A A contains the main target area of the Bombing Range, and several roads are maintained within it. Soil disturbance from the impact of nonexplosive practice bombs is limited to the centermost target portion. RN A A is su bject to fires caused by the bom bing practice. Fires usually spread to the north and east; because of their rapid movement very little damage is done to the vegetative root systems.

Sandblows in RNA B were the focus of a dune stabilization program carried out in 1972 and 1978. At present, the sandblows are largely stabilized. RNA C is the least disturbed section of the Natural Area and has only a few abandoned roads within its boundaries.

Portland General Electric Co. (PGE) operates the Boardman Coal-Fired Power Plant located approximately 4.8 km (8 mil west of the Bombing Range boundary. This plant burns low-sulfur subbituminous coal and was operational 162 days from October 1981 through September 1982 (Portland General Electric Co. 1982). Possible environmental impacts of the power plant on the Natural Area are deposition by the prevailing southwesterly winds of fugitive plant emissions or of dust from the coal yard onto the RNA. and incorporation of the emissions or dust into soils, plants, or animals. PGE maintains an ecological monitoring site on the Bombing Range to assess environmental conditions and to detect ecological impacts in the vicinity of the coal plant. To date, PGE has found no evidence of such impacts (Portland General Electric Co. 1982).

## Research

The Boardman RNA, protected from the pressures of grazing and agricultural development that are occurring in much of the Columbia Basin, offers researchers an opportunity to study high-quality examples of native bunchgrass communities and their associated wildlife. Previous research on the flora and fauna of the-Boardman Bombing Range and RNA. in addition to the studies mentioned in the text, includes plant succession after natural disturbances by resident burrowing mammals,lf) the effects of grazingon breeding passerinesY; and the ecology of the Great Basin pocket mouse (Small and Verts 1988).

Additional opportunities for research on the RNA include the establishment of permam~nt vegetation transects for long-term study of the structure of the different bunchgrass communities. Concurrent monitoring of the plant communities and soils in grazed areas outside the RNA boundaries would offer valuable management information on the effects grazing has on species representation, substrate quality, and erosion. The RNA offers a unique opportunity to study hO\\I the cryptogam ground cover of the Warden soils affects a variety of ecosystem characteristics such as nitrogen fixation, erosion control. moisture relationships, and control of invasion by weedy plant species. In addition, long-term monitoring of the moss and lichen species could serve as an indicator of possible air quality changes resulting from emissions at the Boardman Coal- Fired Power Plant. Other research possibilities include primary plant succession on sand blows of RNA's Band C, successional stages of vegetation reestablishment in burned areas, and continued monitoring of sensitive species such as Swainson's and ferruginous hawks, grasshopper sparrow, and Washington ground squirrel.

## Maps and Aerial Photographs

Maps applicable to Boardman Research Natural Area are: Topographic-Well Springs, Oregon quadrangle, scale 1:24,000, issued by the U.S. Geological Survey in 1968; Strawberry Canyon NE, Oregon quadrangle, scale 1:24,000, issued by the U.S. Geological Survey in 1968; and Geologic-Geologic Map of Oregon East of the 121st Meridian, scale 1:500,000 (Walker 1977). The Naval Facilities

'"Personal communication from Alan Cropsey, Department of Biology. l'Jnivprsity of Oregon, Eugene, 974m3.

"\Janes, Stewart. W. 1981. "Effects of grazing upon t.he breeding avifauna of the Boardman Naval Weapons Training Facilit.y." Unpublished reporl. on file at. The Nature Conservancv office, 12:~4 N.W. 25t.h, Portland, Oreg. 97210 ..

Engineering Command in Seattle, Washington, can provide details on the most recent aerial photo coverage for the area. In addition, Pacific Gas and Electric makes monthly flights at 2700 m (9.000 ft) over the RNA taking true color and color infrared photographs. Photographs are available on request from Richard Davis. Department of Environmental Sciences. Pacific Gas and Electric, 121 S.W. Salmon Street. Portland. Oreg. 97204.

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Portland, Oregon 97208

## APPENDIX B. Washington Ground Squirrel Conference Opinion and Documentation

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# United States Department of the Interior

FISH AND WILDLIFE SERVICE
La Grande Field Office
3502 Highway 30
La Grande, Oregon 97850
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Reply To: 01EOFW00-2013-FC-0017
File Name: NWSTF Boardman_2013 ConfOpinion.doc
TS Number: 12-701
TAILS: 01EOFW00-2013-FC-0017
Doc Type: Final

DEC - 2 2013

Captain M.K. Nortier
Commanding Officer
NAS Whidbey Island
3730 North Charles Porter Avenue
Oak Harbor, WA 98278-5000

Subject: Conference Opinion for Military Readiness Activities at the Naval Weapons Systems Training Facility Boardman, Morrow County, Oregon (*FWS reference* 01EOFW00-2013-FC-0017)

Dear Captain Nortier:

This document transmits the Fish and Wildlife Service's (Service) Conference Opinion (Opinion) for the U.S. Department of the Navy's (Navy) proposed military readiness activities on the Boardman Naval Weapons Systems Training Facility (NWSTF), in cooperation with the Oregon National Guard (ORNG). This document responds to the Navy's April 12, 2012, request for initiating early formal conferencing with the Service on the effects of the proposed Action to the Washington ground squirrel (*Urocitellus washingtoni*), which is a candidate for listing under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The Navy's request for early conferencing was received by the Service on April 19, 2012. A Draft Conference Package (Assessment) was received in April 2013 and a final Assessment was received in May 2013.

The Navy requested formal conference not because it has determined that the proposed Action is likely to jeopardize the Washington ground squirrel but because it wants to streamline future compliance with section 7 of the ESA for the Action should the Washington ground squirrel be listed under the ESA. The Navy determined, and the Service agrees, that the impacts associated with the proposed military readiness activities at NWSTF Boardman ***are likely to adversely affect*** Washington ground squirrel. The complete decision record of this conference is on file at the Service's La Grande Field Office in La Grande, Oregon.

If you have any questions about this Opinion or require more information regarding this conference, please contact me at (541) 962-8509.

Sincerely,

Gary S. Miller
Field Supervisor

Enclosure

cc:
Larry Foster, Department of the Navy, U.S. Pacific Fleet, Pearl Harbor, Hawaii
Amy Burt, NAVFAC Northwest, Silverdale, Washington
John Phillips, NAS Whidbey Island, Oak Harbor, Washington
Paul Henson, U.S. Fish and Wildlife Service, Portland, Oregon

# CONFERENCE OPINION
## Regarding the Effects of Proposed Military Readiness Activities at the Boardman Naval Weapons Systems Training Facility in Morrow County, Oregon on the Washington Ground Squirrel

Action Agency: U.S. Department of the Navy

Conference Conducted by: U.S. Fish and Wildlife Service
La Grande Field Office
La Grande, Oregon

Date Issued: DEC - 2 2013

Issued by: Gary S. Miller
Gary S. Miller
Field Supervisor

File No. : 01EOFW00-2013-FC-0017

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## INTRODUCTION

This document transmits the Fish and Wildlife Service's (Service) Conference Opinion (Opinion) for the U.S. Department of the Navy's (Navy) proposed military readiness activities on the Boardman Naval Weapons Systems Training Facility (NWSTF), in cooperation with the Oregon National Guard (ORNG). This document responds to the Navy's April 12, 2012, request for initiating early formal conferencing with the Service on the effects of the proposed Action to the Washington ground squirrel (*Urocitellus washingtoni*), which is a candidate for listing under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The Navy's request for early conferencing was received by the Service on April 19, 2012. A Draft Conference Package (Assessment) was received in April 2013 and a final Assessment was received in May 2013.

The Navy requested early formal conference not because it has determined that the proposed Action is likely to jeopardize the Washington ground squirrel but because it wants to streamline future compliance with section 7 of the ESA for the Action should the Washington ground squirrel be listed under the ESA. The Navy and ORNG are not required to implement the Terms and Conditions provided in this Conference Opinion unless the Washington ground squirrel is listed under the ESA and the requirements are met (see Section 10, *Reinitiation-Closing Statement*) to confirm the Conference Opinion as a Biological Opinion.

This document is based on information provided in the May 2013 Final Conferencing Package, email correspondence, meetings, phone conversations, and other sources of information. The complete decision record of this conference is on file at the Service's La Grande Field Office, in La Grande, Oregon.

This document has been formatted to facilitate the adoption of this Conference Opinion as a Biological Opinion under appropriate circumstances as described below in the closing statement should the Washington ground squirrel be listed under the ESA.

## CONFERENCE HISTORY

- On April 12, 2012, the Navy submitted a request for early conferencing to the Service for the purpose of determining the potential effects of the proposed Project on the Washington ground squirrel.
- In June 2012, the Navy submitted a preliminary draft EIS (DEIS Version 4) on the proposed Project for review by the Service. On August 1, 2012, the Navy/ORNG met with the Service to discuss Service comments on Version 4 of the DEIS and to discuss mitigation actions and Best Management Practices (BMP) under the proposed Project.
- On October 25, 2012, the Navy/ORNG met with the Service, the Oregon Department of Fish and Wildlife (ODFW), the Confederated Tribes of the Umatilla Indian Reservation, Verne Marr, and The Nature Conservancy (who also represented Defenders of Wildlife) to discuss the ESA conferencing process, Washington ground squirrel monitoring and mitigation, and the proposed Project.
- On December 6, 2012, the Service, through the Department of the Interior, submitted comments on the Draft EIS (ER#12-640).

- On March 18, 2013, the Navy provided the Service with a copy of a report by Dr. Yensen regarding his recommendations for mitigation and long-term monitoring of Washington ground squirrels, related to the proposed activities for the NWSTF Boardman.
- On April 2, 2013, the Navy provided a draft conference package to the Service for review. The draft package provided an analysis of the potential effects of implementing the Preferred Alternative (Alternative 2) in the DEIS on the Washington ground squirrel.
- On April 23, 2013, the Navy sent an email to the Service stating that the Digital Multi-Purpose Training Range had been dropped from the preferred alternative but would still be considered under Alternative 1 in the EIS.
- On April 18, 2013, the Service had a conference call with the Navy/ORNG to discuss the draft conference package and the Service provided follow-up written comments on April 26, 2013.
- On May 23, 2013, the Navy submitted the final Conference Package, which incorporated Service comments.
- On June 20, 2013, the Navy/ORNG held a conference call with the Service, ODFW, The Nature Conservancy, and Defenders for Wildlife to discuss the final conference package mitigation and adaptive management sections.
- On June 25, 2013, the Navy/ORNG held a conference call with the Service to discuss a follow-up email from The Nature Conservancy regarding questions/concerns with the mitigation and adaptive management sections of the conference package.
- On July 10, 2013, the Navy provided the Service with a written response to the questions raised by The Nature Conservancy, a table outlining commitments in the current Integrated Natural Resource Management Plan (INRMP) versus new mitigation commitments for the proposed activities, and tables showing a number of mitigation ratio scenarios considered for the proposed activities.
- On July 30, 2013, the Navy/ORNG held a conference call with the Service to discuss the information they provided on July 10, 2013, and provided an update on the project.
- On August 1, 2013, the Navy provided an addendum to the final conference package (based on discussion that occurred on the July 30$^{th}$ conference call), that addressed long-term monitoring, modifications to the figure showing the 140 dBP area for the Eastern Convoy Live Fire area and a modified table for acres impacted by the various proposed activities.
- On August 22, 2013, the Service provided an agency review draft of this Conference Opinion to the Navy and the ORNG.
- On September 17, 2013, the Service met with the Navy/ORNG to discuss development of the long-term monitoring strategy for the Washington ground squirrel on the NWTSF Boardman.
- On September 26, 2013, the Service received comments on the August 22, 2013 draft Conference Opinion.
- On October 31, 2013, the Service held a conference call with the Navy/ORNG to get clarification on some of the comments provided on September 26$^{th}$. The Navy committed to providing some additional clarification.
- On November 7, 2013, The Navy/ORNG provided the requested clarifications and information.

# CONFERENCE OPINION

## 1. Description of Proposed Action

The Proposed Action involves construction and operation of new range facilities and changes in existing training activities at NWSTF Boardman. The Proposed Action would result in enhancements and increases in training that are necessary to ensure NWSTF Boardman supports military training and readiness objectives. The components of the Proposed Action stem from U.S. Navy training requirements (Fleet Response Training Plan) and other military training requirements, including Army Regulation 350-1, *Army Training and Leader Development*; Army Regulation 350-2, *Reserve Component Training*; Department of the Army Pamphlet 350-38, *Standards in Training Commission*; and ORNG regulations and policies. In general, the Proposed Action would:

- Increase the types of training activities and the number of training events conducted at NWSTF Boardman
- Accommodate force structure changes
- Provide enhancements to training facilities and operations at NWSTF Boardman and its associated Special Use Airspace (SUA)

### *1.1 Training and Testing Activities*

Descriptions of training and testing activities analyzed in this Opinion are organized by the Navy's primary mission areas, regardless of the entity (Navy or ORNG) that is conducting the activity. This grouping or bundling of similar activities helps to streamline the analysis of potential impacts and ensures that the overall potential effects of a particular activity are considered, irrespective of the entity conducting the activity. For example, the potential effects of an air-to-ground gunnery exercise conducted by the Navy are expected to be the same as one conducted by the Air National Guard. Separate descriptions are presented when an entity's activity does not align with a Navy primary mission area. Training and testing activities conducted under the Proposed Action at NWSTF Boardman include the following:

- Anti-Air Warfare Training – Low-Altitude Tactical Training (LATT), and Surface-to-Air Counter Tactics
- Strike Warfare – Air-to-Ground Bombing Exercises, Air-to-Ground Gunnery Exercises, and Air-to-Ground Missile Exercises (captive-carry only, nothing is dropped/released from the aircraft)
- Unmanned Aerial System (UAS) Operations
- Electronic Warfare Training – Electronic Attack and Electronic Surveillance
- Equipment and Personnel Insertion and Extraction Training
- Helicopter Training Operations (Low-Level Training Flights, Hoisting Operations, Sling-Load Operations, and Austere Landings and Take-Offs)
- Live Fire Range Operations (marksmanship and small arms training) and Dismounted Maneuver Training (Maneuver to Contact Live-fire Training)
- Intelligence, Surveillance, and Reconnaissance Training

Table 1 provides the annual number of testing and training events at NWSTF Boardman under the Proposed Action. Table 2 and Table 3 present the annual ordnance use at NWSTF Boardman. Table 4 presents the annual estimates of aircraft overflights in the NWSTF Boardman Special Use Airspace under the Proposed Action.

**Table 1. Training and Testing Activities at NWSTF Boardman under the Proposed Action**

| Range Activity | Representative Platform | Annual Number of Training Events | Location |
|---|---|---|---|
| **Anti-Air Warfare** | | | |
| Surface to Air Counter Tactics and Low-Altitude Tactics Training | EA-6B, EA-18G, F-15, F-16, FA-18, F-35,C-130 | 1,047 | Boardman MOA, Restricted Areas |
| **Strike Warfare** | | | |
| Air-to-Ground Bombing Exercise | FA-18, F-35, AV-8 | 133 | Main Target Area |
| Air-to-Ground Gunnery Exercise | F-15 , F-35, CH-47, H-60 | 70 | Main Target Area, Strafe Pit |
| Air-to-Ground Missile Exercise/High Speed Anti-Radiation Missile Exercise (non-firing) | EA-6B, EA-18G | 180 | Main Target Area, Boardman MOA, Restricted Areas |
| Intelligence, Surveillance, and Reconnaissance | P3-C, EP-3, EA-18G, EA-6B | 9 | Boardman MOA, Restricted Areas |
| **Electronic Warfare** | | | |
| Electronic Attack and Electronic Support | EA-6B, EA-18G, EP-3 | 500 | Boardman MOA, Restricted Areas |
| **Support Activities** | | | |
| Unmanned Aerial System/Tactical Unmanned Aerial Systems Operations | RQ-7, RQ-11 | 1,709 | TUAS Airfield, R-5701 (all), R-5706 |
| Insertion and Extraction | C-130, C-17, C-23 HH-53, CH-46, CH-47 UH-60 | 12 Days | NWSTF Boardman, Drop Zone |
| Small Arms Training | 5.56, 7.62, 20mm, 25mm, 40mm, 50 mm caliber weapons | 18 Days | Main Target Area MPMGR |
| Mortar Firing | M224 60mm, 81mm and 120mm (using sub-caliber training rounds) | 18 | Main Target Area |
| **Conduct Airborne Operations** | | | |
| Night Vision Goggle Low-Level Training | EA-18G, H-60, CH-47 | 48 | Boardman MOA, Restricted Areas |

| Range Activity | Representative Platform | Annual Number of Training Events | Location |
|---|---|---|---|
| **Conduct Fire Support** | | | |
| Convoy Live Fire Training | HMMWV, FMTV M1A2 Abrams, M2/M3 Bradley, M88 Wrecker | 45 days | CLFR |
| Multi-Purpose Machine Gun Range Training | HMMWV (weapons systems would include M249 SAW, M240B, M60, M2, Mk 19, Sniper rifles up to and including 50 cal) | 117 days | MPMGR |
| **Ordnance Disposal and Demolition** | | | |
| Land Demolition Training | EOD personnel, ORNG Engineers | 50 | DTR |

Notes: MOA = Military Operations Area, TUAS = Tactical Unmanned Aerial Systems, MPMGR = Multi-Purpose Machine Gun Range, CLFR = Convoy Live Fire Range, EOD = Explosive Ordnance Disposal, ORANG = Oregon Air National Guard, DTR = Demolition Training Range, FMTV =Family of Medium Tactical Vehicles--mostly 2.5-ton LMTV = light medium tactical vehicle, and 5-ton MTV
All items are non-explosive practice munitions except for Demolition Training.
Platforms presented are representative platforms and other similar platforms could be used.

**Table 2. Estimated Total Annual Ordnance Use at NWSTF Boardman under the Proposed Action**

| Training Area and Ordnance Type | Number of Rounds Per Year[1] |
|---|---|
| **Practice/Training Ordnance** | |
| MK-76 | 392 |
| MK-82 | 10 |
| MK-83 | 3 |
| MK-84 | 2 |
| Laser-Guided Training Rounds | 20 |
| **Mortar Rounds** | |
| M224 60mm mortars (non-explosive) | 1,440 |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 269,500 |
| 7.62 mm | 333,000 |
| 20 mm | 88,800 |
| 40 mm grenades (non-explosive) | 10,500 |
| .50 caliber | 102,000 |
| **High Explosive Charges** | |
| 200 pounds net explosive weight or less | 50 |

[1] Actual values will vary based on specific training requirements, which are influenced by factors such as deployments and world events.

Note: All items are non-explosive practice munitions except for Demolition Training.

**Table 3. Summary of Estimated Annual Ordnance Use by Range Area under the Proposed Action**

| Training Area and Ordnance Type | Number of Rounds Per Year[1] |
|---|---|
| **Main Target Area (includes strafing pit)** | |
| **Practice/Training Ordnance** | |
| MK-76 | 392 |
| MK-82 | 10 |
| MK-83 | 3 |
| MK-84 | 2 |
| Laser-Guided Training Rounds | 20 |
| **Total** | **427** |
| **Mortar Rounds** | |
| M224 60mm mortars (non-explosive) | 1,440 |
| **Total** | **1,440** |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 19,500 |
| 7.62 mm | 13,000 |
| 20 mm | 88,800 |
| 40 mm grenades (non-explosive) | 500 |
| .50 caliber | 2,000 |
| **Total** | **123,800** |
| **Multi-Purpose Machine Gun Range** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 160,000 |
| 7.62 mm | 220,000 |
| .50 caliber | 75,000 |
| **Total** | **455,000** |
| **Convoy Live Fire Range (Eastern)** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 45,000 |
| 7.62 mm | 50,000 |
| 40 mm | 5,000 |
| .50 caliber | 12,500 |
| **Total** | **112,500** |
| **Convoy Live Fire Range (Western)** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 45,000 |
| 7.62 mm | 50,000 |
| 40 mm | 5,000 |
| .50 caliber | 12,500 |
| **Total** | **112,500** |
| **Demolition Training Range** | |
| **High Explosive Charges** | |
| 200 pounds net explosive weight or less | 50 |
| **Total** | **50** |

[1] Actual values will vary based on specific training requirements, which are influenced by factors such as deployments and world events.

**Table 4. Annual Estimates of Aircraft Overflights in the NWSTF Boardman Special Use Airspace under the Proposed Action**

| Aircraft | Sorties | Flight Time (Hours) | % Above 3,000 ft. MSL | % Nighttime |
|---|---|---|---|---|
| **Fixed-Wing** | | | | |
| EA-6B Prowler | 0 | 0 | 0% | 0% |
| EA-18G Growler | 1,348 | 2,791 | 35% | 0% |
| F-15 | 60 | 120 | 65% | 0% |
| F-16 | 5 | 8 | 35% | 0% |
| F-35 | 64 | 126 | 35% | 0% |
| FA-18 | 129 | 154 | 35% | 0% |
| AV-8 | 0 | 0 | 0 | 0% |
| P-3/EP-3/P8 | 50 | 25 | 100 | 20 |
| Parachute Drops from C-130, C-17, CH-47 or C-23 | 12 | 12 | 50% | 20% |
| **Helicopters** | | | | |
| CH-47 Chinook | 65 | 97 | 0% | 33% |
| UH-60 Blackhawk | 22 | 32 | 0% | 33% |
| UH-72 Lakota | 6 | 8 | 0% | 33% |
| **Unmanned Aerial Systems** | | | | |
| RQ-7 Shadow | 204 | 408 | - | 15% |
| RQ-11 Raven | 30 | 100 | - | 15% |
| SCANEAGLE | 1475 | 5,900 | 85% | 15% |
| **GRAND TOTAL** | **3,470** | **9,781** | | |

Notes: Flight Time (Hours) = Total flight in NWSTF (Naval Weapons Systems Training Facility) Boardman Military Operating Area; % Above 3,000 ft. (914.4 m) MSL = estimated percentage of total flight time that occurs at an altitude above 3,000 ft. (914.4 m) above MSL; % nighttime = percentage of total flight time that occurs between 10 pm and 7 am.
Flight Time in hours is a summation of all operations, which often occur concurrent to each other. The total flight hours are not a representation of sequential flight hours.
The F-35 is not currently planned for basing with Navy units in the northwest; however, as with other military aircraft types, potential infrequent utilization of NWSTF Boardman is possible from transient units.

### *1.2 Maintenance Activities*

In addition to training and testing activities, personnel stationed at the facility are tasked with ongoing activities to maintain the usability and safety of the facility:

- Chief of Naval Operations Instruction 3571.4 *Operational Range Clearance Policy for Navy Ranges* (9 October 2009) establishes the policy and requirements for performing operational range clearance on Navy ranges in accordance with DoD Directive 4715.11.
    - Areas that support various range management activities as well as areas that pose a potential concern to human health or the environment shall undergo clearance activities.
    - To ensure the safety of maintenance personnel, operational range clearance requirements must address ingress/egress routes, run-in lines, maintenance roads,

  - and sufficient area around each target to afford safe movement and operation of personnel and equipment.
  - To ensure all targets resemble the objective of the mission and are distinguishable from its surroundings, all material potentially presenting an explosive hazard located on the surface and partially buried that are greater than 4 in. (10.2 cm) in any dimension, must be removed to an appropriate distance from the target and at an appropriate frequency.
- Range control procedures at NWSTF Boardman limit unanticipated interactions with the public. NWSTF Boardman is fully fenced; entrance into these areas is controlled by unmanned gates. Signs also are posted and maintained to warn the public of potentially hazardous activities.
- Vegetation is managed under the *NWSTF Boardman INRMP* (U.S. Department of the Navy 2012a). Actions focus on minimizing disturbance, controlling invasive plants and weeds, and restoring of native habitats.
- Wildlife species are managed under the *NWSTF Boardman INRMP* (U.S. Department of the Navy 2012a). Actions focus on minimizing disturbance and restoring native habitats.
- Commander, Navy Region Northwest implements a regional fire management plan. The Navy is currently revising, updating, and expanding the specific portion of that plan applicable to NWSTF Boardman. The current fire strategy is to use the existing road system as the staging lines at which fires will be fought. The Navy currently maintains a system of 60 ft. (18.3 m)-wide fire breaks throughout NWSTF Boardman. A detachment of six Navy personnel are stationed at NWSTF Boardman. Their responsibilities are to maintain the buildings, roads, wells, fences, and other infrastructure and provide security in accordance with NAS Whidbey Instruction 3120.6 (NWSTF Boardman Standard Operating Procedures). Navy personnel stationed at NWSTF Boardman are required to hold Wildland Firefighting Red Cards. Additionally, the Navy personnel stationed at NWSTF Boardman are equipped with appropriate wildland protective clothing. NWSTF Boardman firefighters have nine vehicles assigned to them; however, only two are used for actual firefighting operations, a dedicated firefighting vehicle (Type VI Brush truck) and a General Services Administration truck that has a 250-gallon firefighting skid unit mounted (a "skid" is a water pump with a large water capacity that sits in the rear of a flatbed truck). In addition, the Navy leases a tractor and disc during the 4-month fire season to maintain fire/fuel breaks. In extreme situations, the tractor could also be used for incipient wildland fire suppression efforts when the application of foam lines is unavailable, exhausted, or ineffective.

### *1.3 Range Enhancements*

The Proposed Action could include the establishment and use of an additional MOA to the northeast of existing NWSTF Boardman airspace, an increase in existing training activities, new training activities, and range enhancements to meet Navy and ORNG training requirements. Some ongoing training activities could increase as a result of force structure changes associated with the introduction of new aircraft or other equipment. The following proposed range enhancements would support new training activities and some ongoing activities.

- Establishment and use of an additional MOA to the northeast of existing NWSTF Boardman airspace. Low-altitude flight tracks would be oriented along a northeast axis to facilitate the use of this additional MOA (Figure 1 in the Assessment), avoiding existing and proposed wind turbines on the far eastern end of R-5701C.

- Construction and operation of a Multi-Purpose Machine Gun Range (MPMGR), with a heavy sniper lane, and associated support facilities (Figure 1). The MPMGR would be used to train and qualify Soldiers in the use of various crew-served weapons.
- Construction and operation of eastern and western Convoy Live Fire Ranges (CLFR). The CLFRs would be used for training Soldiers in planning and conducting vehicle convoy operations, including immediate action response using weapons live fire against threats encountered during convoy operations utilizing wheeled and tracked vehicles.
- Construction and operation of a Demolition Training Range (DTR). The DTR would be used by Explosive Ordnance Disposal (EOD) personnel, Combat Engineers, and others for land demolition training (i.e., safely detonating explosive charges).
- Designation and establishment of a Drop Zone to accommodate parachute operations of personnel and small-medium sized equipment (Containerized Delivery Systems)
- Establishment and use of three mortar firing positions
- Construction and use of a UAS Training and Maintenance Facility with small airstrip
- Construction and use of a Range Operations Control Center (separate from the UAS facility)

Table 5 presents the approximate footprints associated with proposed range enhancements.

### *1.3.1 Establishment and Use of Additional Special Use Airspace*

To meet Navy Mission Essential Tasking, the EA-18G and the EA-6B aircraft stationed at NAS Whidbey Island have a training requirement that necessitates low-altitude flying and combat style maneuvering at 350 to 480 knots at 200 ft. (60.9 m) to 500 ft. (152.4 m) AGL. Established wind energy projects have reduced the usable airspace for Low Altitude Tactical Training (LATT) from 205 $nm^2$ to 201.2 $nm^2$. Due to the anticipated continued development of wind energy projects inside R-5701 airspace, larger portions of R-5701C in the southeast and R-5701-E would no longer be usable for low-altitude flight training. Range capacity at other military installations is very limited and the expectation of range time availability at other ranges is problematic. Flight training capacity at other military installations with low-level restricted-use airspace is very limited, and the airspaces at other Navy or DoD ranges outside of Boardman do not have the capacity to accommodate additional flight training time. All military installations with low-level restricted-use airspace are fully scheduled by locally assigned aircrews currently training in those airspaces. It is not possible to obtain sufficient training time within another installation's airspace for the aircraft crews at NAS Whidbey Island, who require more than 2,000 hours of daytime use. If aircraft crews are unable to accomplish their required training, they would be required to obtain waivers of necessary training qualifications and might even have to deploy without this important training.

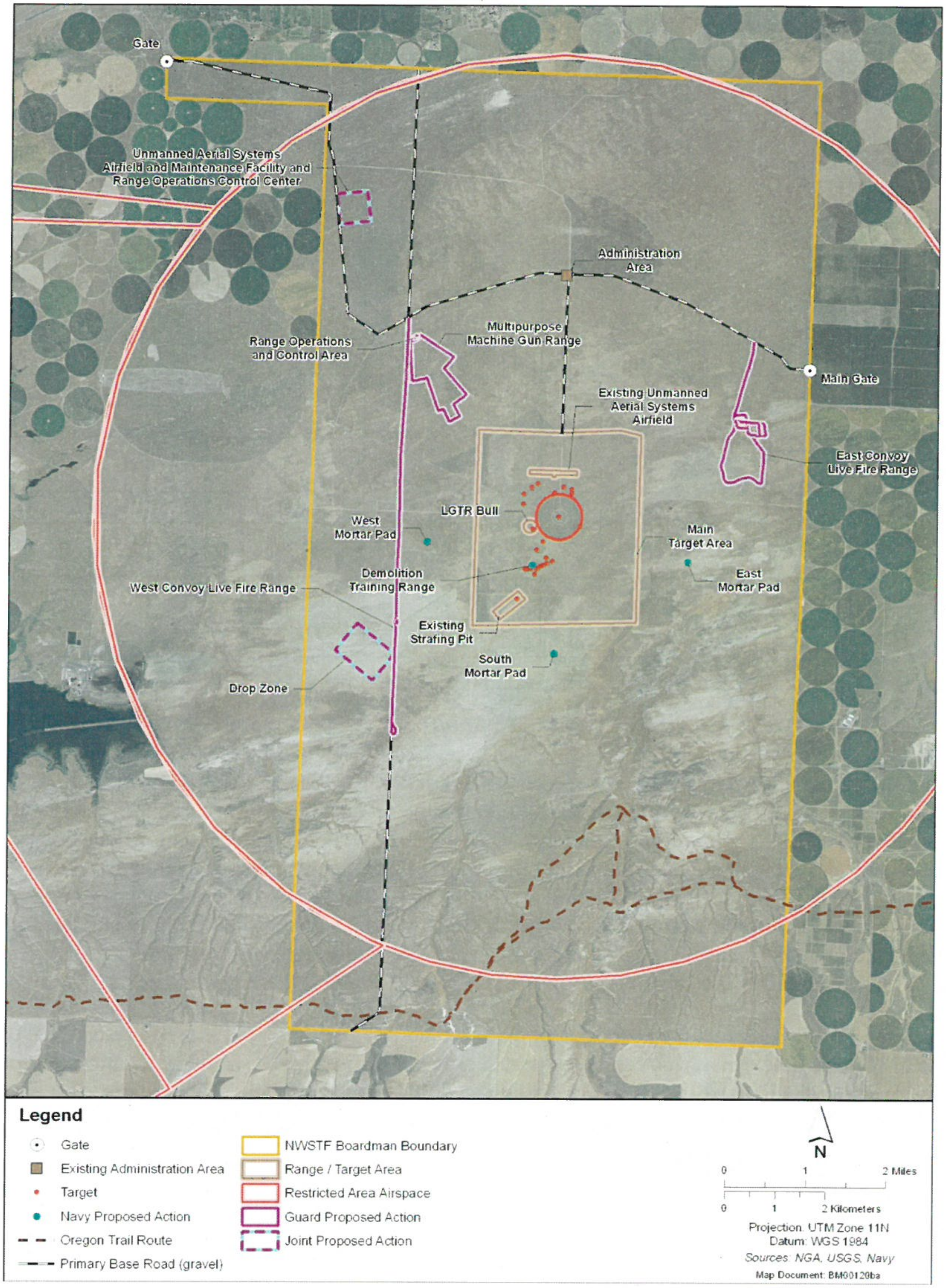


**Figure 1. Navy and ORNG Range Enhancements Under the Proposed Action**

**Table 5. Summary of Proposed Range Enhancements**

| Proposed Range Enhancement | Total Area of Construction Disturbance (acres) | | | Total Area of Construction Disturbance (acres) |
|---|---|---|---|---|
| | Undisturbed Area (acres) | Previously Disturbed Area (acres) | Area Temporarily Disturbed and Revegetated (acres) | |
| MPMGR and Range Operations Control Area | 16 | 0 | 14 | 30 |
| CLFR (Eastern) | 0 | 12 | 0 | 12 |
| CLFR (Western) | 0 | 12 | 0 | 12 |
| DTR | 0 | 1 | 0 | 1 |
| TUAS Training and Maintenance Facility | 8 | 0 | 1 | 9 |
| Drop Zone | 0 | 0 | 0 | 0 |
| Three Mortar Firing Points | 0 | 0 | 0 | 0 |
| Joint-Use Range Operations Support Center | 0.5 | 0 | 0 | 0.5 |
| **TOTAL** | **24.5** | **25** | **15** | **64.5** |

Notes: MPMGR = Multi-Purpose Machine Gun Range, CLFR = Convoy Live Fire Range, DTR = Demolition Training Range, TUAS = Tactical Unmanned Aerial Systems

A solution to this problem is the creation of the Boardman Northeast MOA as shown in Figure 1 in the Assessment. This new training airspace would be 46 $nm^2$ (157.8 $km^2$) and join the current Boardman MOA. The Boardman Northeast MOA would overlie the current national security area that is above the Umatilla Army Depot. The Umatilla Chemical Depot National Security area has a zone of surface to 5,000 ft. MSL. The National Security Area is only "active" during emergencies, all other times it is a recommended no-fly area. Low-altitude flight tracks would be oriented along a northeast axis to facilitate the use of this additional MOA, avoiding existing wind turbines on the far eastern end of R-5701C (Figures 5 and 6 in the Assessment).

It is important to note that the proposed airspace would not be designated as a restricted area. The difference between a MOA and a restricted area is that, in a MOA, military aviation units may be using the airspace, but they are not engaged in any firing or bombing activities. Restricted areas denote the existence of unusual, often dangerous, hazards to aircraft such as weapons firing, or aerial gunnery.

### *1.3.2 Construction and Operation of MPMGR with Heavy Sniper Overlay*

**<u>Construction</u>**

The ORNG would use the MPMGR to train Soldiers in the use of various crew-served small arms such as the M240B 7.62mm machine gun, the M249 5.56mm machine gun, MK19 40mm

Grenade Machine Gun, and the M2 .50 cal machine gun. The proposed design is essentially the same as the Army-Standard MPMGR depicted in Department of the Army Training Circular 25-8, with the addition of one heavy sniper range lane, which includes additional targets and extends from 1,500 m (4,921.3 ft.) to 1,775 m (5,823.5 ft.)(Figure 2). Various sniper rifles, up to and including the .50 cal sniper rifle, would be used on the heavy sniper range lane.

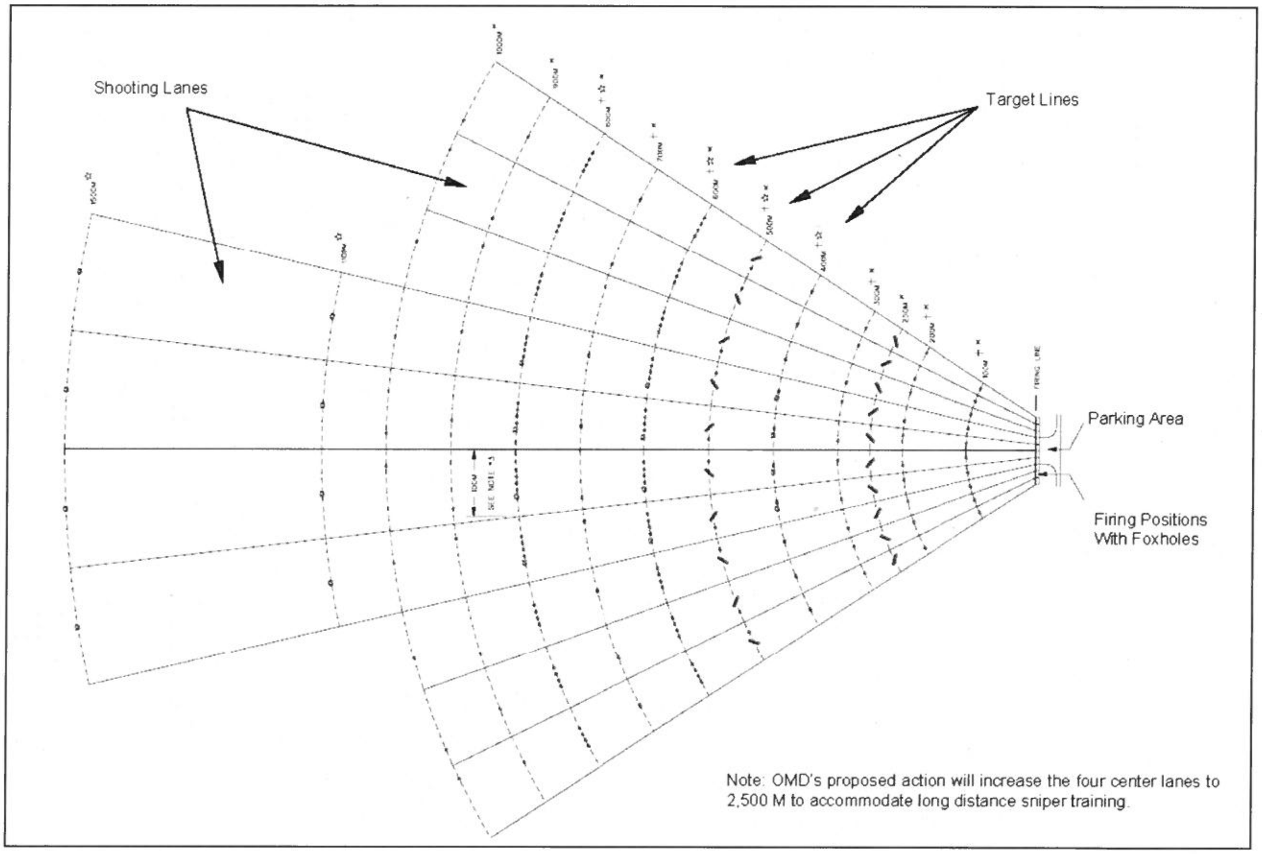


**Figure 2. Army-Standard MPMGR**

The MPMGR would consist of 10 firing lanes with multiple stationary and moving targets in each lane. Six of the firing lanes extend to 1,000 m (3,280.8 ft.). Four lanes extend to 1,500 m (4,921.3 ft.). One 1,500 m (4,921.3 ft.) lane would be lengthened to 1,775 m (5,823.5 ft.) and would contain additional targetry for training and qualification with sniper weapons. The range would be constructed so that the firing points would accommodate a parked vehicle with a mounted machine gun. The range would contain a total of 151 target emplacements. Each target would be mounted on a mechanism to raise the target when it is activated or create a moving target. Each target support structure would be set on a concrete or gravel pad behind an earthen berm to shield the target support equipment from projectile damage. Utility trenching would be required to bring underground power, control, and data cable from the range control tower to each target emplacement within 1,500 m (4,921.3 ft.) of the firing points on the range, targets beyond that would be battery powered and Radio Frequency operated.

Close to the MPMGR, the ORNG also would construct a 10 lane zero range. The zero range would allow Soldiers to adjust ("zero") the sights of their weapons, each using a single target at a distance of 10 m (32.8 ft.), prior to shooting on the MPMGR. The zero range would be approximately 10 by 40 m (32.8 by 131.2 ft.) in size and would include a range control tower. The Range Operations and Control Area would provide support facilities for the MPMGR. It would occupy approximately 2.2 ac. (0.89 ha) and would consist of about eight small metal-sided buildings, a gravel vehicle parking area, and gravel walking paths. One building would be elevated on legs and used as a control tower. Another would be a ground-level storage building.

Other structures include a set of covered bleachers, a general instruction building (classroom), an after-action review building, a covered eating area, an ammunition breakdown building, and concrete slabs for placement of self-contained portable latrines. The layout of the range and Range Operations and Control Area would be sited so as to minimize disturbance and reduce effects to sensitive species where possible.

The MPMGR, along with an associated zero range, Range Operations Control Area, access roads, parking areas, and maintenance trails to access the target emplacements would encompass approximately 260 ac. (105.2 ha). Surface danger zones (SDZ) for the MPMGR and zero range would cover approximately 12,500 ac. (5058.6 ha). The MPMGR and the zero range would be sited so both ranges could operate simultaneously and so that their SDZs would overlap the existing main target area. A SDZ is the mathematically predicted, three-dimensional area that a projectile or fragment could travel through the air and impact the earth, either by direct fire or ricochet. A SDZ is calculated using procedures found in Department of the Army Pamphlet 385-63 - Range Safety. Except for areas on the ranges themselves, none of the areas within SDZs would be disturbed during construction. A SDZ serves only as a human safety buffer downrange from a firing point.

Of the 260 ac. (105.2 ha) occupied by the MPMGR and associated development, approximately 27.5 ac. (11.1 ha) would be disturbed during construction. The disturbance would consist of the construction of access roads, parking areas, maintenance trails, the Range Operations and Control Area, weapons firing positions, target emplacements, earthen berms, and associated underground power control and data cables. Of the 27.5 ac. (11.1 ha) of disturbed area, approximately 11.6 ac. (4.7 ha) would be revegetated with native vegetation following construction. The remaining 15.9 ac. (6.4 ha) would contain buildings, concrete structures, or gravel surfaces and would remain permanently altered.

Construction of the MPMGR would be accomplished using typical construction equipment. Building materials, including concrete and gravel and soil for berms, would likely be imported from one or more off-site sources. The Range Operations and Control Area parking area would be constructed first and used for staging construction of the MPMGR and the remainder of the Range Operations and Control Area. Additional construction staging areas, if needed, would be established within previously disturbed areas at the Navy administrative area.

**Operation and Maintenance**

The ORNG would use the MPMGR and associated zero range year-round, approximately 117 days annually. Typically, use would occur primarily on weekends between approximately 9:00 am and 6:00 pm, although some night time training and qualification also would be conducted. Firing would typically occur in approximately 20 minute blocks while the range is in use. Firing time for a day would usually be around 2 hours, with breaks in shooting to change crews, take meal breaks, repair targets, and for other reasons.

Except for tracer rounds, all ammunition used on the range would be inert/non-explosive. Munitions casings would be collected at the conclusion of training. Tracer rounds would be prohibited during periods of high fire danger. Tracer ammunition (tracer rounds) are bullets that are built with a small pyrotechnic charge in their base. Ignited by the burning powder, the pyrotechnic composition burns very brightly, making the projectile visible to the naked eye. This enables the shooter to follow the bullet trajectory in order to make aiming corrections. If pyrotechnic devices, such as smoke grenades, were used, they would be placed in metal containers to minimize their potential to start a fire.

Maintenance activities on the range would include periodic maintenance, repair, and replacement of targets and target support mechanisms. Periodic vegetation control on the range will be conducted to reduce fire fuel loading or manage exotic vegetation.

Solid wastes would be collected for transportation and disposal at permitted off-site solid waste management facilities. No on-site waste disposal is planned. Waste from the portable latrines would be removed periodically by a local contractor and transported to a local treatment facility by a contractor.

*1.3.3 Construction, Operation, and Maintenance of two (Eastern and Western) CLFRs*

**Construction**

The eastern CLFR would be used to train Soldiers in conducting vehicle convoy operations, up to and including immediate action response using weapons live fire against encountered threats. The eastern CLFR would be developed along an approximately 8.0 km (5 mi.) route on the eastern portion of NWSTF Boardman. Portable targets would be sited within approximately 100 m (328.1 ft.) of the road course and used to simulate an ambush. The targets would be periodically relocated to change training scenarios. Temporary structures, such as plywood facades, steel shipping containers (conex boxes), or hay bale walls, may be used to simulate small urban environments and help conceal targets. No permanent construction or alteration of the existing terrain would be anticipated for the eastern CLFR.

The ORNG has sought to develop a proposed CLFR on NWSTF Boardman such that (1) existing roads would be used, (2) the SDZ would be completely contained within the installation boundaries, and (3) the relatively undisturbed wildlife habitat located on the southern portion of the installation would be avoided. These factors have resulted in the proposal to locate the CLFR along an existing north/south road with potential targets located toward the center of NWSTF Boardman. The SDZs for this range would be mostly within those of the proposed MPMGR and the existing main target area.

Construction of the range would consist of graveling existing two-track roads to support increased vehicle traffic and to reduce fugitive dust emissions during training. Construction also would involve placing portable target-lifters within 100 m of the existing roads and encircling them with sandbags and steel plates to protect the battery power-supply and radio controllers from damage. The target lifters would encompass an area approximately 2 by 3 ft. (0.6 by 1.8

m). Shipping containers, plywood, and hay bales may also be used to create building facades and simulated village walls.

In addition to the eastern CLFR, a second, western CLFR would allow at least one of the CLFRs to be used while the MPMGR is in use. Having two CLFRs also would permit the ORNG to accommodate surges in required training prior to deployments, when many Soldiers need to be trained in a short period of time. The diversity added by these training assets would also increase training realism.

The second (western) CLFR would be established along approximately 4 mi. (6.4 km) of an existing north-south road located west of the proposed MPMGR location and would likely include a simulated traffic round-about near the center of the range and a turn-around area at the southern end (Figure 1). Target emplacements would be located toward the center of NWSTF Boardman to contain the SDZ on NWSTF Boardman. The construction and development of the second, western CLFR would be similar to the eastern CLFR, as described above. The footprint of the western CLFR, not including the SDZ, would cover approximately 68 ac. (27.5 ha). The ORNG has estimated the SDZ for this range would require approximately 15,600 ac. (6,313.1 ha), including the range itself. Most of the SDZs would overlap the SDZs for the MPMGR, eastern CLFR, and the existing main target area.

**Operations and Maintenance**

Up to Platoon-sized (25 to 50 personnel) convoys armed with M249, M240B, M2, and MK 19 machine guns would navigate the installation roads training in Command, Control, and Communications; upon entering the CLFR, the range would become "hot" (firing activities can occur) and units would detect activated targets and engage those simulated hostile targets. Training would occur according to standardized procedures and under the guidance of a Range Safety Officer up to 45 days a year.

Except for tracer rounds, all ammunition used on the CLFRs would be inert/non-explosive. Use of tracer rounds would be prohibited during periods of high fire danger. Any pyrotechnic devices would be placed in metal containers to minimize their potential to start a fire. Training would take place during both day and night hours.

Range maintenance would entail typical gravel road maintenance and periodically servicing the power supply and radio controllers of the target lifters. Targets may be relocated to vary the training scenarios and former target locations would be revegetated with native species. Periodic vegetation control may be required to reduce fire fuel loading or manage exotic vegetation and would be conducted as authorized in approved natural resource and fire management plans.

*1.3.4 Construction and Operation of a Demolition Training Range*

Under the Proposed Action, the Navy proposes to construct a demolition training range (DTR) to accommodate land demolition training (Figure 1). The range would be constructed as a cleared area with approximately 10 ft. (3.1 m) berms on each side of the range to reduce detonation fragments outside the immediate range area. Details regarding ordnance that would be used in the DTR and frequency of use are outlined in Table 2 and Table 3. Additionally, Office of the Chief of Naval Operations Instruction 3501.97G requires that explosive ordnance disposal personnel conduct periodic demolition training in order to retain qualifications and the DTR will assist in maintaining those qualifications. The demolition training range would be utilized up to 50 times annually and could support a maximum Net Explosive Weight (NEW) of 200 pounds (lb) (90.7 kilograms [kg]). Training with explosive charges of NEW between 100 lb (45.4 kg) and 200 lb (90.7 kg) would not be a regularly scheduled occurrence, and would only be conducted in special training circumstances. For the analysis of potential impacts, two detonations per year at a NEW of 200 lb (90.7 kg) were included; however, it is anticipated that explosive charges of this size would be a rare occurrence. If requirements to train with charges greater than 100 lb (45.4 kg) are put into place, then special mitigations to help reduce noise levels would be implemented, such as training during times with optimal weather conditions to attenuate noise, burying the explosive charge or bunkering the charge with sand bags. Ordnance used annually at the NWSTF Boardman DTR would consist of explosive charges with a NEW of 200 lb or less, and would include up to two 200 lb charges, five 100 lb charges, ten 50 lb charges, twenty 25 lb charges, and thirteen charges less than 25 lb. Demolition training would normally occur between the hours of 10:00 a.m. and 4:00 p.m. Training is not normally planned to occur in the June to September time frame to help mitigate wildland fire potential, though seasonal conditions and training times may vary.

### *1.3.5 Establishment and Use of a Drop Zone*

A drop zone would be established at the location shown in Figure 1 under the Proposed Action. The drop zone would be approximately 2,250 ft. (685.5 m) by 3,150 ft. (960.1 m), with an approximate footprint of 167.2 ac. (65.8 ha). No construction or ground disturbance would be required to establish the drop zone. The drop zone would be a designated area, certified to be clear of obstructions (such as fences or telephone poles) for the safety of personnel conducting parachute operations.

Insertion and extraction activities train military forces to deliver and extract equipment and personnel using a variety of techniques. These activities encompass parachute, fastrope, rappel, and troop extractions. The C-130 aircraft, HH-53, CH-46, CH-47 and UH-60 helicopters are typically used for equipment and personnel inserts. Insertion and extraction activities at NWSTF Boardman would be centered on paradropping of military equipment and supplies. This activity typically lasts anywhere from 30 minutes to 1 hour and would occur up to 12 days annually.

### *1.3.6 Establishment and Use of Three Mortar Firing Positions*

Three mortar firing positions would be established at the locations shown in Figure 1 under the Proposed Action. No construction or ground disturbance would be required to establish the mortar firing points. Weapons Danger Zones (WDZs) for the mortar firing positions would be concentrated on the main target bull and not extend off the NWSTF Boardman boundary. The M224 60 mm lightweight mortar (or a similar system) would be fired for qualification certification or during ground troop support exercises using practice rounds. The M766 60 mm short-range practice cartridge has a flash-bang/smoke fuse. The M224 system is made up of the cannon, bipod, baseplate, and sight unit. The system is very portable and is placed on the ground surface, sighted at a stationary target, and fired. Only non-explosive training rounds would be used and these rounds would be retrieved for reuse or recycling after they are fired. Additionally, 81 mm and 120 mm mortars using sub-caliber training rounds would be used and these spent rounds would be retrieved and scrapped after firing. The mortar firing points (3) would be used for 6 days annually (18 days total), with up to 1,440 rounds being fired annually.

*1.3.7 Construction, Operation, and Maintenance of an UAS Training and Maintenance Facility*

An ORNG platoon is assigned to operate and maintain the RQ-7B (Shadow 200) tactical UAS. The platoon is currently equipped with four Shadow 200 aircraft, ten trucks, and nine trailers. The Shadow 200 is a composite structure aircraft with a 14 ft. (4.3 m) wingspan, powered by a small, gasoline-fueled, rotary engine. The Shadow 200 can carry 15 gallons (56.8 liters) of fuel and 60 lb. (27.2 kg) of sensor and electronic warfare systems equipment and has a maximum flight endurance of 6 to 7 hours. The Shadow is designed for reconnaissance missions and does not currently have a strike capability.

**Construction**

The ORNG would construct a UAS training and maintenance facility that would consist of a single building (approximately 12,200 square feet [$ft.^2$] [1,133.4 square meters {$m^2$}]) for platoon operations, training, maintenance, and storage associated with the Shadow 200 aircraft. The building would be constructed of metal or masonry and would contain space for a UAS maintenance shop, equipment storage, flight simulator, and administrative offices. The facility also would include a building (approximately 4,800 $ft.^2$ [446.03 $m^2$]) for the storage of ground vehicles and a paved UAS runway and an unpaved operations area. The runway would be approximately 50 ft. (15.2 m) wide and 1,000 ft. (304.8 m) long. A gravel operating area used for a UAS launcher, UAS control equipment, and portable generators, would be 164 ft. (50.01 m) wide and 700 ft. (213.4 m) long. The runway would be oriented east to west, the direction of the prevailing winds. A vehicle parking area would be constructed adjacent to the operations and maintenance building. A 500 gallon (1,892.7 liter) aboveground fuel tank in a secondary containment would be located in the vicinity of the building. Additional gravel wildland fire buffers would surround the facility. A well would be drilled in the vicinity of the building to provide non-potable water and a septic system and leach field would be installed for wastewater disposal. In total, the facility is expected to occupy approximately 7 ac. (2.8 ha). The existing road between the northwest gate onto NWSTF Boardman and the UAS training and maintenance facility may be improved to support construction operations access by grading the road and adding rock and gravel.

The UAS facility would be built using typical construction equipment and techniques. Building materials, including concrete and gravel and soil for berms, would likely be imported from one or more off-site sources.

**Operations and Maintenance**

The UAS platoon would have a full-time staff of approximately seven Soldiers working at the facility. During drill weekends and annual training periods, the full platoon of 27 Soldiers would be present at the facility. Training on UAS simulators, maintenance and repair of the UAS aircraft, and UAS aircraft flights would occur at the facility. Maintenance of the truck and trailer rolling stock would likely occur at ORNG facilities located elsewhere in the state.

The Scan Eagle UAS is a relatively small aircraft that is currently operated at NWSTF Boardman. Typically these activities are conducted in NWSTF Boardman airspace, result in 800 to 1,000 sorties a year, and consist of testing and training. The UAS activity lasts approximately 6 hours. UAS activities can only be conducted in Restricted Area 5701 and Restricted Area 5706. Scan Eagle UAS Research, Development, Test, and Evaluation activities in Restricted Area 5701 and Restricted Area 5706 are anticipated to continue. The Broad Area Maritime Surveillance system is a future Navy system that may be used for training within Restricted Area 5701 and Restricted Area 5706. The specific UAS to be used for this system has yet to be determined, but it will likely be a large aircraft such as the Global Hawk, Predator B, or a similar UAS. These aircraft are roughly the size of common military tactical aircraft such as the EA-6B Prowler or FA-18 Hornet. If the Broad Area Maritime Surveillance system is likely to have a strike capability, that training would be covered in a separate NEPA analysis.

#### *1.3.8 Construction and Use of a Joint Use Range Operations Control Center*

The Proposed Action would include the construction of an additional building (approximately 10,000 $ft.^2$ [929 $m^2$]) to house Navy and ORNG range control personnel and equipment. The Range Operations Control Center building would be constructed in proximity to the UAS Training and Maintenance Facility to enable shared use of a water well, septic system, and electrical service.

### *1.4 Best Management Practices (Conservation Measures)*

The current management practices contained in the *NWSTF Boardman INRMP* and other applicable plans would continue to be implemented, and existing programs and plans would be updated to reflect new conditions. The following additional BMPs would be implemented to avoid and minimize potential impacts under the Proposed Action:

- Applicable erosion control measures would be implemented during construction to avoid and minimize the potential for wind and water erosion in accordance with the Oregon Department of Environmental Quality *Erosion and Sediment Control Manual* (ODEQ 2005).
- Drip pads would be placed under equipment when parked to avoid soil contamination from leaking fluids.
- Under the Navy's Range Sustainability Environmental Program Assessment (RSEPA), Range Condition Assessment 5-year Reviews would continue to be conducted and appropriate steps would be taken to analyze environmental conditions on the range and to prevent or respond to a release or substantial threat of a release of munitions constituents of potential concern to off-range areas that could pose risks to human health or the environment. RSEPA focus would be expanded to incorporate new range activities and new training areas under periodic assessments.
- Assessments would be conducted for the MPMGR and both CLFRs in accordance with the Army's Operational Range Assessment Program. These assessments would first determine qualitatively if munitions constituents were leaving the operational range footprint and whether pathways exist for human or ecological receptors. A quantitative assessment would be conducted if the qualitative assessment were inconclusive. The assessments would be conducted on a 5-year review cycle, even if the initial qualitative assessment identified no issues. In addition, ORNG would proactively manage the new

ranges using applicable strategies outlined in the *Army Small Arms Training Range Environmental Best Management Practices Manual.*

- Surveys would be conducted during the project design phase to identify existing habitat, evaluate habitat quality, and identify wildlife currently using these habitats. This information would be used during project design to support micrositing decisions. Areas of higher quality habitat (e.g., undisturbed areas with a relatively high percentage of native plant cover) or high wildlife use (e.g., existing Washington ground squirrel burrows) would be avoided in favor of areas of lower quality habitat (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable. Micrositing efforts would be limited to buildings and structures, as opposed to targetry or other range components, because even minor changes to the range design could affect the associated surface danger zone or impact range safety in other ways. The survey data would also be used to support post-construction restoration efforts.
- Habitat temporarily disturbed during construction would be restored in accordance with the proposed post-construction restoration plan (Appendix A). The restoration plan would be implemented by the ORNG in accordance with the Host-Tenant Agreement and Inter-Service Agreement that would be updated prior to implementing the proposed action.
- The management practices contained in the *NWSTF Boardman INRMP* and other applicable plans that are relevant to WGS conservation would continue to be implemented. Invasive plants would continue to be managed and controlled under the *NWSTF Boardman INRMP*, with an increase in control effort to reflect new threats introduced by the Proposed Action. The Plan would be updated in cooperation with ORNG, the Service, ODFW, and The Nature Conservancy during routine annual reviews to reflect the evolving invasive plant management situation associated with construction and operation of the new ranges. Updates to the Plan would include provisions for short- and long-term monitoring of invasive plants; responsibilities and procedures for integrating efforts of the Navy, ORNG, and The Nature Conservancy; criteria for prioritizing management actions and adaptive management strategies to control invasive plants; and annual work plans, including funding requirements and funding sources. After the range becomes operational, qualitative surveys would be conducted annually within the range footprint to detect noxious weeds (Morrow County list of noxious weeds) within the identified affected areas. The purpose of these surveys is to detect noxious weeds so that they can be controlled immediately, most likely through targeted application of a glyphosate herbicide. Surveys would continue indefinitely, and controls would be implemented as necessary.
- The NWSTF Boardman Draft Integrated Wildland Fire Management Plan (Appendix H of the DEIS) would be finalized and implemented. In addition to other fire protection measures, the Plan includes proposed modifications to the existing system of fire breaks. The width of some fire breaks would be reduced to the width of the adjacent road, some fire breaks that do not follow roads would be eliminated, and some new fire breaks would be created. The total area of fire breaks that would be maintained annually by mechanical disturbance (plowing or disking with a tractor) would decrease from 462 ac. (187 ha) to 243 ac. (98 ha). A long-term re-vegetation plan (Appendix A) would be implemented to restore the areas removed from mechanical maintenance. These areas would be re-vegetated with native bunchgrasses, primarily Sandberg's bluegrass with some needle and thread or bluebunch wheatgrass, to provide a low-structure and low-fuel load area next to the road/fire break, and also to provide wildlife habitat value. Grass revegetation would

be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80 percent density of a representative bunchgrass stand area within 2 to 3 years of seeding. Selective herbicide treatments or other appropriate management actions would be used to control invasive plants until these areas are completely restored.

- As part of the *NWSTF Boardman INRMP*, the Navy, in cooperation with The Nature Conservancy, is proposing to relocate RNA-A to a more suitable location. Three RNAs were established on NWSTF Boardman in 1978 and are co-managed by The Nature Conservancy under a Memorandum of Understanding with the Navy. The RNA program was created to (1) preserve examples of all significant natural ecosystems for comparison with those influenced by man, (2) provide educational and research areas for ecological and environmental studies, and (3) preserve gene pools of threatened and endangered plants and animals. RNA-A encompasses the Main Target Area at NWSTF Boardman, which must be used and maintained to meet mission requirements. Portions of the Main Target Area are highly disturbed by military use. While the rationale for originally establishing RNA-A within the Main Target Area appears to have been in part based on its isolation from cattle grazing, it has become clear that this area is not functioning as a RNA and is not providing the intended scientific and educational benefits of an RNA. Therefore, the Navy, in coordination with The Nature Conservancy, is proposing to relocate RNA-A to one or more suitable locations on NWSTF Boardman. The new RNA would be sited to avoid possible conflicts with military activities, and the new location would be more representative of the unique habitat types RNAs are designed to protect. Similar to existing RNA-B and RNA-C, access to the relocated RNA would normally be limited to research activities, invasive plant control, and emergency response. The Washington ground squirrel, as well as other wildlife species and wildlife habitat, would benefit from the increased protection and management provided by relocating RNA-A to a more suitable location.
- Explosive demolition training is not normally planned to occur in the June to September time frame to help mitigate wildland fire potential, though seasonal conditions and training times may vary.
- DTR training includes additional BMPs to help reduce noise levels for training with charges greater than 100 lbs (45.4 kg) NEW. These could include: training during times with optimal weather conditions to attenuate noise, burying the explosive charge, or bunkering the charge with sand bags.
- On NWSTF Boardman, to improve vehicle operation safety, be protective of wildlife, and reduce dust emissions, the vehicle speed limit for the range is 25 mph unless otherwise posted; however, emergency situations, operational necessities and certain training events may require vehicle speeds to exceed this standard speed limit. At all times on the range, vehicle operators shall use extreme caution and operate at a slow, safe speed consistent with the mission, safety, and current road and environmental conditions. Vehicle operators shall be cognizant and protective of pedestrians and wildlife while conducting all range activities.
    - The only road posted above 25 mph is the Admin Main road from the main gate access to the range from Bombing Range Road to the on-range road known as "The Interstate". Speed limit on the Admin Main Road is 30 mph.
    - It is not expected that training requirements will require speeds in excess of 25 mph on a routine basis; however, in some training events, vehicles need to be able to react to changing tactical situations in training as they would in actual combat.

Training differently than that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities. During these activities, the 25 mph speed limit may need to be exceeded for brief periods.

## *1.5 Proposed Mitigation Measures*

### *1.5.1 Introduction*

The proposed BMPs described above would be implemented to avoid, minimize, and rectify impacts on natural resources. Nonetheless, the analysis presented in Section 5, *Effects of the Proposed Action*, indicates that the Proposed Action would result in unavoidable impacts on historically occupied and suitable Washington ground squirrel habitat. This section provides the mitigation framework to compensate for these unavoidable impacts. The mitigation goal is no net loss of habitat quantity or quality, and to provide a net benefit of habitat quantity or quality, which would be achieved through in-kind and in-proximity habitat restoration and enhancement. A summary of commitments identified in the current INRMP and the new mitigation commitments (creating additional "uplift") are provided in Appendix B. As each individual proposed action is funded and constructed, mitigation measures and adaptive management of the area involved with the proposed action would be implemented.

Despite being one of the largest remaining blocks of predominantly native shrub-steppe and grassland habitats in Oregon's portion of the Columbia Plateau Ecoregion, non-native plant species invasions have degraded plant communities and wildlife habitat at NWSTF Boardman. Lightning-caused wildfire, historic livestock grazing, plowing, and other land uses have contributed to the spread of non-native plant species on NWSTF Boardman. Non-native plant species were identified as one of the greatest threats to the Boardman Grasslands (Kagan *et al.* 2000), because they replace native vegetation and degrade wildlife habitat.

In particular, cheatgrass (*Bromus tectorum*) is a serious threat because it alters natural fire regimes by creating more abundant and continuous fine fuels that can result in more intense, larger, and frequent fires. Intense fires that burn through high-quality native habitats can convert a diverse multi-story habitat of cryptogams, perennial grasses and forbs, and shrubs to a monoculture of cheatgrass and other invasive species that is difficult to reverse without active restoration (Elseroad 2007). Since 1998, more than 85 percent of NWSTF Boardman has been burned by wildfires, which have caused short- and long-term habitat alterations. Cheatgrass is a factor that has contributed to the intensity, size, and frequency of wildfire at NWSTF Boardman.

Restoring habitats on NWSTF Boardman that have been degraded by wildfire, non-native invasive plants, plowing, and other causes offers opportunities for in-kind and in-proximity habitat mitigation. Successful restoration or enhancement efforts on ample acreage at NWSTF Boardman could increase available native habitat for the Washington ground squirrel and other wildlife, decrease the frequency and intensity of wildfire, and improve long-term stability of the ecosystem, thus ensuring no net loss and a net benefit of habitat quantity and quality at NWSTF Boardman.

### *1.5.2 Location of Mitigation Sites*

Proposed habitat restoration activities would occur at selected locations on the southern portion of NWSTF Boardman. The NWSTF Boardman resource management area is identified in Figure 3. This area of the range consists of approximately 11,226 ac. (4,543 ha) and was selected for habitat restoration activities for the following reasons:

- This portion of NWSTF Boardman has not been used for ground-based military training activities since Navy ownership of the property in about 1960.
- None of the proposed range enhancements are sited in this area.
- Current and proposed military readiness activities are not expected to have significant impacts on natural resources in the area.
- Proposed habitat restoration activities in this area would be compatible with current and proposed military readiness activities. Long-term habitat mitigation goals could be pursued with no loss to military training or testing capabilities and capacity.
- Proposed habitat restoration areas would not preclude future military training activities in this area.
- The area offers opportunities for in-proximity mitigation because it is within the boundaries of NWSTF Boardman and has connectivity to habitats that would be affected by the Proposed Action.
- This southern portion of the range includes a mosaic of shrub-steppe and grassland habitats representing a range of ecological condition classes (e.g., low to high), offering opportunities to achieve ecological uplift through habitat restoration.
- Washington ground squirrels occur in the area and the Warden and Sagehill soils found in this area are thought to provide the most suitable burrowing habitat located on the range property. Therefore, ecological uplift achieved through native plant community restoration would benefit this species by improving forage quality, cover, and ecological stability (e.g., decrease in wildfire frequency and intensity).
- This portion of NWSTF Boardman receives higher annual precipitation than the northern portions of NWSTF Boardman, which would facilitate native vegetation restoration activities.
- This area of the range is directly adjacent to the Boardman Conservation Area (BCA) and to Research Natural Area (RNA)-C (Figure 4). Proposed management activities would complement similar ongoing efforts on the BCA and in RNA-C. The fact that these habitats are connected maximizes the cumulative benefits of management activities in these different areas.
- Habitat restoration activities in the resources management area would be consistent and compatible with the protection of historic sites and cultural resources in this part of the property.

### *1.5.3 Mitigation Site Types*

Mitigation sites within the NWSTF Boardman resource management area would be classified into the five categories listed in Table 6. These site categories have been adapted from those used at the Boardman Conservation Area (Elseroad 2007).

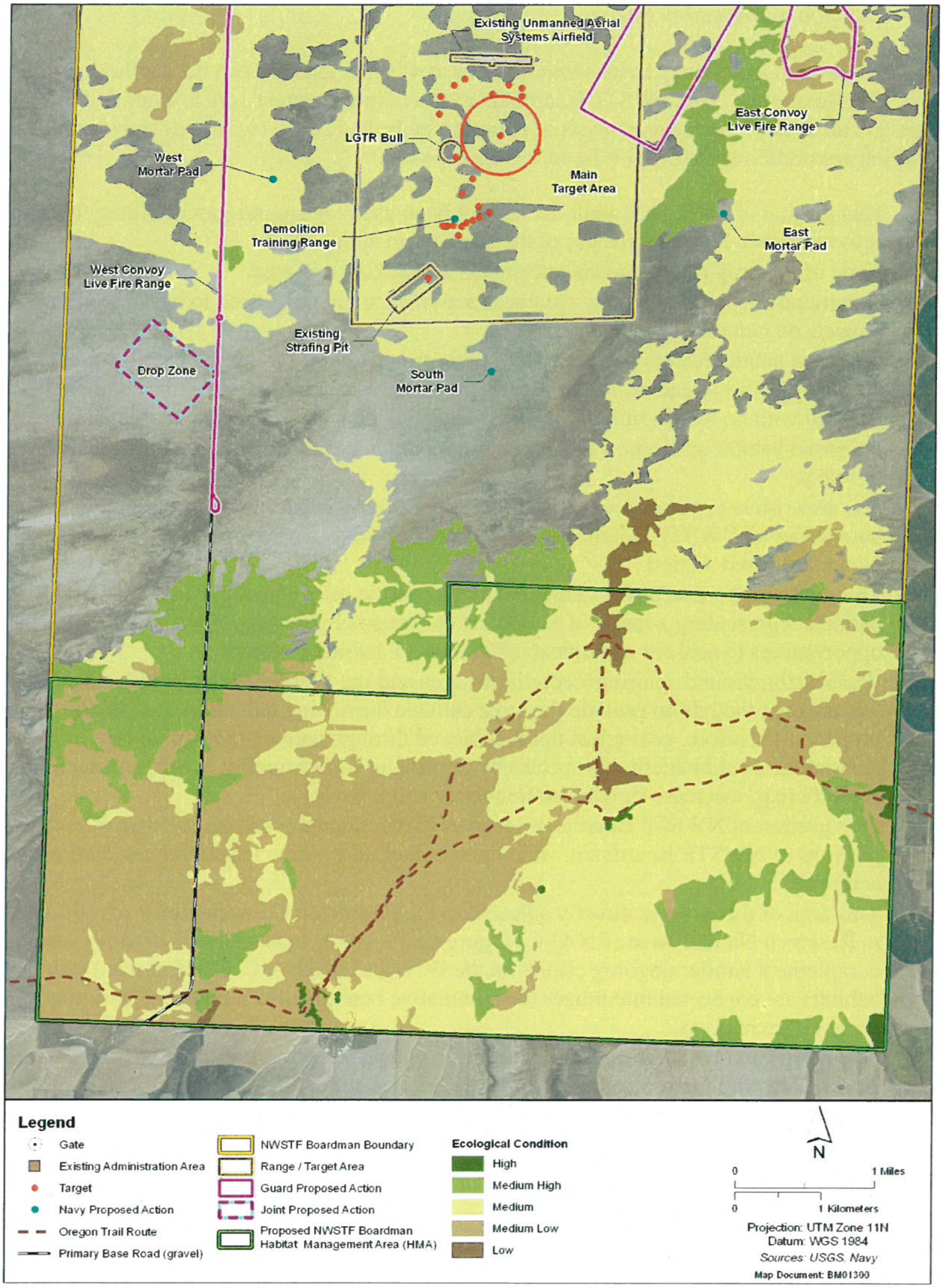


**Figure 3. Ecological Conditions in NWSTF Boardman Resource Management Area**

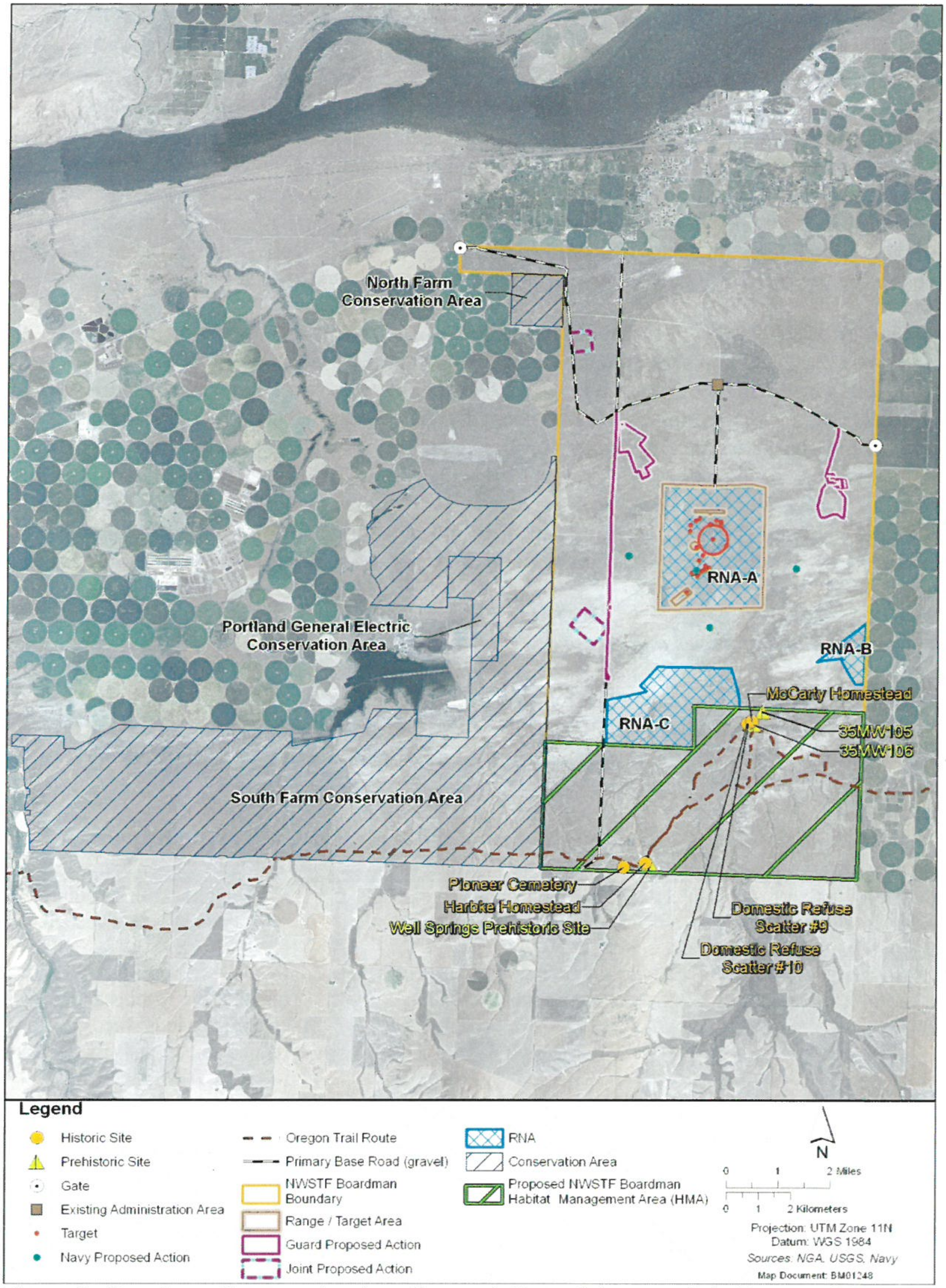


**Figure 4. Boardman Conservation Area, Research Natural Areas, and the Resource Management Area**

### *1.5.4 Desired Future Conditions*

As discussed above, the mitigation goal is no net loss of habitat quantity or quality, and to provide a net benefit of habitat quantity or quality. Defining specific objectives for desired future habitat conditions provides a means for measuring success in achieving these goals. The resource management area includes a mosaic of shrub-steppe and grassland habitats representing a range of ecological condition classes (e.g., low to high) based on past disturbance. As noted by Elseroad (2007) for the Boardman Conservation Area, re-creating pre-disturbance conditions is unlikely given that large areas are degraded to some degree and because restoring these semi-arid systems in the presence of highly competitive non-native species will be difficult.

Restoration efforts at NWSTF Boardman would focus on: 1) reducing threats to existing high-quality native grassland and shrub-steppe and 2) increasing the proportion of native-dominated grassland and shrub-steppe by restoring degraded sites to the greatest extent possible (Elseroad 2007). Restoring the dominant grasses, forbs, and shrubs at degraded sites will provide the structure of the pre-disturbance plant communities, increase resistance to further weed invasion, and reduce the risk of high-intensity, frequent fires. Over time, if soil disturbance is minimized, cryptogamic soil crusts may slowly recover. Ideally, existing conditions can be improved such that the grassland and shrub-steppe systems can be self-sustaining with minimal management inputs and their ecosystem functions can be maintained within their historic range of variability (Elseroad 2007).

### *1.5.5 Restoration Objectives and Strategies by Site Type*

As summarized in Table 6, proposed restoration objectives and strategies would vary based on the current conditions and likelihood of improving current conditions at a given site. Objectives for high-quality habitats will focus on maintaining current conditions by reducing threats from degraded areas on NWSTF Boardman

**Table 6. Restoration Site Types, Objectives, and Strategies for NWSTF Boardman**

| Site Type | Restoration Objectives | Restoration Strategy |
|---|---|---|
| High quality native grassland and shrub-steppe with low non-native species cover (high and medium-high ecological condition) | 1. Maintain current native plant and soil crust conditions<br>2. Maintain non-native species cover at or below baseline levels | 1. Within sites, control outbreaks of noxious weed as needed<br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire<br>3. Plant sage in burned areas previously dominated by sage. |

| | | |
|---|---|---|
| Type 5 – Dominated by a diverse array of native plant species with high cheatgrass densities (medium ecological condition) | 1. Maintain or increase current native plant and soil crust conditions<br><br>2. Detect and control noxious weeds as necessary to maintain conditions | 1. Within sites, control noxious weeds by using herbicides<br><br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire |
| Type 4 – Dominated by native shrubs with a low diversity of native herbaceous species (medium ecological condition) | 1. Maintain current native shrub conditions<br><br>2. Increase native perennial herbaceous plant density to provide uniform coverage of at least 80% of a representative bunchgrass stand within 3 years of initial restoration effort<br><br>3. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds<br><br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire |
| Type 3 – Burned area previously dominated by native shrubs and currently dominated by non-native annual plant species (medium-low ecological condition) | 1. Increase native shrub density to one seedling per square meter over a 10 square meter area in each seedling focus area with five focus areas per acre<br><br>2. Increase native perennial herbaceous plant density to provide uniform coverage of at least 80% of a representative bunchgrass stand within 3 years of initial restoration effort<br><br>3. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds |

| | | |
|---|---|---|
| Type 2 – Dominated by non-native annual plant species with a low diversity of native perennial species (medium-low ecological condition) | 1. Increase native perennial herbaceous plant density to provide uniform coverage of at least 60% of a representative bunchgrass stand within 3 years of initial restoration effort<br><br>2. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds |
| Type 1 – Dominated by non-native annual plant species (low ecological condition) | 1. Increase native perennial herbaceous plant density to provide uniform coverage of at least 50% of a representative bunchgrass stand within 3 years of initial restoration effort<br><br>2. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control weeds |

Source: Adapted from Elseroad (2007)

### *1.5.6 Prioritization of Restoration Sites*

Restoration efforts would first be allocated to priority 1 restoration sites, followed by priorities 2 through 8, as necessary, until the agreed-upon mitigation acreage requirements have been met. Priorities would be based on the plant species composition of the restoration site, its proximity to high or medium-high quality native plant communities, and Washington ground squirrel occupancy. Reducing threats to high-quality native habitats by restoring degraded adjacent sites would be a top priority. Moody and Mack (1988) modeled the non-native species invasion process and clearly showed the importance of eradicating non-native species in founding populations ("nascent foci").

Site constraints, technical feasibility, and the likelihood of achieving the restoration objectives would also be considered when prioritizing sites for restoration. Factors considered include the following:

- The terrain in some areas of the resource management area would preclude the safe and efficient use of restoration equipment such as a tractor and seed drill. These areas would be considered a lower priority.

- Cultural resources sites, unexploded ordnance areas, and appropriate buffers would be off limits to any ground-disturbing activity.
- Restoration feasibility and the likelihood of success would be carefully considered for sites in low ecological condition. For example, it might be futile to attempt to increase native bunchgrass densities in valley bottoms that currently support a monoculture of cheatgrass because the additional moisture in these areas provides cheatgrass a competitive advantage.
- Availability of desired plant materials.

The following priorities would be used to guide the habitat mitigation efforts at NWSTF Boardman:

- Priority 1 – Type 2 and 3 restoration sites adjacent to existing native grassland and shrub-steppe habitats rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 2 – Type 4 and 5 restoration sites adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 3 – Burned sites in medium-high ecological condition previously dominated by sagebrush.
- Priority 4 – Remaining Type 2, 3, 4, and 5 restoration sites that include historically occupied Washington ground squirrel habitat, but are not adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition.
- Priority 5 – Remaining Type 2, 3, 4, and 5 restoration sites.
- Priority 6 – Type 1 restoration sites adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 7 – Remaining Type 1 restoration sites that include historically occupied Washington ground squirrel habitat, but are not adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition.
- Priority 8 – Remaining Type 1 restoration sites.

### *1.5.7 Mitigation Ratios*

Mitigation ratios often vary depending on the acreage, functions, and values of the habitat lost, the type of mitigation proposed, and other factors. Additional acreage beyond that lost through development is usually required, because of interim losses in habitat acreage and functional capacity, and because the success and resulting value of compensatory mitigation projects are uncertain.

The proposed mitigation ratios for NWSTF Boardman were developed to help ensure that there is no net loss of habitat quality and a net benefit of habitat quantity or quality. Factors considered in development of the mitigation ratios include the following:

- **Location of the mitigation sites –** The resource management area offers opportunities for in-proximity mitigation because it is within the boundaries of NWSTF Boardman and has connectivity to habitats that would be affected by the Proposed Action. In addition, the resource management area is adjacent to the BCA and RNA-C, which maximizes the cumulative benefits of management activities in these different areas. Based on these factors, the proposed location of the mitigation sites offers benefits that could not be achieved if mitigation were accomplished in off-site locations. As such, mitigation ratios can be lower than those typically used for off-site mitigation.

- **Quality of the habitat affected by the Proposed Action –** High-value habitat would be affected by the Proposed Action because much of the affected habitat is considered occupied or historically occupied by Washington ground squirrels. Nonetheless, the affected area includes a mosaic of habitats representing a range of ecological condition classes (e.g., low to high). Higher mitigation ratios are proposed for areas assigned higher ecological condition classes.

- **Nature of the habitat impacts –** Habitat impacts have been grouped into two categories for mitigation planning purposes:

    - **Permanent habitat loss –** Includes areas that would be converted to structures or facilities such as gravel roads and targets. Complete loss of habitat functions and values are expected in these areas. Higher mitigation ratios are proposed for these areas.
    - **Long-term habitat degradation –** Includes areas temporarily disturbed by construction and areas that would likely be affected by projectiles striking the ground, training-caused wildfires, invasive plants, training-related noise, and disturbance caused by increased human activity. Long-term habitat degradation is expected in these areas, but complete loss of habitat functions and values are not expected. The mitigation ratios proposed for these areas are lower than those proposed for permanent habitat loss.

- **Condition of the habitat on the proposed mitigation sites –** Similar to the affected area, the resource management area includes a mosaic of habitats representing a range of ecological condition classes (e.g., low to high). The potential to achieve ecological uplift through restoration or enhancement depends, in part, on the existing conditions within the resource management area. In general, restoration or enhancement of sites in low ecological condition would seem to provide the greatest potential to achieve ecological uplift. To be successful, however, the overall mitigation strategy must focus on ecological uplift at a landscape-scale, rather than simply focusing on restoring or enhancing the sites in the lowest ecological condition. This is especially true given the landscape-scale of the historic impacts and future threats to the resource management area (e.g., invasive plants and lightning-caused wildfire). The overall mitigation strategy must also consider the technical feasibility and likelihood of successfully restoring specific mitigation sites. Accordingly, the restoration strategies, objectives, and priorities outlined above reflect the importance of protecting and managing habitats in relatively high ecological condition, as well as restoring or enhancing habitats in lower ecological condition. Implementing mitigation activities in accordance with the established priorities is expected to maximize ecological uplift at the landscape-scale; therefore, the Navy is not proposing a system of variable mitigation credits based on the ecological condition class of specific mitigation sites.

Proposed habitat mitigation ratios for NWSTF Boardman are provided in Table 7. Mitigation ratios assume that all affected habitat is occupied by Washington ground squirrels. The ratios increase with increasing ecological condition of the affected habitat to ensure no net loss of habitat quality and a benefit of habitat quantity. In addition, higher mitigation ratios are proposed for permanent habitat loss, compared to long-term habitat degradation. A minimum ratio of 2:1 is proposed for permanently lost habitat to ensure no net loss of habitat quantity. A minimum ratio of 1.25:1 is proposed for long-term habitat degradation. Setting this ratio above 1:1 acknowledges and compensates for the possibility that even habitats with a low ecological condition class could be occupied by Washington ground squirrels. Proposed habitat mitigation acreage for each range enhancement is provided in Table 8, based on the ratios presented in Table 7 and the habitat impacts summarized in Table 17.

**Table 7. Proposed Wildlife Habitat Mitigation Ratios for NWSTF Boardman**

| Ecological Condition Classification of Affected Habitat | Mitigation Ratio for Type of Impact | |
|---|---|---|
| | Permanent Habitat Loss | Long-term Habitat Degradation |
| High | 3:1 | 2.25:1 |
| Medium-high | 2.75:1 | 2:1 |
| Medium | 2.5:1 | 1.75:1 |
| Medium-low | 2.25:1 | 1.5:1 |
| Low | 2:1 | 1.25:1 |
| Unclassified | 2.5:1 | 1.75:1 |

**Table 8. Proposed Wildlife Habitat Mitigation Acreage for NWSTF Boardman**

| Range Enhancement | Permanent Habitat Loss | | Long-term Habitat Degradation | | Total Mitigation (acres) |
|---|---|---|---|---|---|
| | Affected (Acres) | Mitigation (acres) | Affected (Acres) | Mitigation (acres) | |
| Multi-Purpose Machine Gun Range | 16 | 38 | 218 | 380 | 418 |
| Eastern Convoy Live Fire Range | 0 | 0 | 113 | 198 | 198 |
| Western Convoy Live Fire Range | 0 | 0 | 229 | 398 | 398 |
| Demolition Training Range | 1 | 2.5 | 0 | 0 | 2.5 |
| Unmanned Aerial Systems Airfield and Maintenance Facility and Range Operations and Control Center | 8 | 16 | 1 | 1.25 | 17.25 |
| **Total =** | **25** | **56.5** | **561** | **977** | **1,034** |

### *1.5.8 Restoration Methods*

The Nature Conservancy initiated a shrub-steppe and grassland habitat restoration program at the Boardman Conservation Area in 2006 and has implemented restoration efforts on approximately 500 ac. as of 2012. These efforts achieved varying degrees of success and provide valuable information and lessons learned for future restoration efforts in the area. The Navy and ORNG propose to accomplish habitat restoration at NWSTF Boardman, using methods or refinement of methods that The Nature Conservancy successfully used at the Boardman Conservation Area, if the decision is made to implement the Proposed Action. In general, the proposed restoration methods for NWSTF Boardman would follow those outlined in the *Boardman Conservation Area Restoration Plan* (Elseroad 2007) and the *Boardman Conservation Area Five-Year Restoration Implementation Plan* (Elseroad 2008). Specific restoration methods would be finalized as part of the ongoing conferencing process with the Service. Methods would continue to be refined throughout the restoration process and documented in annual restoration work plan updates (see Section 1.6, *Adaptive Management and Monitoring*).

Most restoration efforts at NWSTF Boardman would include the following components: obtaining plant materials, site preparation, planting, and post-planting weed control. Options and guidelines for each of these components are described by Elseroad (2007).

## *1.6 Adaptive Management and Monitoring*

### *1.6.1 Introduction*

Adaptive management is a decision process (Figure 5) that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. Adaptive management requires stated management objectives to guide decisions about what to try, and explicit assumptions about expected outcomes to compare against actual outcomes. It is important to know what the available management options and alternative assumptions are, in case the action that is tried does not work as expected (Williams *et al.* 2009).

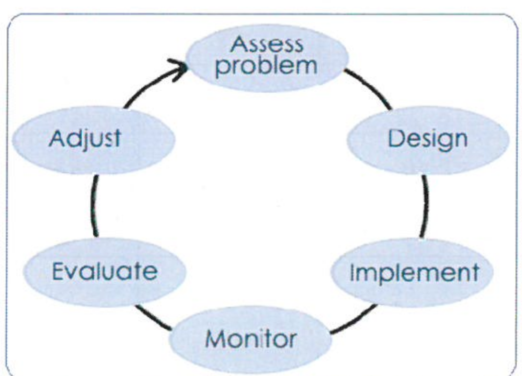


**Figure 5. Adaptive Management Process**

This section outlines the Navy and ORNG's proposed adaptive management process that would be used to help reduce uncertainty associated with the anticipated effects of the action and the anticipated effectiveness of the proposed BMPs and mitigation measures. As discussed above, the *NWSTF Boardman INRMP* currently provides a mechanism to adaptively manage natural resources cooperatively with the Service and ODFW. If a decision is made to implement the Proposed Action, specific commitments to an adaptive management process would be made in the Record of Decision. These commitments would be incorporated into the INRMP, and the INRMP would continue to provide the overall management structure for implementing adaptive management. This management structure includes a requirement to review and update the INRMP annually through natural resources metrics meetings that include the Service and ODFW. The remainder of this section outlines the proposed adaptive management process, including expected outcomes and uncertainties, management objectives and decision points, monitoring, and alternative management actions.

### *1.6.2 Expected Outcomes and Uncertainties*

Adaptive management requires explicit assumptions about expected outcomes to compare against actual outcomes (Williams *et al.* 2009). The anticipated effects of the action and associated uncertainties are analyzed in detail in Section 5, *Effects of the Proposed Action*. Following is a very brief summary of the expected outcomes of implementing the Proposed Action, including the proposed BMPs and mitigation measures:

- Proposed range construction and military readiness activities would result in permanent habitat loss (25 ac. [10 ha]) and long-term habitat degradation (561 ac. [227 ha]). Washington ground squirrel use of the affected area would decline, foraging and breeding would be adversely affected, and the Washington ground squirrel population on NWSTF Boardman could decline. Uncertainties that can be addressed through adaptive management include the possibility that impacts could be overestimated or underestimated.
- BMPs would avoid and minimize impacts. Mitigation measures (habitat restoration and enhancement) would compensate for lost habitat functions and values and provide a net benefit. Ecosystem stability would improve in restored/enhanced areas, and Washington ground squirrels would persist and possibly increase in numbers in these areas. Uncertainties that can be addressed through adaptive management include the effectiveness and benefits gained from the proposed restoration.

### *1.6.3 Management Objectives and Decision Points*

An adaptive approach requires explicit and measurable objectives. Uncertainty about how to achieve objectives is what motivates adaptive management and drives the design of the monitoring system. To address this uncertainty, stakeholders must agree on the objectives (Williams *et al.* 2009). The management objectives for the Proposed Action are grouped under two broad management goals that are focused on: 1) reducing uncertainties associated potential impacts of the Proposed Action, and 2) reducing uncertainties associated with the effectiveness and benefits gained by the proposed restoration. Specific management objectives under these broad goals would serve as decision points that could trigger evaluation and adjustment phases of the adaptive management process, based on monitoring. Management objectives should be specific, measurable, achievable, results-oriented, and appropriately scheduled. Therefore, an important consideration in establishing management objectives is the availability of reliable and practical monitoring methods that can be used to accurately measure achievement.

The Navy and the ORNG would develop appropriate metrics and use these metrics to design the study. Ideally, management objectives for the Washington ground squirrel at NWSTF Boardman would be defined in terms of populations (i.e., groups of animals in specified areas at specified times) and quantitative monitoring would be conducted to determine if and how the Proposed Action affects population trends. However, several factors currently preclude definition of squirrel management objectives at NWSTF Boardman in terms of populations. These factors include limited knowledge of Washington ground squirrel population dynamics, lack of long-term baseline population data, and limitations of standard survey protocols. Standard Washington ground squirrel protocols (Morgan and Nugent 1999) historically used at NWSTF Boardman and elsewhere focus on documenting Washington ground squirrel "active detections," and are not designed to estimate population size or density (i.e., number of animals per ac. or ha).

Based on the limitations discussed above, the proposed adaptive management process includes a phased approach to defining measurable Washington ground squirrel management objectives and developing or refining survey protocols to measure achievement of the objectives. Management objectives, survey protocols and sampling design would be established through ongoing coordination with the Service. Specific objectives under the two broad management goals are defined below and associated monitoring is described in Section 1.6.4, *Monitoring*.

**Management Goal 1 –** Limit impacts on the Washington ground squirrel to the affected areas identified in the impact analysis. This broad goal addresses the need to reduce uncertainty and validate findings of the impact analysis through monitoring and includes the following specific management objectives:

- Management Objective 1a – Develop site-specific Washington ground squirrel monitoring protocols, in consultation with the Service by July 1, 2014, that provide an index of population trends.
- Management Objective 1b – Develop long-term, site-specific Washington ground squirrel management objectives based on data obtained by implementing monitoring protocols developed under management objective 1a.
- Management Objective 1c (interim) –Monitor Washington ground squirrel habitat in areas immediately adjacent to proposed range areas for continued Washington ground squirrel occupancy.
- Management Objective 1d – Minimize Washington ground squirrel mortality during construction and military readiness activities.
- Management Objective 1e – Detect and control noxious weeds annually within the identified affected areas.
- Management Objective 1f – Limit training-caused wildfires to the range footprint.

**Management Goal 2 –** Achieve no net loss of habitat quantity or quality and a net benefit of habitat quantity and quality through habitat restoration and enhancement. This broad goal addresses the need to confirm the effectiveness and benefits of compensatory mitigation and includes the following specific management objectives:

- Management Objective 2a – Begin implementing habitat restoration/enhancement for permanently lost habitat at 2:1+ ratio (ratio between 2:1 and 3:1 depending on existing ecological condition) within 2 years following construction. Achieve site-specific restoration objectives (see Table 6) within 3 years of beginning restoration effort.

- Management Objective 2b – Implement habitat restoration/enhancement for degraded habitat at 1.25:1+ (ratio between 1:25 and 2:25 depending on existing ecological condition) starting 3 years following construction at a rate of at least 50 ac. (20 ha) per year until requirements are met. Achieve specific restoration objectives (see Table 6) for individual restoration sites within 3 years of initial restoration effort.

### *1.6.4 Monitoring*

**<u>Washington Ground Squirrel Monitoring</u>**

***Overview***

Monitoring efforts would be implemented to determine if and how the Proposed Action affects Washington ground squirrels at NWSTF Boardman and to determine if management objectives are achieved. In addition, long-term monitoring would be conducted to obtain data on Washington ground squirrel distribution, status, and trends throughout NWSTF Boardman. The monitoring program would consist of the following components, which are described in more detail below:

- Long-term facility-wide monitoring
- Pre-construction surveys
- Construction monitoring and after-action inspections
- Project-specific Washington ground squirrel surveys

Construction activities for the range enhancements would be spaced over a period of several years as funding becomes available. Therefore, components of the monitoring program would be implemented on an as-needed basis, starting prior to construction of the first range enhancements.

***Long-term Facility-wide Monitoring***

Washington ground squirrel surveys have been conducted on large portions of NWSTF Boardman since 1979, but a systematic survey of the entire property has not been conducted. A long-term, facility-wide monitoring program would be initiated to inform the adaptive management process and assess the effects of the increased training on the Washington ground squirrel. As discussed above in Section 1.6.3, *Management Objectives and Decision Points*, survey design, and site-specific protocols for these surveys would be developed in consultation with the Service. The Navy will develop a sampling design that will incorporate a random stratified sampling strategy which would be designed to provide an index of population trends over the entire property and support the evaluation of effects of training activities. Given the large size of NWSTF Boardman and the fact that most or all of the property is potentially suitable Washington ground squirrel habitat, methods would be evaluated to identify the most effective and efficient approach to collecting facility-wide squirrel data. Additionally, the sampling design would also consider how to incorporate existing long-term term monitoring plots. Secondary goals include estimating habitat relationships and identifying home range metrics. Since training is not scheduled to begin immediately, the timeline would allow the

Navy to implement a before and after control impacts design to collect baseline data to also support the assessment of impacts due to facilities construction. Information collected would be used to continuously inform the adaptive management process, with appropriate modifications based on findings.

***Pre-Construction Surveys***

Site-specific survey protocols per *Long-term Facility-wide Monitoring* (above), would be used to survey individual construction sites prior to construction. Data from the long-term facility-wide monitoring would be used to meet these data needs to the extent possible. These surveys would cover the "affected area" of a given range enhancement where permanent habitat loss or long-term degradation of habitat is expected to occur. These affected areas include the range enhancement footprints for all projects and areas within the single-event 140 dBP contours associated with the MPMGR and CLFRs. Data from these surveys would provide baseline information and would be used to avoid impacts on Washington ground squirrels during construction, to the extent possible.

***Construction Monitoring and After-Action Inspections***

Construction monitoring and after-action inspections would be conducted to determine if objective 1d is achieved and report any Washington ground squirrel mortality to the Service. Monitoring would be conducted during construction to avoid strikes by construction equipment. Any incidental mortality during construction would be documented and reported to the NWSTF Boardman Natural Resources Manager and the Service.

Standard operating procedures for after-action range inspections would be updated to include identification and reporting of any wildlife mortality that might be associated with training activities. Range control personnel would inspect the training area, including target areas and heavily travelled roads, at the conclusion of a ground-based training exercise. Location and description of any observed wildlife carcasses would be recorded. Washington ground squirrels would be recovered, tagged, bagged, and delivered to the range administration building for storage (freezing). Any Washington ground squirrel mortality would be reported to the NWSTF Boardman Natural Resources Manager and the Service.

***Project-specific Washington Ground Squirrel Surveys***

Site-specific survey protocols per *Long-term Facility-wide Monitoring* (described previously), would be used to measure achievement of management objective 1c (interim) (ensure that Washington ground squirrel continue to occupy habitat in areas adjacent to the proposed ranges), as well as other management objectives developed in consultation with the Service during the adaptive management process. These surveys would be conducted in areas adjacent to the identified affected areas for the MPMGR, eastern CLFR, western CLFR, and DTR and in control areas. "Adjacent areas" are defined as a 1,312 ft. (400 m) buffer around the affected areas. These areas are outside the range enhancement footprints, but could be exposed to single-event noise levels less than 140 dBP. Based on the analysis presented in Section 5, *Effects of the Proposed Action*, no habitat loss, long-term habitat degradation, or decline in Washington ground squirrel numbers is expected in these adjacent areas. The proposed surveys are intended to help validate conclusions of the analysis and reduce uncertainty. When possible, data from the long-term facility-wide monitoring surveys would be used to meet these data needs.

The project-specific Washington ground squirrel survey areas would encompass the following approximate acreages:

- MPMGR: 1,120 acres
- Western CLFR: 1,375 acres (exclusive of the area overlapped by MPMGR monitoring)
- Eastern CLFR: 1,020 acres
- DTR: 300 acres
- Control areas: 300 acres each.

One or more paired controls would be established for each sampling location. The controls would be located on NWSTF Boardman (well outside areas affected by the action or subject to restoration) or on the Boardman Conservation Area in areas with similar squirrel occupancy, soils, and vegetation. Baseline surveys would be conducted prior to the start of construction for the CLFRs and the DTR, and for two years prior to the MPMGR. After a range is operational, surveys would be conducted once every 2 years for a period of 10 years to evaluate long-term trends. Vegetation surveys would also be conducted within the survey areas to help determine if any observed differences in squirrel abundance or distribution might be attributable to vegetation conditions.

***Noxious Weed Surveys and Control***

After a given range is operational, qualitative surveys would be conducted annually within the range footprint to identify noxious weeds (Morrow County list of noxious weeds) and address management objective 1c (detect and control noxious weeds annually within the identified affected areas). The purpose of these surveys is to detect noxious weeds so that they can be controlled immediately, most likely through targeted application of a glyphosate herbicide. These surveys would continue indefinitely and controls would be implemented as necessary. Objective 1c is effort-based; therefore, quantitative monitoring of noxious weeds is not proposed.

***Wildfire Monitoring***

The causes, size, and location of all wildfires at NWSTF Boardman and associated suppression efforts would continue to be documented. This information would be reviewed after each wildfire to identify lessons learned and opportunities to improve fire prevention and suppression efforts.

*1.6.5 Alternative Management Actions*

Like any iterative decision process, decision making in adaptive management involves the selection of an appropriate management action at each point in time, given the status of the resources being managed at that time (Williams *et al.* 2009). If any of the alternative actions are determined to be required, then further consultation with the Service would be required. Potential alternative management actions for NWSTF Boardman include:

- Review of ongoing training activities to determine if BMPs need to be revised or additional measures or BMPs, such as seasonal adjustments to training schedules could be implemented to avoid or minimize impacts on the resources of concern while still meeting training and readiness requirements.
- Modify or refine restoration methods. For example, use more aggressive invasive plant controls on restoration sites such as pre-emergent herbicides, alter planting strategies, or restore additional acreage.
- Refine fire prevention and suppression methods.
- Evaluate the feasibility of offsite mitigation by initiating a search for suitable properties to serve as a compensatory mitigation site that could be acquired under the Navy's Readiness and Environmental Protection Initiative or the Army's Compatible Land Use Buffer Program.

## *1.7 Term of the Proposed Action*

The term of the Proposed Action is indefinite. There are currently no set time frames for implementation of each proposed activity; timing is dependent on agency needs and approved funding.

## *1.8 Action Area*

The area likely to be affected, directly or indirectly, by the proposed Project is the NWSTF Boardman located in north-central Oregon in Morrow County, approximately 2 miles (mi.) (3.2 kilometers [km]) south of Boardman, Oregon and the Columbia River and 16 mi. (25.7 km) southwest of Hermiston, Oregon. NWSTF Boardman consists of 47,432 acres (ac.) (19,195 hectare [ha]) of land and 358 square nautical miles ($nm^2$) of associated Special Use Airspace (SUA). The SUA includes several different airspace designations that are depicted in Figure 1 in the Assessment, and are explained in greater detail in Section 1.2.2.

### *1.8.1 Training Land*

NWSTF Boardman consists of 47,432 ac. (19,195.1 ha) of relatively flat, vegetated landscape. The land area is predominantly rectangular in shape and is approximately 12 mi. by 6 mi. (19.3 km by 9.6 km). Several air-to-ground targets currently exist within the boundaries of NWSTF Boardman and have been in place for many years, although their scoring systems have been removed. There are several structures (administrative building, etc.) that currently exist to support training activities as well as an unimproved Unmanned Aerial System (UAS) airstrip used by the ORNG. The land component of NWSTF Boardman is federally withdrawn land with title held by the United States but with management functions held by U.S. Navy, Commander, Navy Region Northwest. The Commander, Navy Region Northwest has delegated the management functions to Naval Air Station (NAS) Whidbey Island. As such, NAS Whidbey Island is responsible for environmental resource management in those areas (i.e., natural and cultural resources, hazardous waste, air monitoring, etc.).

As part of the natural resource management at NWSTF Boardman and before the designation of the Boardman Conservation Area, three Research Natural Areas (RNAs) were established on NWSTF Boardman in 1978 and are co-managed by The Nature Conservancy under a long-standing Memorandum of Understanding with the Navy. The RNAs are part of a federal government system established for research and educational purposes. Natural features are preserved for scientific purposes and natural processes are allowed to dominate. The RNA program was created to (1) preserve examples of all significant natural ecosystems for comparison with those influenced by man, (2) provide educational and research areas for ecological and environmental studies, and (3) preserve gene pools of threatened and endangered plants and animals. The RNAs on NWSTF Boardman were the first established on Department of Defense (DoD) lands. The Nature Conservancy activities in the RNAs include research and monitoring of the native habitat types and wildlife species, as well as control of noxious weeds.

### *1.8.2 Special Use Airspace Training Areas*

The airspace over NWSTF Boardman is comprised of two different types of SUA: Restricted Areas (R-5701 [A-E] and R-5706) that overlay portions of the NWSTF Boardman land areas and a Military Operating Area (MOA) (Boardman MOA, OR) that overlies most of the Restricted Areas (Figure 1 in the Assessment). Designated by the Federal Aviation Administration (FAA), Restricted Areas are SUA within which the flight of non-participating aircraft, while not wholly prohibited, is subject to restrictions. Activities taking place in the airspace must be confined due to their nature and the need to adhere to limitations imposed on aircraft activities for which the SUA is designated (FAA JO 7400.8U). Non-participating military and civilian aircraft are not allowed into the Restricted Areas without the controlling authority's approval.

A MOA is airspace established outside Class A airspace (18,000 to 60,000 feet [ft.] [5,486.4 to 18,288 meters {m}] Mean Sea Level [MSL]) to separate or segregate nonhazardous military activities from Instrument Flight Rules traffic and to identify for Visual Flight Rule (VFR) traffic where these activities are conducted. The designation of a MOA identifies for other users the areas where military activity occurs, provides for segregation of that activity from other fliers, and allows charting to keep airspace users informed. MOAs do not restrict VFR operations; however, pilots operating under VFR should exercise extreme caution while flying within, near, or below an active MOA. The Boardman SUA currently has only one MOA and it provides military aircraft maneuver space for training. Table 9 provides additional information on NWSTF Boardman's Restricted Areas, which make up the only Restricted Areas in Oregon.

### *1.8.3 Surrounding Land Use*

NWSTF Boardman is located approximately 0.5 mi. (0.8 km) south of the Boardman city limits. Interstate 84 runs east-west through the city of Boardman, dividing it roughly one-third to the north and two-thirds to the south of the highway. Within the city limits, land use zoning is a combination of residential, industrial, commercial, open space, and easements, as designated by the City of Boardman. NWSTF Boardman property is located wholly within Morrow County. The land use zoning established by Morrow County immediately surrounding NWSTF Boardman on all sides is Exclusive Farm Use. Land uses to the east, south, and west of NWSTF Boardman are predominantly agricultural production, but also include a Boeing Company test facility, a commercial solid waste landfill, and a Portland General Electric (PGE) electrical generation plant.

**Table 9. Existing NWSTF Boardman Airspace**

| Area Designation | Description |
|---|---|
| Boardman Military Operations Area | Located above north-central Oregon and covers 358 $nm^2$ in area. This Military Operations Area is available from 4,000 ft. (1,292 m) to but not including 18,000 ft. (5,486 m) MSL. The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| Boardman Air Traffic Control Assigned Airspace | Superimposes the Boardman Military Operations Area, covers 358 $nm^2$ and starts at 18,000 ft. (5,486 m) MSL with an upper limit of FL200 (6,096 m [20,000 ft]). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701A | A 78 $nm^2$ circular area over the central portion of Boardman that extends from the surface to 20,000 ft. (6,096 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701B | An 11 $nm^2$ rectangular area immediately east of R-5701A that extends from the surface to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701C | A 31 $nm^2$ rectangular area immediately east of R-5701B that extends to the east slightly outside the Boardman Military Operations Area boundary. R-5701C extends from the surface to 6,000 ft. (1,829 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701D | A 21 $nm^2$ area south and west of R-5701A that extends from the surface to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701E | A 64 $nm^2$ area immediately west of R-5701D that extends from the surface to 6,000 ft. (1,829 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5706 | A 107 $nm^2$ area in the north and western portions of the Boardman Military Operations Area that extends from the 3,500 (1,067 m) to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |

Notes: $nm^2$ = square nautical miles, $km^2$ = square kilometers, ft. = feet, m = meters, NAS = Naval Air Station, MSL = mean sea level, FL = Flight Level, R = Restricted Areas, Seattle Center = Air Route Traffic Control located in Auburn, WA, FAA = Federal Aviation Administration

Source: FAA JO7400.T, National Geospatial-Intelligence Agency 2008

In 2004, Threemile Canyon Farms (the "Farm"), a large, privately-owned farm located immediately west of NWSTF Boardman, and PGE, whose Boardman power plant is located approximately 2.8 mi. (4.5 km) west of the Installation and within the Farm's land, agreed to designate 23,430 ac. (9,502 ha) as conservation areas for management by The Nature Conservancy, to protect habitat for several animal species, including the Washington ground squirrel. Collectively, the designated conservation areas are known as the Boardman Conservation Area (BCA). The BCA was established under the terms of a Multi-Species Candidate Conservation Agreement with Assurances between the Farm, PGE, the Service, and the ODFW. Other areas of the Farm, including the Boeing test facility and the PGE property, may be used and developed. The ODFW holds a permanent conservation easement on the 22,600 acres of the Farm property included in the BCA (Evans and Associates 2004).

Oregon has vast wind energy resources and ranks in the top ten states with the most wind energy generation capacity installed (U.S. Department of Energy 2011). Several wind energy generation projects have been developed in the vicinity of NWSTF Boardman and others are planned. Section 6. *Cumulative Effects*, provides additional information on surrounding land uses and wind energy projects in the area.

### *1.8.4 Description of Habitats in the Action Area*

The vegetation at NWSTF Boardman primarily consists of shrub-steppe and grassland habitats. In contrast to much of the surrounding area, large-scale agriculture has not taken place at NWSTF Boardman. As a result, the installation persists as a large tract of predominately native shrub-steppe and grassland habitats. In fact, the installation and the adjacent Boardman Conservation Area represent one of the largest remaining single blocks of predominantly native shrub-steppe and grassland habitats in Oregon's portion of the Columbia Plateau Ecoregion (approximately 69,000 ac. [27,923 ha]) (National Audubon Society 2011).

The composition of existing vegetation communities at the installation is influenced by numerous factors including climate, soils, military use, wildfire, past grazing, a limited amount of past agricultural use, and introduction of invasive plants (noxious weeds). In particular, two related factors, wildfire and invasive plants, have affected vegetation in recent years. Since 1998, more than 85 percent of NWSTF Boardman has been burned by wildfires, which have caused short- and long-term habitat alterations. Large fires swept portions of the installation in 1998 (17,514 ac. [7,088 ha]), 2007 (11,664 ac. [4,720 ha]), and 2008 (30,612 ac. [12,388 ha]), while smaller areas burned in 2002 (1,639 ac. [663 ha]) and 2009 (618 ac. [250 ha]). With the exception of the 2009 fire, all of these fires were started by lightning strikes. The cause of the 2009 fire is unknown (U.S. Department of the Navy 2012a). Training-related wildfires also occur occasionally at NWSTF Boardman. Range safety monitoring by participating military units allows for early detection of training-related fires and rapid response. Therefore, fires that start during training activities are typically contained to relatively small areas compared to lightning-caused fires, which might go undetected for a period of time after ignition.

Historically, the area was comprised of fire-adapted vegetation communities with fire return intervals that likely ranged from about 20 to 70 years based on information for similar habitats (Leenhouts 1998, Paysen *et al.* 2000). With the widespread introduction of invasive, non-native annual grasses such as cheatgrass, the amount of fuel for wildfires has increased. Wildfires now tend to be more frequent and more severe (burn hotter), and can be long-term or permanent habitat altering events. Frequent and hot burning fires like those that have occurred at NWSTF Boardman favor a shift from shrublands to grasslands. Humple and Holmes (2001) documented decreases in sagebrush cover and increases in cover of grass, primarily cheatgrass, in study plots following the 1998 fire at NWSTF Boardman.

Maintaining an up-to-date vegetation inventory and associated mapping for NWSTF Boardman has been a challenge given the recent wildfire history. Habitat types were mapped and described for the entire installation in 1997 by interpreting aerial photographs and conducting ground-truthing studies (U.S. Department of the Navy 2012a). In 2007, the U.S. Navy initiated a survey to update vegetation mapping for the entire installation. However, the large 2007 wildfire (11,664 ac. [4,720 ha]) occurred soon after the aerial imagery data were collected. A decision was made not to finalize the vegetation mapping effort because fire-induced vegetation changes rendered the imagery data obsolete. The *NWSTF Boardman INRMP* (U.S. Department of the Navy 2012a) includes a project recommendation to collect high-resolution aerial photography to map all vegetation and produce geographic-information-system-based vegetation mapping in the near future.

The remainder of this section provides descriptions of vegetation communities and habitat types based on information taken from the *NWSTF Boardman INRMP*. As discussed above, the best available vegetation/habitat data are from 1997, prior to a series of wildfires that occurred from 1998 through 2009. Vegetation conditions have changed at the installation since 1997 and will continue to change based on future fire regimes and other factors such as invasive species.

A list of plant species known to occur on NWSTF Boardman is provided in Appendix A in the Assessment. The following six major plant associations occur on NWSTF Boardman (U.S. Department of the Navy 2012a).

- Big sagebrush/bluebunch wheatgrass
- Bluebunch wheatgrass/Sandberg's bluegrass
- Big sagebrush/western needle-and-thread grass
- Antelope bitterbrush/needle-and-thread grass
- Needle-and-thread grass/Sandberg's bluegrass
- Snowy buckwheat/Sandberg's bluegrass

Lesser represented communities include the matchweed (an introduced species) variant of the big sagebrush/bluebunch wheatgrass association, and relict stands of western juniper/big sagebrush/bluebunch wheatgrass association. It should also be noted that large portions of nearly all of these associations are currently invaded by cheatgrass. Finally, there are some largely unvegetated sand dune and "alkali" areas.

Sagebrush/wheatgrass and wheatgrass/bluegrass plant associations dominate the southern half of NWSTF Boardman where soils are deeper and loamier. The presence of sagebrush differentiates these communities. Sagebrush is more prevalent in the draws and lowlands where deep, subsurface water resources are easier obtained. Both of these communities have been severely impacted by grazing (circa 1870s to 1950s) and now are largely dominated by cheatgrass. Healthy stands of wheatgrass are mostly limited to small patches on north-facing slopes, while sagebrush/wheatgrass association stands have been often heavily invaded with cheatgrass.

Moving south to north on the facility the soils become sandier, resulting in a replacement of the sagebrush/wheatgrass and wheatgrass/bluegrass plant associations with the sagebrush/ needle-and-thread grass and needle-and-thread grass/bluegrass associations. Prior to the invasion of alien weedy annuals around the early 1900s, much of the land now supporting these associations was characterized as isolated patches of western needle-and-thread surrounded by blowing sand. Outlines of the extensive dune systems that dominated this portion of the range are still evident in aerial photographs. While much of the original needle-and-thread stands have been replaced by dense stands of cheatgrass, needle-and-thread appears to also be establishing in areas of former dunes now stabilized by weedy annuals, including cheatgrass. Quality stands of needle-and-thread can still be found on the center portion of the range, especially where historically protected from grazing in the RNAs. The resilience of needle-and-thread, compared to bluebunch wheatgrass, to withstand grazing probably resides in its lesser palatability to livestock. However, gray and green rabbitbrush now dominate large portions of these communities because of disturbance from fire and historic grazing.

On the farthest northern edge of NWSTF Boardman is found the sandiest soils supporting the bitterbrush/needle-and-thread association and, where parent soils are slightly rocky, small patches of buckwheat/bluegrass plant associations. Very little needle-and-thread is found in these communities because it has either been replaced by cheatgrass, Russian thistle, and other alien weedy annuals, or has not yet colonized these areas since dune stabilization. Finally, due east of RNA-C is a small community of matchweed, a small, non-native shrub that apparently established in the John Day River drainage in the late 1940s and has been moving eastward since. This plant is an indicator of previous severe grazing.

In their pristine state, apparently none of these plant associations supported a diverse floristic composition, largely because of harsh climatic conditions and the deep soil lichen layers that developed between the grasses. Usually no more than 1 shrub and 1 or 2 species of grass, along with soil lichens and bare ground, accounted for greater than 90 percent of the ground cover. Phlox, lomatium, yarrow, and various members of the pea family were the most conspicuous forbs. However, livestock trampling of the lichen layer and intensive grazing of the palatable forage species has encouraged the invasion of alien weedy annuals such as cheatgrass, Russian thistle, tumblemustard, and whitlow-grass. It has dramatically increased the number of unpalatable native species, such as hairy golden-aster in the sagebrush/wheatgrass plant associations, and fiddleneck tarweed, lance-leaf scurf-pea, and hairy plantain in the needle-and-thread grass associations.

Table 10 provides a summary of major habitat types that were identified during the mapping effort completed in 1997 (U.S. Department of the Navy 2012a). Habitat types are units that can be mapped with discrete characteristics that separate them from other habitat types, and provide a specific set of components important as life requisites for specific wildlife species. Most habitat types are based loosely on the plant communities described earlier using vegetative structure and floristic composition as classification parameters.

**Table 10. Summary of Habitat Types and Acreage at NWSTF Boardman**

| Habitat Type | Size (Acres)[1] | Description | Wildlife Uses |
|---|---|---|---|
| Sagebrush | 7,415 | Sagebrush stands can be found throughout much of the facility, but are most prevalent in and near Juniper Canyon. Sagebrush can be structurally separated into a lowland type of larger plants with an understory of cheatgrass or sandy bare ground, and a structurally shorter upland type with lichen typically covering the understory. | Birds such as the black-billed magpie, Brewer's blackbird, lark sparrow, and loggerhead shrike appear to prefer the larger lowland sagebrush, while the sage sparrow and Brewer's sparrow may prefer the upland sage. |

| Habitat Type | Size (Acres)[1] | Description | Wildlife Uses |
|---|---|---|---|
| Bitterbrush | 2,555 | Antelope bitterbrush dominates large portions of the sandy-soiled region in the northern edge of the facility. Structurally it can become very tall (greater than six feet) and is sometimes co-dominated with gray rabbitbrush. | Larger bitterbrush plants provide nesting habitat for black-billed magpies, black-throated sparrows, and loggerhead shrikes, and perching habitat for burrowing owls. It also provides important cover for black-tailed jackrabbits and northern sagebrush lizards. |
| Bunchgrass | 12,100 | Bunchgrass habitat types include areas on the central and northern portion of the facility dominated by western needle-and-thread grass, and on the southern end by bluebunch wheatgrass. Portions of these habitats have been purposely historically protected from grazing. | Wildlife species typically found here include the grasshopper sparrow and Washington ground squirrel. |
| Open Low Shrub | 9,150 | The low shrub habitat type includes areas throughout the facility dominated by gray rabbitbrush, although green rabbitbrush and matchweed may comprise a significant portion of the shrub component. The presence of rabbitbrush on the facility, extensive in some areas, is largely a result of past fires as both rabbitbrush species are fire-tolerant, especially compared to other dominant shrubs. | The black-tailed jackrabbit, northern pocket gopher, gray partridge, and western meadowlark are among the dominant wildlife species found here. |
| Annual Grass/Forb | 15,840 | Annual grass/forb habitats are the areas on the facility dominated by cheatgrass, or co-dominated with the perennial Sandberg's bluegrass, usually associated with weedy forbs such as lance-leaf scurf-pea, fiddleneck tarweed, Jim Hill mustard, whitlow-grass, and hairy plantain. These habitats typify areas that were once heavily disturbed by grazing or crop production, or have invaded sandy areas that they have subsequently stabilized. | This habitat type provides nesting habitat for long-billed curlews, burrowing owls, horned larks, and western meadowlarks, and Great Basin pocket mice are very common here. |
| Juniper | Not applicable[2] | The juniper habitat type includes both the small juniper "forest" found in the Juniper Canyon, and the scattered juniper trees found on the periphery of Juniper Canyon and the western edge of the facility. In 1999 there were 188 mature juniper trees found on the facility. Some of these trees have since died and a number of young junipers have been found. | Junipers provide nesting habitat for Swainson's hawks, ferruginous hawks, ravens, long-eared owls, western kingbirds, and black-billed magpies. They also provide shade for mule deer and cover for porcupines. |

| Habitat Type | Size (Acres)[1] | Description | Wildlife Uses |
|---|---|---|---|
| Human Structures/ Disturbed | 145 | This habitat type includes buildings associated with the existing headquarters area, previous locations of buildings that have been demolished, and disturbed areas such as the old moving target indicator track, the main bulls-eye, the old cattle corrals, and used weapons accumulation areas. | Buildings may provide habitat for a variety of non-native pests such as starlings, house sparrows, and house mice. The observation tower in the southeastern corner of the target area has been used for several years by nesting ravens. |
| Dune | 210 | Dune habitats are found mostly on the north central end of the facility and within central Juniper Canyon. | Sagebrush lizards are commonly found along the dune edges. |
| Alkali | 45 | Alkali habitats occur in southern Juniper Canyon and at Well Springs. These habitats are devoid of vegetation. | The short-horned lizard is one of the few wildlife species found here. |

[1] Acreages are based on data collected in 1997, prior to a series of lightning-caused wildfires.
[2] Acreage was not calculated because most junipers are scattered and largely fall within another habitat type.
Source: U.S. Department of the Navy 2012a.

Surveys were conducted in late February 2013 to assign ecological condition classifications to habitats on selected portions of NWSTF Boardman to support impact assessment and mitigation planning efforts (Figure 3). Ecological condition classes were assigned based on the following classifications, which have also been used at the BCA by The Nature Conservancy (Elseroad 2002):

- High: Understory plant community dominated by native perennial bunchgrasses. Bunchgrasses abundant and robust, soil crust intact. Very few if any exotic species present.
- Medium-high: Understory plant community dominated by native perennial bunchgrasses. Cheatgrass and other exotic species present but in very low amounts or only in small isolated patches.
- Medium: Native perennial bunchgrasses present, but cheatgrass and other exotic species are widespread throughout the community.
- Medium-low: Community dominated by cheatgrass, other exotic species, and disturbance-adapted native species such as rabbitbrush. *Poa sandbergii* is often the only native perennial bunchgrass present.
- Low: Community dominated by cheatgrass and other exotic species. Few if any native species present (although rabbitbrush may be a dominant species) and no native perennial bunchgrasses present.

### *1.8.5 Soil Types at NWSTF Boardman*

Three major soil associations occur on the facility as shown in Figure 3 in the Assessment: Quincy-Koehler, Sagehill-Taunton, and Warden (USDA 1983). These major associations are represented by 34 soil mapping units, some of which are classified as prime farmland or farmland of statewide importance (Table 3 in the Assessment). More detailed information is provided in the Assessment and is incorporated herein by reference.

## 2. Analytical Framework for the Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Conference Opinion relies on four components: (1) the *Status of the Species*, which evaluates the Washington ground squirrel range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the Washington ground squirrel in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the Washington ground squirrel; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the Washington ground squirrel; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the Washington ground squirrel.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the Washington ground squirrel's current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the Washington ground squirrel in the wild.

The jeopardy analysis in this Conference Opinion places an emphasis on consideration of the range-wide survival and recovery needs of the Washington ground squirrel and the role of the action area in the survival and recovery of the Washington ground squirrel as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

## 3. Status of the Washington Ground Squirrel (Rangewide)

### *3.1 Listing Status*

Washington ground squirrels (*Urocitellus washingtoni*) were recognized as a Category 2 species in 1994. The Category 2 designation meant the Service had information to indicate that proposing to list the squirrel as endangered or threatened was possibly appropriate, but lacked sufficient data on biological vulnerability and threats to support a proposed rule. The Washington ground squirrel was designated a candidate for listing in the 1999 Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa That Are Candidates or Proposed for Listing as Endangered or Threatened (64 FR 57534, October 25, 1999). In the Service's 2012 annual status review, the Service re-confirmed that listing of the species is warranted. However, to date, publication of a proposed rule to list the Washington ground squirrel has been precluded by other higher priority listing actions (USFWS 2012). The species is also listed as endangered by the State of Oregon (ODFW 2011) and as a candidate species in the State of Washington.

Historical and current threats to Washington ground squirrels include the following (USFWS 2011a):

- Destruction, modification, or curtailment of its habitat or range from agricultural, energy, and other development; non-native plant infestations and associated increases in wildfire frequency; and overgrazing (grazing can be compatible with this species).
- Historical poisoning and shooting for pest management purposes and recreational shooting.
- Disease, predation, drought, and wildfire.
- Isolated, small populations

### *3.1.1 Life History*

The Washington ground squirrel is diurnal (active during the day) and spends much of the year (approximately July through December) underground in a state of dormancy called estivation (summer) and hibernation (winter). The annual cycle for this species is summarized in Table 11. All of their foraging, social, and reproductive activity takes place during a relatively short active period above ground. Washington ground squirrels produce one litter annually. Uterine litter sizes range between 5 and 11 with an average of 8 (Scheffer 1941). Carlson *et al.* (1980) reported an average litter size of five. They usually live less than 5 years and have high annual mortality rates.

Washington ground squirrels are ecologically significant for the following reasons (USFWS 2011a):

- They provide an important prey base for predators such as badgers, ferruginous hawks, and golden eagles.
- Burrowing action reduces soil compaction, loosens and aerates soils, and increases the rate of water infiltration into soil.
- Burrowing increases soil fertility, plant diversity and productivity, and microhabitat diversity by bringing nutrients and buried seeds from deep soil layers to the surface.
- Burrows are reused by many species including snakes, lizards, insects, and burrowing owls.

**Table 11. Washington Ground Squirrel Annual Cycle at NWSTF Boardman**

| Activity / Month | Jan | | | | Feb | | | | Mar | | | | Apr | | | | May | | | | Jun | | | | Jul-Dec | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weeks | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | | | | |
| Emergence of adults | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Breeding | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | |
| Emergence of young | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | |
| Juvenile dispersal | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | |
| Most adult males return to burrows | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | |
| Most adult females return to burrows | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | |
| Juveniles return to burrows (through 1st week of July) | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | | | |
| Population in estivation/hibernation | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |

Source: Information summarized in Northwest Wildlife Consultants, Inc. (2007)

### *3.1.2 Distribution*

The Washington ground squirrel is endemic to the Columbia Plateau, south and east of the Columbia River and east of the John Day River (Betts 1990). Until recently, the squirrel's range was thought to consist of three clusters of sites, with two in Washington (the Columbia Basin and Badger Mountain) and one in Oregon. The Service no longer describes the current range as three clusters of sites based on more recent data. Washington ground squirrel sites (detections of individuals and colonies) have been documented between the Columbia Basin and Badger Mountain clusters, as well as at least two sites near the Oregon and Washington border, well outside the three previously described clusters (USFWS 2012).

In Oregon, Washington ground squirrels occur in Gilliam, Morrow, and Umatilla counties. When the squirrel became a Federal candidate species, almost its entire known distribution in Oregon was centered on the NWSTF Boardman. Based on more current information provided by ODFW in 2013, 46 percent of all verified records in Oregon occur on NWSTF Boardman and the adjacent Boardman Conservation Area. Washington ground squirrels are also found on private and Bureau of Land Management (BLM) land west of these properties, on The Nature Conservancy-managed Lindsay Prairie, and on some additional scattered private lands. Many of the more recent Oregon records were documented by contractors conducting wildlife surveys to assist with micro-siting wind energy and transmission projects on private lands. The NWSTF Boardman and adjacent Boardman Conservation Area constitute the largest known continuous area of occupied habitat in the range of the Washington ground squirrel, as it covers approximately 70,000 ac (28,340 ha). Squirrel distribution on this area fluctuates such that not all of the area is occupied, although large portions of the properties are covered at various densities. Although the NWSTF Boardman is important for the species, the current distribution of Washington ground squirrel in Oregon is broader than was previously thought based on Betts' (1999) work.

In Washington, this species occupies sagebrush-steppe and grassland habitat east of the Columbia River in Adams, Douglas, Franklin, Grant, Lincoln, and Walla Walla counties. Most sites occur in Adams, Grant, and Douglas counties. As of 2012, the Washington Natural Heritage Program contained 567 verified Washington ground squirrel polygons (i.e., mapped estimate of areas containing squirrels) and 65 verified point locations in its database, any one of which could constitute an individual, small, or large colony. This database does not include all the detections that were made during a 2009–2010 survey in the Odessa area. Sites from the Oregon and Washington databases are not directly comparable because a number of factors collectively create a degree of variability and uncertainty in the use of naming conventions to describe areas used by Washington ground squirrels (USFWS 2012). However, there are also large areas of squirrel habitat in Washington, such as in the Smyrna Bench/Saddle Mountain Area.

### *3.1.3 Habitat and Diet*

The Washington ground squirrel occurs in shrub-steppe and grassland habitat. Historically, they occupied primarily sagebrush and bluebunch-wheatgrass habitats. However, cheatgrass and rabbitbrush have replaced much of the native vegetation within its current range and they are regularly found in these degraded habitats as long as there is sufficient forage. The Washington ground squirrel occupies sites with sandy or silt-loam texture soils that are deep and supportive enough to accommodate its burrow structures. This species seldom constructs burrows in areas of heavily disturbed soils, such as areas affected by plowing, disking, and crop production (USFWS 2011a). Habitats that provide a more stable food source during droughts appear to be important for these squirrels (USFWS 2011a).

Washington ground squirrels eat a broad range of succulent forb and grass stems, buds, leaves, flowers, roots, bulbs, and seeds (Greene 1999). Diverse diets help squirrels acquire sufficient fat and protein for reproduction and survival through estivation and hibernation (Tarifa and Yensen 2004a), Sherman and Shellman Sherman 2011. Native plants appear important to Washington ground squirrels, with Sandberg bluegrass (*Poa secunda*) playing a key role in their diet (Tarifa and Yensen 2004a).

A more detailed description of the species account is found in the Service's latest annual status review for Washington ground squirrel (USFWS 2012) and is incorporated herein by reference.

## 4. Environmental Baseline

The preamble to the implementing regulations for section 7 (51 FR 19932; third paragraph, left column) contemplates that the evaluation of "...the present environment in which the species or critical habitat exists, as well as the environment that will exist when the action is completed, in terms of the totality of factors affecting the species or critical habitat...will serve as the baseline for determining the effects of the action on the species or critical habitat." The regulations at 50 CFR 402.02 define the environmental baseline to include "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." The analyses presented in this section supplement the above *Status of the Species* evaluation by focusing on the current condition of the Washington ground squirrel in the action area, the factors responsible for that condition (inclusive of the factors cited above in the regulatory definition of environmental baseline), and the role the action area plays in the survival and recovery of the Washington ground squirrel. Relevant factors on lands surrounding the action area that are influencing the condition of the Washington ground squirrel were also considered in completing the status and baseline evaluations herein.

### *4.1 Status of the Species in the Action Area*

Several Washington ground squirrel surveys and research studies have been conducted at NWSTF Boardman. Several characteristics of the squirrel make studying them a challenge, including the short periods when they occur above ground, a tendency for male dispersal, and short-term population fluctuations. These factors and inconsistencies have led to uncertainty and variability among researchers in the use of terms to describe areas used by Washington ground squirrels. There is not a clear definition of what constitutes a single colony for this species, and terms such as site, patch, detection, and occurrence have been used to describe what might be called a colony (USFWS 2011a). The Service (2011a) hopes to eventually bring a standardized convention to describing squirrel populations.

While various survey methods and terms have been used at NWSTF Boardman, most surveys followed standard protocols (Morgan and Nugent 1999) focused on documenting Washington ground squirrel "active detections." This approach determines if squirrels are using a specific area based on sighting squirrels, hearing squirrels, and finding holes recently used by squirrels as determined by the presence of the current year's droppings (Northwest Wildlife Consultants 2005, 2006; Marr 2001). These surveys are not designed to estimate population size or density (i.e., number of animals per ac.). Furthermore, this approach does not make a distinction between a colony, active site, active hole, or individual squirrel that is part of a colony or a lone disperser. Large portions of NWSTF Boardman have been surveyed since 1979, but a systematic Washington ground squirrel survey of the entire property has not been conducted.

Figure 6 provides a compilation of known Washington ground squirrel detections at NWSTF Boardman from surveys conducted through 2009. The points shown in Figure 6 indicate locations where squirrels have been present in the past and are part of regular survey efforts. In some cases, the locations represent colonies. In other cases, they represent only an incidental sighting, where there may or may not be a colony (U.S. Department of the Navy 2012b). For some of the surveys conducted at NWSTF Boardman, detections were classified as small, medium, or large colonies or sites based on Morgan and Nugent (1999). However, these classifications were not recorded for all detections across all surveys. Consequently, Figure 7 makes no distinction based on colony or site size.

Although higher concentrations of Washington ground squirrels are said to be associated with Warden Soils (e.g., Greene *et al.* 2009), definitive studies have not been done to identify core areas or variables that are most important to Washington ground squirrels at NWSTF Boardman. Several variables are changing together and moving south on NWSTF Boardman. The precipitation and productivity appear to be increasing with elevation, while soil particle size is generally decreasing. Yensen (2013) suggests that that productivity is as important, or more important, than soil textures on NWSTF Boardman. Although ground squirrels prefer loams, silts, silt loams and sandy loams, most of the soils on NWSTF Boardman, with the exception of the clay pockets, should be suitable for ground squirrels. Higher productivity should translate into denser, more stable ground squirrel populations irrespective of other variables, and productivity generally increases moving south on NWSTF Boardman (Yensen 2013).

Figure 7 shows historically occupied Washington ground squirrel habitat at NWSTF Boardman. This historically occupied habitat was mapped by applying a 785 ft. (239 m) radius buffer to the known squirrel detections shown in Figure 6. The buffer distance is based on that used by Morgan and Nugent (1999) to estimate actual use-areas (i.e., the expected area of squirrel movement around a detection site) and represents a known maximum travel distance described by Carlson *et al.* (1980). As shown in Figure 7, historically occupied habitat is located on or near the proposed range enhancement sites. Based on the lack of recent, systematic survey data the entire affected area was assumed to be occupied by Washington ground squirrels for impact assessment and mitigation planning purposes. With the exception of highly disturbed areas such as maintained roads, maintained fire breaks, and excavated area, it is reasonable to assume that all of NWSTF Boardman is suitable Washington ground squirrel habitat, especially during high years of a population cycle. Surveys conducted in 2005, 2006, and 2008 also documented Washington ground squirrels on the proposed MPMGR and DMPTR locations (Table 12) (Northwest Wildlife Consultants, Inc. 2005, 2006, 2008).

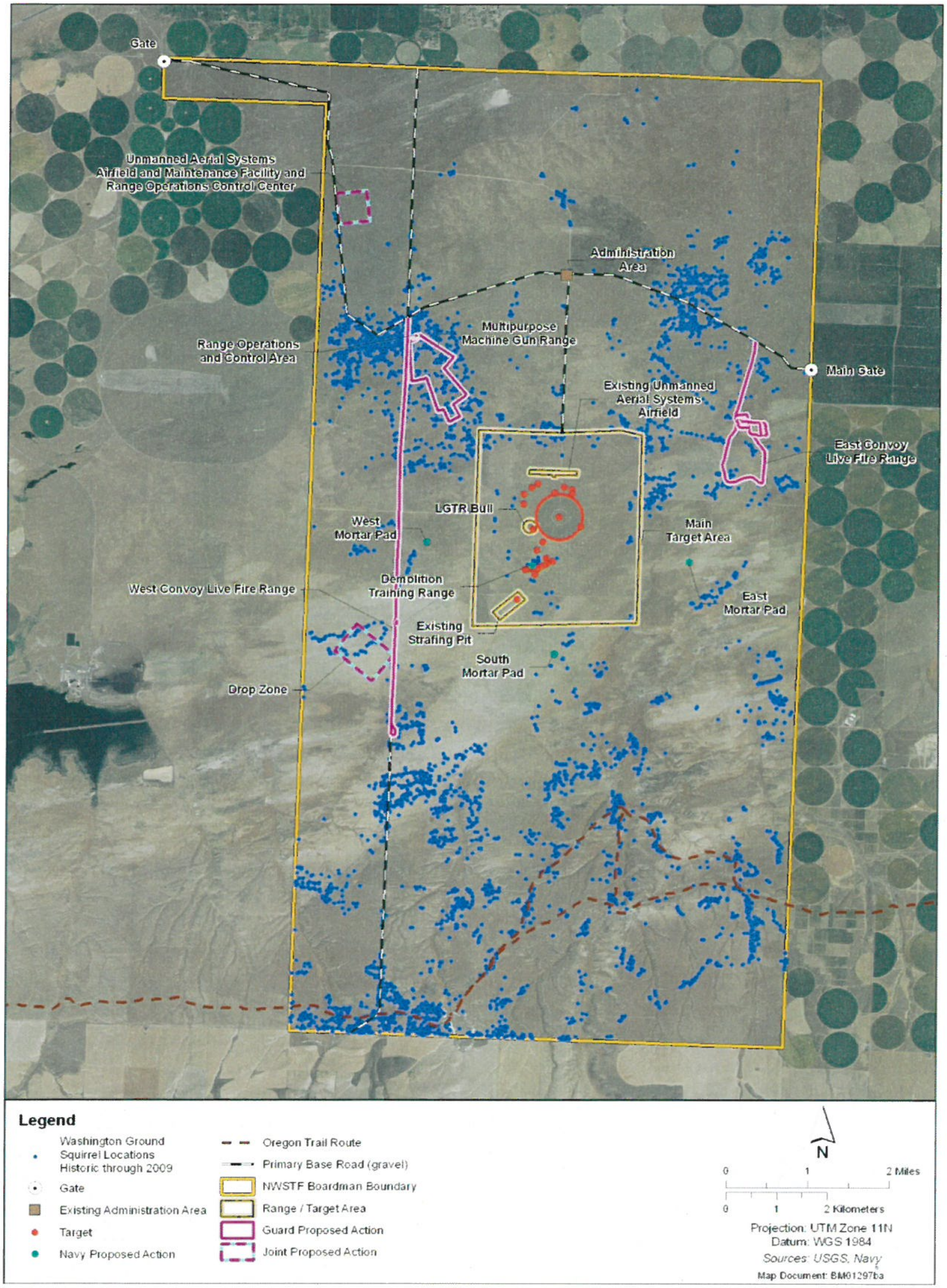


**Figure 6. Known Washington Ground Squirrel Detections at NWSTF Boardman Historic through 2009**

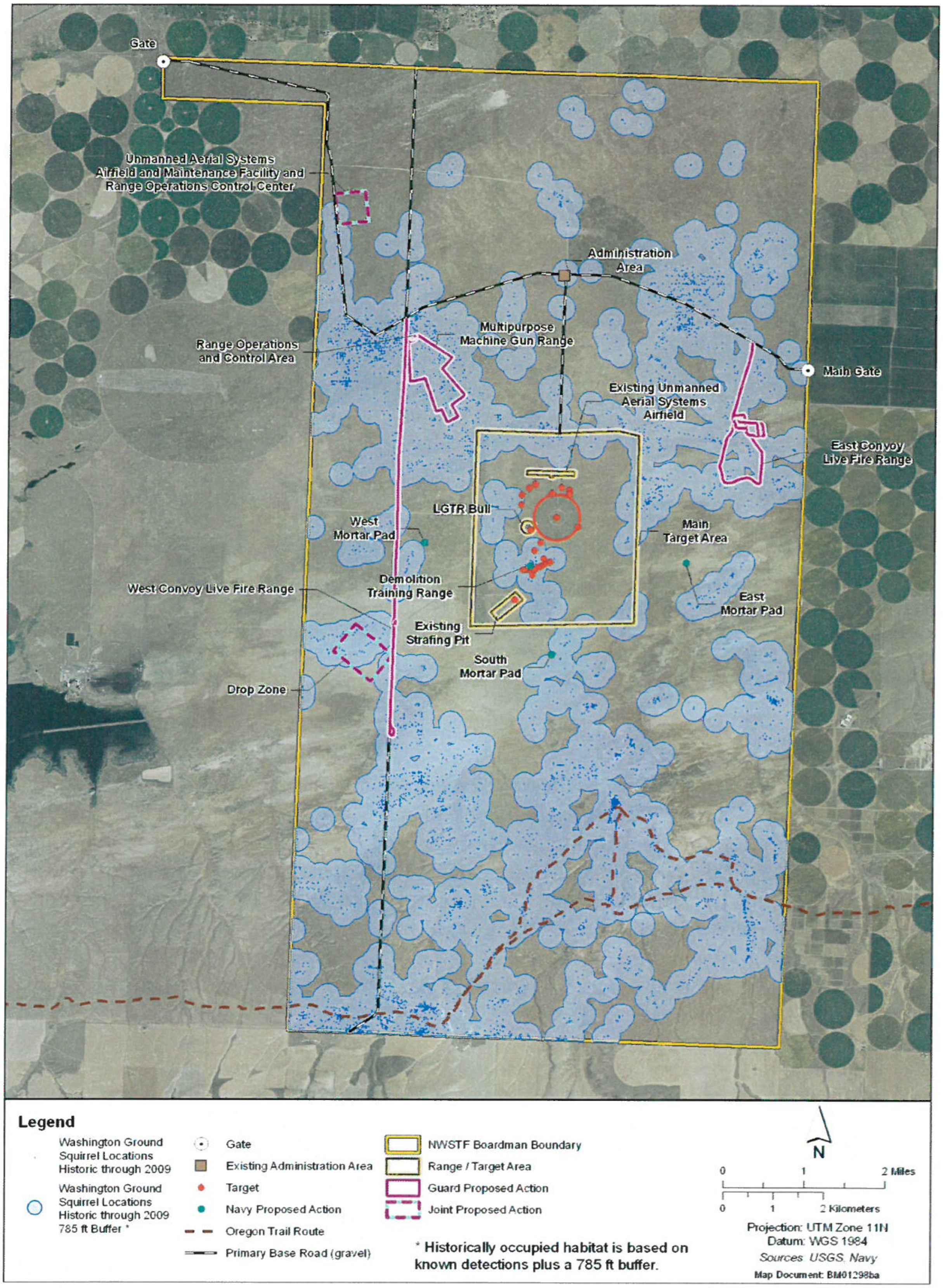


**Figure 7. Historically Occupied Washington Ground Squirrel Habitat at NWSTF Boardman**

The DMPTR is not part of the Proposed Action addressed in this conferencing package, but it is included in one of the alternatives analyzed in the NWSTF Boardman EIS. While numerous detections were recorded in 2005 (211) and 2006 (636), it should be noted that the surveys were conducted in June when squirrel activity is low. It is possible that additional detections would have been recorded if the surveys were conducted during the peak activity period (late-March through mid-May). Nonetheless, the results provide further confirmation that Washington ground squirrels use habitats at the proposed MPMGR location.

**Table 12. Washington Ground Squirrel Surveys Conducted for the Proposed MPMGR and DMPTR at NWSTF Boardman**

| Survey Date | Location | Area Surveyed (acres [hectares]) | Active Detections |
|---|---|---|---|
| June 2005 | Northern portions of Multi-Purpose Machine Gun Range and Digital Multi-Purpose Training Range | 604 (244) | 211 |
| June 2006 | Multi-Purpose Machine Gun Range | 1,700 (688) | 636 |
| March-May 2008 | Digital Multi-Purpose Training Range | 2,996 (1,212) | 76 |

Notes: MPMGR = Multi-Purpose Machine Gun Range, DMPTR = Digital Multi-Purpose Training Range, NWSTF = Naval Weapons Systems Training Facility. The DMPTR is not part of the Proposed Action addressed in this conferencing package, but it is included in one of the alternatives analyzed in the Naval Weapons Systems Training Facility Boardman Environmental Impact Statement.
Source: Northwest Wildlife Consultants, Inc. 2005, 2006, 2008.

During the 2008 surveys, only 76 active detections were recorded for the DMPTR location, despite being conducted during the peak activity period and covering a larger area than the 2005 and 2006 surveys. Portions of the 2008 survey area were also surveyed in 2005. In the common survey area, there were 211 active detections in 2005 and only 8 active detections in 2008. Anecdotal observations suggest that the late winter and spring of 2008 received below normal precipitation, and the quality of plants that Washington ground squirrels typically forage on were poor when compared to previous years such as 2005 and 2006. Drought or other factors such as disease or squirrel movements to other areas might explain this change in active detections (Northwest Wildlife Consultants, Inc. 2008).

Three research studies conducted at NWSTF Boardman used mark-recapture methods to estimate Washington ground squirrel density. As shown in Table 13, density estimates varied substantially and ranged from 0.2 animal per ac. (0.5 per ha) to 36.5 animals per ac. (82.7 per ha). It should be noted that Delavan (2008) and Klein (2005) sampled relatively small study areas known to be occupied by Washington ground squirrels.

**Table 13. Washington Ground Squirrel Density Estimates from Mark-Recapture Surveys**

| Year | Site Name and Vegetation | Density (animals per acre [hectare]) | Reference |
|---|---|---|---|
| 1997 | Sagebrush 1 | 6.4 (15.7) | Greene *et al.* 2009 |
| 1997 | Sagebrush 2 | 1.6 (3.9) | Greene *et al.* 2009 |
| 1997 | Sagebrush 3 | 0.5 (1.1)[2] | Greene *et al.* 2009 |
| 1997 | Low Shrub 1 | 1.1 (2.6) | Greene *et al.* 2009 |
| 1997 | Low Shrub 1 | 0.5 (1.2)[2] | Greene *et al.* 2009 |
| 1997 | Low Shrub 1 | 0.2 (0.4)[2] | Greene *et al.* 2009 |
| 1997 | Bunchgrass 1 | 0.5 (1.2)[2] | Greene *et al.* 2009 |
| 1997 | Bunchgrass 2 | 0.2 (0.5)[2] | Greene *et al.* 2009 |
| 1997 | Bunchgrass 3 | 0.8 (2.0)[2] | Greene *et al.* 2009 |
| | | | |
| 2004 | Open Low Shrub, open low shrub | 4.3 (10.7) | Delavan 2008 |
| 2004 | Cemetery, annual grass | 18.9 (46.6) | Delavan 2008 |
| 2004 | Large Stipa, bunchgrass[1] | 5.2 (12.9) | Delavan 2008 |
| 2005 | Sage, sagebrush[1] | 11.4 (28.1) | Delavan 2008 |
| | | | |
| 2002 | Tub Springs, annual grass/forbs | 33.4 (82.5) | Klein 2005 |
| 2003 | Tub springs, annual grass/forbs | 35.8 (88.4) | Klein 2005 |
| 2002 | Mystery Road, perennial grass/low shrub | 4.5 (11.1) | Klein 2005 |
| 2003 | Mystery Road, perennial grass/low shrub | 8.2 (20.3) | Klein 2005 |
| 2002 | Cemetery, annual grass, bunchgrass and sagebrush nearby | 16.2 (40.0) | Klein 2005 |
| 2003 | Cemetery, annual grass, bunchgrass and sagebrush nearby | 36.5 (90.3) | Klein 2005 |
| 2003 | Spigot, not described by author | 7.2 (17.7) | Klein 2005 |
| | | | |
| | **Mean =** | **9.7 (23.9)** | |

[1] Site is located on Boardman Conservation Area; all other sites are located on NWSTF Boardman.
[2] Estimated values interoperated from graph presented by Greene *et al.* (2009). The authors did not present numeric values for these sites.

To support the overall research objectives (estimate home range, movement, and dispersal), Klein (2005) sampled areas where squirrels were known to be abundant and Delavan (2008) sampled areas that were expected to support different population sizes (e.g., small, medium, and large). Therefore, density estimates from these studies are not representative of NWSTF Boardman as a whole. Greene *et al.* (2009) established plots randomly within specific habitat types.

The Washington ground squirrel also occurs at the BCA and was recently documented along the proposed Carty Lateral Project alignment (Gas Transmission Northwest 2011), portions of which are located beneath the NWSTF Boardman airspace. This species may occur in other areas beneath the airspace where suitable soils exist that have not been converted to agriculture. The Washington ground squirrel has not been documented at Umatilla Chemical Depot (UCD) (U.S. Department of the Army 2007).

### *4.2 Factors Affecting Species Environment within the Action Area*

The Service's Species Assessment and Listing Priority Assignment Form, completed in 2012, provided a detailed discussion of threats to the Washington ground squirrel (USFWS 2012). This information is incorporated by reference and has been considered in the analysis presented in Section 5. *Effects of the Proposed Action.* Historical and current threats to Washington ground squirrels include:

- Destruction, modification, or curtailment of its habitat or range from agricultural, energy, and other development; non-native plant infestations and associated increases in wildfire frequency; and overgrazing.
- Historical poisoning and shooting for pest management purposes and recreational shooting.
- Disease, predation, drought, and wildfire.
- Isolated, small populations

The two major current factors affecting Washington ground squirrel in the action area are invasive plants and wildfire. Non-native invasive plants, including cheatgrass, threaten squirrels by competing with native plants that are important for ground squirrel diets. Exotic annual plant species provide an unstable food resource for ground squirrels because their productivity fluctuates with annual precipitation (Yensen *et al.* 1992). Washington ground squirrels do eat non-native species, including cheatgrass (Tarifa and Yensen 2004a, Tarifa and Yensen 2004b), but native perennial plant species are more drought-tolerant than annuals. When annual plants dominated the landscape, there is less forage for ground squirrels during drought years and it is available for a shorter period of time (Yensen *et al.* 1992). Further, plant communities dominated by exotic annuals have lower diversity, reducing dietary choices and probably the ability to avoid toxic secondary compounds (Quade 1994). Exotic-dominated communities are also far more likely to burn than native vegetation (Whisenant 1990).

Wildfire, in combination with invasive plants, has affected vegetation and Washington ground squirrel habitat at NWSTF Boardman in recent years. Since 1998, wildfires burned more than 85 percent of NWSTF Boardman causing short- and long-term habitat alterations. Large fires swept portions of the installation in 1998 (17,514 ac. [7,088 ha]), 2007 (11,664 ac. [4,720 ha]), and 2008 (30,612 ac. [12,388 ha]), while smaller areas burned in 2002 (1,639 ac. [663 ha]) and 2009 (618 ac. [250 ha]) (Figure 14). With the exception of the 2009 fire, all of these fires were started by lightning strikes. The cause of the 2009 fire is unknown (U.S. Department of the Navy 2012b). Training-related wildfires also occur occasionally at NWSTF Boardman.

### *4.3 Role of the Action Area in the Conservation of the Washington ground squirrel*

The greatest concentration of Washington ground squirrel sites in Oregon is located on the Navy's NWSTF Boardman and the adjacent BCA in Morrow County, Oregon. Together these properties contain 46 percent of all verified records in Oregon. This area constitutes the largest known continuous area of occupied habitat in the range of the Washington ground squirrel, as it covers approximately 70,000 ac (28,340 ha). There are, however, other large areas of squirrel habitat across the species range, such as the Smyrna Bench/Saddle Mountain Area of Washington. Because the NWSTF Boardman and adjacent BCA contain such a large amount of occupied habitat and provides the main connection between smaller sites to the west of this area and possible movement east and south, this area is important for the species long-term survival and recovery.

On the BCA and NWSTF Boardman, squirrel site distribution fluctuates such that not all of the area is occupied, although large portions of the properties are covered at various densities. For example, Marr's 2006 data showed a 10 percent extirpation rate of sites (or patches) on the BCA and NWSTF from 2005, balanced in part by new patches which may or may not be actual colonies. More specifically, 34 patches were vacated and only 16 new patches were located, showing a net loss of 18 patches between 2005 and 2006 (Marr 2006).

The NWSTF Boardman alone includes 47,432 ac (19,195.1 ha), approximately two miles south of Boardman, Oregon. Large portions of NWSTF Boardman have been surveyed since 1979, but a systematic Washington ground squirrel survey of the entire property has not been conducted (Assessment, p.37). Figure 6 shows known squirrel detections at the NWSTF Boardman historically through 2009. Although Greene *et al.* (2009, p. 39) found that Warden soils were important, squirrels occupy a variety of soil types on the NWSTF, soil productivity may be equally or more important than soil textures in determining squirrel distribution on this site (Yensen 2013, p. 5).

## 5. Effects of the Proposed Action

Effects of the action are defined as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will be added to the environmental baseline" (50 CFR 402.02). The Service's effects analysis is based on information provided in the Assessment, as well as our assessment of baseline conditions and expected changes from the proposed action.

### *5.1 Approach to Analysis*

The impact analysis for the Washington ground squirrel considered effects of the Proposed Action on individual animals and populations. The analysis first looked at how individuals would respond to a stressor or combination of stressors and whether the response would affect the fitness of an individual. Fitness refers to changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. If individual fitness is not affected, then no impacts to populations would be expected. The potential for impacts to occur at the population level depends on several things, including whether individual fitness has been reduced, the number of individuals affected, the size of the affected population, and numerous life history and ecological factors.

The scientific limitations associated with predicting the responses of individuals and populations to stressors create a relatively high degree of uncertainty. Accordingly, a conservative approach was used in making conclusions when the level of uncertainty was considered high.

In addition, the analysis considered the amount of the year that Washington ground squirrels were above ground. We assume that most of the potential impacts would occur during this approximately 5-6 month period each year. Information was not always available to determine exactly how many of the annual days of training would occur during this above-ground timeframe so a conservative estimate was used.

## *5.2 Noise*

### *5.2.1 Overview*

Under the Proposed Action, Washington ground squirrels in the NWSTF Boardman Action Area would be exposed to noise associated with the following:

- Fixed-wing aircraft overflights
- Helicopter overflights and takeoffs and landings
- UAS overflights and takeoffs and landings
- Weapons firing
- Non-explosive practice munitions striking a target or the ground
- Vehicle and equipment operations
- Explosive detonations

The following section summarizes information about how wildlife, in general, and the Washington ground squirrel may respond to noise. The effects of noise on Washington ground squirrel under the Proposed Action are then analyzed for each noise source.

### *5.2.2 Wildlife Responses to Noise*

Numerous studies have documented that wild animals respond to human-made noise (National Park Service 1994, Bowles 1995, Larkin 1996). The manner in which animals respond to noise depends on several factors including life history characteristics of the species, characteristics of the noise source, loudness, onset rate, distance from the noise source, presence/absence of associated visual stimuli, and previous exposure. Noise may cause physiological or behavioral responses that reduce the animals' fitness or ability to grow, survive, and reproduce successfully. The potential effects of noise on wildlife can take many forms, including changing habitat use and activity patterns, increasing stress response, decreasing immune response, reducing reproductive success, increasing predation risk, degrading communication, and damaging hearing if the sound is sufficiently loud (Larkin 1996).

Behavioral responses are the most commonly used endpoints when studying the effects of noise on wildlife. This is largely based on practical considerations and the difficulty in measuring animal fitness or physiological and ecological endpoints. Researchers have documented a range of behavioral responses to noise, ranging from indifference to extreme panic. Common behavioral responses include alert behavior, startle response, flying or running away, and increased vocalizations (National Park Service 1994, Bowles 1995, Larkin 1996). In some instances, behavioral responses could interfere with breeding, raising young, foraging, habitat use, and physiological energy budgets, particularly when an animal continues to respond to repeated exposures.

While difficult to measure in the field, all behavioral responses are accompanied by some form of physiological response such as increased heart rate or a startle response. A startle is a rapid, primitive reflex that is characterized by rapid increase in heart rate, shutdown of nonessential functions, and mobilization of glucose reserves. Animals can learn to control the behavioral reactions associated with a startle response and often become habituated to noise (National Park Service 1994, Bowles 1995, Larkin 1996). Habituation keeps animals from expending energy and attention on harmless stimuli, but the physiological component might not habituate completely (Bowles 1995). Therefore, animal fitness could still be affected when an animal has habituated to noise (Barber *et al.* 2009). Gill *et al.* (2001) described theoretical circumstances when habituation to or tolerance of a stressor could be more detrimental to a population than a strong avoidance reaction. Nonetheless, what appears to be habituation has been observed in many studies and is well-demonstrated in studies evaluating bird control devices (e.g., noise cannons, pyrotechnics, and recorded sounds), which are used to scare birds away from airfields and agricultural areas (Larkin 1996). Larkin (1996) describes one example where red-winged blackbirds began resting on the noise cannon that was intended to scare them away. The birds learned to fly a short distance away when they heard the click of the mechanism that released the gas and signaled an impending explosion.

Likewise, a strong and consistent behavioral or physiological response is not necessarily indicative of negative consequences to individuals or to populations (National Park Service 1994, Bowles 1995, Larkin 1996). For example, many of the reported behavioral and physiological responses to noise are within the range of normal adaptive responses to external stimuli, such as predation, that wild animals face on a regular basis. In many cases, individuals would return to homeostasis or a stable equilibrium almost immediately after exposure. The individual's overall metabolism and energy budgets would not be affected assuming it had time to recover before being exposed again. If the individual does not recover before being exposed again, physiological responses could be cumulative and lead to reduced fitness. However, it is also possible that an individual would have an avoidance reaction (i.e., move away from the noise source) to repeated exposure or habituate to the noise when repeatedly exposed.

Washington ground squirrel responses to noise have not been studied and no anecdotal accounts of responses to noise have been found in the literature. Washington ground squirrel predator alarm calls have been noted in response to moving vehicles, but it is not known if they were responding to vehicle noise or movement (Northwest Wildlife Consultant 2008). Increased calling by individuals can make them more susceptible to predation (Sherman 1977).

Although Washington ground squirrel responses to noise have not been studied, some information exists for other ground squirrels. California ground squirrels (*Otospermophilus beecheyi*), which are in the same family (Sciuridae) as Washington ground squirrels, show higher levels of alertness in the presence of continuous windmill noise (Rabin 2005). Reliance on alert behavior, as opposed to anti-predator calls, is incompatible with other behaviors (e.g., foraging and social behavior) essential in ground squirrel daily activity (Rabin 2005). However, it is unlikely that a pronounced shift from anti-predator call to alert behavior would be observed in an environment where noise was intermittent and infrequent.

Hooper (2011) demonstrated that road noise has the potential to mask the alarm calls of Belding's ground squirrels (*Urocitellus beldingi*), but mainly at peak amplitude levels and only for roadside locations. The effective range of alarm calls produced alongside the road was reduced significantly for all traffic levels. While Hooper (2011) points out that such signal range reductions can have fitness repercussions in the form of increased predation risk, the study did not specifically evaluate predation risk for these apparently stable roadside colonies.

A few studies have evaluated the effects of aircraft overflights on rodent populations in the wild. A three-year study at a U.S. Air Force range evaluated three species of hibernating desert rodents exposed to frequent low-altitude aircraft overflights (Bowles *et al.* 1995). The mean number of overflights greater than 80 dBA (reported as maximum, fast, A-weighted sound pressure level) recorded on the exposed site was 33.22 flights per day. The highest sound exposure level (SEL) recorded for this area was 115.5 dBA and the mean SEL for the loudest 30 events was 103.4 dBA. Treatment areas did not differ significantly in abundance or population density relative to control populations (Bowles *et al.* 1995). Mouse densities in a field near Memphis International Airport (80 to 120 dB) were not significantly different than densities in a nearby rural field (80 to 85 dB) (Chesser *et al.* 1975). These studies suggest that absolute density of rodent populations does not appear to be affected by aircraft noise at these locations (Bowles *et al.* 1995). However, Chesser *et al.* (1975) found that mice collected from the airport field had significantly larger adrenal glands than those collected from the rural field. To determine if noise was the causative factor, mice collected from the rural field were exposed to recorded jet noises at 105 dB for two weeks. The experimental group had significantly larger adrenal glands than a control group (Chesser *et al.* 1975). This appears to be a case where aircraft noise caused a measurable physiological response with no apparent effects to the population. The frequency of overflights in the studies discussed above was substantially higher than those that would occur at NWSTF Boardman.

Long-term monitoring data indicate that military training at Orchard Training Area in southwestern Idaho does not affect population dynamics of the Piute ground squirrel (*Urocitellus mollis*, formerly known as the Townsend's ground squirrel [*Spermophilus townsendii mollis*]). Washington ground squirrels and Piute ground squirrels are members of the same genus (*Urocitellus*). The 138,936-ac. (56,227-ha) training area has been used for military training by the Idaho Army National Guard since 1953. Military training activities conducted at Orchard Training Area include small arms, tank gunnery (firing 120 mm gun), artillery training (firing 155 mm howitzer), armored vehicle maneuver training, helicopter training, troop transport, and bivouac. Active Piute ground squirrel burrows have been counted at 79 monitoring plots on Orchard Training Area. Data collected from 1989 through 2001 indicated a significant increasing trend in burrow abundance at approximately 40 percent (32) of the 79 plots (Hlohowskyj *et al.* 2004). An increasing trend in active burrow abundance was also indicated for 36 (46 percent) other plots, but the trend for these plots was not significant. A negative trend in active burrow abundance was observed at nine (11 percent) monitoring plots, but the trend for these plots was not significant. While no obvious spatial pattern is evident among the plots exhibiting an increasing trend in burrow abundance, 10 of the 32 plots exhibiting a significant increasing trend in the number of active burrow counts were located within the impact area (Hlohowskyj *et al.*

2004). Both high explosive ordnance and non-explosive practice ordnance is fired at targets located within the Orchard Training Area impact area. Van Horne and Sharpe (1998) investigated the effects of armored vehicles on Piute ground squirrel on Orchard Training Area. Sagebrush areas and areas dominated by bluegrass have been subjected to low-intensity tracked vehicle operations for 50 years and were compared against similar areas that had no tracked vehicle operations. The study did not detect any effects on ground squirrel population dynamics associated with long-term tracked vehicle operations. While the studies conducted at Orchard Training Area did not specifically evaluate Piute ground squirrel responses to noise, the long-term monitoring data suggest that noise and other potential stressors associated with military training do not appear to be impacting Piute ground squirrel populations at the training area. We anticipate Washington ground squirrel responses will be similar and noise and stressors associated with military training will not substantially impact the Washington ground squirrel populations in the training area but long-term data have not yet been collected to support this.

While the effects of noise on wildlife have been addressed in numerous studies, research is hampered by a preponderance of small, disconnected, anecdotal, or correlational studies as opposed to coherent programs of controlled experiments (Larkin 1996). These factors, coupled with differences between species, individuals of the same species, and other factors such as habitat, make it difficult to definitively predict how wildlife populations will respond to noise under a specific exposure scenario. As a result, there are no well-established thresholds or criteria for predicting impacts of noise on terrestrial wildlife.

### *5.2.3 Conceptual Framework for Assessing Effects from Noise-Producing Activities*

#### Introduction

This conceptual framework describes the different types of effects that are possible and the potential relationships between sound stimuli and long-term consequences for the individual and population. The conceptual framework is central to the assessment of acoustic-related effects and is consulted multiple times throughout the process. It describes potential effects and the pathways by which an acoustic stimulus or sound-producing activity can potentially affect animals. The conceptual framework qualitatively describes costs to the animal (e.g., expended energy or missed feeding opportunity) that may be associated with specific reactions. Finally, the conceptual framework outlines the conditions that may lead to long-term consequences for the individual and population if the animal cannot fully recover from the short-term effects.

An animal is considered "exposed" to noise if the received sound level at the animal's location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to noise-producing activities. The severity of these effects can vary greatly between minor effects that have no real cost to the animal, to more severe effects that may have lasting consequences. Whether an animal is significantly affected must be determined from the best available scientific data regarding the potential physiological and behavioral responses to sound-producing activities and the possible costs and long-term consequences of those responses.

The major categories of potential effects of noise addressed in this analysis are:

- Hearing loss
- Behavioral responses
- Physiological stress
- Disruption of estivation/hibernation

Masking of biologically meaningful sounds is not expected to be an issue because noise associated with the Proposed Action would be intermittent and the loudest noise events (e.g., ground-based weapons firing) would typically only occur during 2-day, weekend training events. Auditory masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest. Masking is primarily a concern for continuous or near-continuous noises such as traffic noise. Therefore, auditory masking is not addressed in detail in this analysis.

**Hearing Loss**

A familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). The distinction between permanent threshold shift and temporary threshold shift is based on whether there is complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), temporary threshold shift has occurred. The recovery time is related to the exposure duration, SEL, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran *et al.* 2005; Mooney *et al.* 2009). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a permanent threshold shift.

The threshold of physiological hearing damage to the human ear is approximately 140 decibels peak (dBP) (Humes *et al.* 2005, U.S. Army Public Health Command 2010). Much of the data used to predict human hearing loss from exposure to impulsive sounds is from studies conducted on chinchillas, which are burrowing rodents. Therefore, it is reasonable to use chinchilla hearing threshold shift data to predict hearing threshold shift in Washington ground squirrels. Hamernik *et al.* (1987) observed varying degrees of temporary and permanent threshold shift in chinchillas exposed to 1, 10, or 100 noise impulses (one every three seconds) having peak intensities of 131, 135, 139, or 147 dBP. Damage to the cochlear sensory epithelia was also observed for some exposures. Based on the reported responses of chinchillas, exposure to single event noise levels of 140 dBP or higher is used in this analysis to indicate the potential for hearing threshold shift in Washington ground squirrels. In addition, the number of exposures to a single event noise level above 140 dBP and the time interval between exposures is considered when assessing the potential for threshold shift to occur. In general, a threshold shift is more likely when repeated exposures occur over a short duration.

Long-term effects on a Washington ground squirrel that might experience a threshold shift would depend on whether the shift was temporary or permanent, the severity of the shift, the hearing frequencies affected by the shift, and the time required to recover from a temporary threshold shift. Squirrels with impaired hearing could be more susceptible to predation and would be expected to expend more time and energy trying to detect predators via visual cues, rather than auditory cues (e.g., listening for sounds made by an approaching predator or alarm calls of other squirrels). This could lead to decreased foraging success and decreased fitness. Recovery from a temporary threshold shift can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically-relevant sound. Consequently, a threshold shift would not necessarily result in long-term effects on the individual.

**Behavioral Responses, Physiological Stress, and Habituation**

Based on information presented above in Section 5.2.2 and literature summarized for the other species (National Park Service 1994, Bowles 1995, Larkin 1996), Washington ground squirrels could exhibit a range of behavioral and physiological responses to noise depending on distance from the noise source. It is also likely that squirrels would habituate to some sound levels. Washington ground squirrels exposed to high sound levels would likely perceive the noise and any associated visual or other cues (e.g., vehicle and equipment movement, other human activity, vibration, or projectile impacting the ground nearby) as a threat and exhibit predator defense behavior including alarm calls and taking cover underground. With repeated exposure over a two-day training event, such responses have the potential to reduce an animal's fitness by limiting foraging time, increasing energy expenditure, inducing a stress response, and interfering with breeding.

Lost foraging time could make it difficult to obtain enough fat and protein to supply their nutritional needs in hibernation (resulting in high overwinter mortality) or support reproduction (Sherman and Sherman 2011). This would be of particular concern where native perennial food plants favored by Washington ground squirrels have been replaced by exotic perennials and annuals that produce less nutritious seeds or bear seeds too late in the summer for consumption (Sherman and Sherman 2011). In addition, some training would likely coincide with the breeding season (Table 12). Washington ground squirrels produce one litter annually. Females are sexually receptive on only one afternoon per season, usually within a few days of emergence from hibernation (USFWS 2011a). Reproductive success could be diminished if range use coincides with the breeding season.

Various studies have indicated that some animals respond to repeated loud noises by temporarily or permanently abandoning habitat (National Park Service 1994, Bowles 1995, Larkin 1996). While relatively little is known about Washington ground squirrel behavior, this species has several traits that suggest that habitat abandonment might not be a preferred strategy for coping with elevated noise levels. They rely on burrow systems, which they have expended energy to develop, for shelter, protection from predators, and estivation/hibernation. Therefore, abandoning existing habitat would put them at risk. Females are known to form social groups and defend territories (Sherman and Sherman 2011). In addition, home ranges are relatively small and documented dispersal distances of juvenile and adult males are relatively short. Females are not known to disperse and dispersal of juvenile females has not been studied. These factors suggest that habitat abandonment in response to noise is unlikely. If habitat were abandoned, individuals could suffer other consequences such as increased risk of predation. While habitat abandonment seems unlikely, it is possible that animals dispersing from other areas would be deterred from immigrating into areas with high noise levels.

Assuming habitat abandonment does not occur, individuals, particularly those exposed to the highest noise levels, could experience reduced fitness and cumulative stress from noise exposure. It is also possible that individuals would recover during the relatively quiet days (i.e., weekdays between training events). Habituation to some level of noise is also very likely. For example, individuals occupying areas away from the noise source would be most likely to habituate because noise levels would be lower and visual and other cues would be limited. As discussed above, long-term monitoring data indicate that military training at Orchard Training Area in southwestern Idaho, which is similar to the training proposed at NWSTF Boardman, does not appear to affect population dynamics of the Piute ground squirrel.

**Disruption of Estivation/Hibernation**

A possible response to high noise levels would be for Washington ground squirrels to emerge from estivation/hibernation at inappropriate times. If squirrels emerged in response to noise, they would expend energy at a time when they need to minimize energy use. Frequent emergence could result in decreased fat reserves when limited resources are available to replenish those reserves.

Recorded motorcycle noise (95 dBA) caused estivating spadefoot toads to emerge from their burrows in a laboratory experiment (Brattstrom and Bondello 1983). In the wild, auditory cues (e.g., thunder and rain) stimulate spadefoot toads to emerge (Dimmitt and Ruidal 1980). There is no indication that estivating/hibernating Washington ground squirrels or other rodents would be stimulated by auditory cues in the same manner. Bowles (1995) reports that sleeping, estivating, and hibernating mammals are difficult to arouse with noise, particularly meaningless noise (i.e., noise that is not accompanied by an actual threat to the animal). However, Bowles (1995) does not present specific data on noise levels that would or would not arouse sleeping, estivating, and hibernating mammals. Speakman *et al.* (1991) evaluated energy expenditure in hibernating bats in response to various tactile and non-tactile stimuli, including 5-second bursts of generated sound (greater than 90 dB including background). The susceptibility of bats, as measured by energy expenditure, to all five classes of non-tactile stimulation was low. Only one positive response was measured in 39 applications of sound. The failure of non-tactile stimuli to cause arousals from hibernation may arise because there are selective advantages (i.e., energy conservation) to not arousing to such stimuli in the wild (Speakman *et al.* 1991). This study suggests that loud impulsive noises (e.g., detonating a large explosive charge), which also produce substantial ground vibration (i.e., tactile stimulation), might be more likely to wake a Washington ground squirrel compared to higher frequency noises that produce less ground vibration (e.g., aircraft overflights).

### *5.2.4 Fixed-Wing Aircraft Noise*

Fixed-wing aircraft overflights take place at various altitudes and airspeeds throughout the special use airspace (Figure 1 in the Assessment) and most occur during the daytime (Table 7). Fixed-wing aircraft do not takeoff or land at NWSTF Boardman and military aircraft do not fly at supersonic speeds in NWSTF Boardman airspace. Only low-altitude flights are a concern from a wildlife exposure perspective because aircraft flying above 3,000 ft. (914.4 m) above ground level are not expected to produce a meaningful response in most wildlife. Low-altitude flights generally occur below 3,000 ft. (914.4 m) above ground level and as low as 200 ft. (30.5 m) above ground level for brief periods. These low-altitude flights take place in Restricted Areas 5701A-E, which consists of 209 $nm^2$ of airspace (Figure 1in the Assessment).

The aircraft noise levels that Washington ground squirrels could be exposed to would vary based on exercise-specific conditions including flight tracks, altitude, air speed, and the type of aircraft. Animals on or near the ground and directly under the flight track centerline could be exposed to the noise levels listed in Table 14.

**Table 14. Estimated Average Sound Exposure Level of Single Aircraft Overflights at Various Distances**

| Representative Aircraft Type | Sound Exposure Levels (dBA) at Distance from Source (feet) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **100** | **200** | **400** | **800** | **1,600** | **3,200** | **6,400** |
| **Fixed-Wing** | | | | | | | |
| EA-6B | 130.4 | 125.8 | 120.9 | 115.6 | 109.6 | 102.5 | 93.8 |
| F-15 | 123.6 | 119.0 | 114.1 | 108.8 | 102.8 | 95.8 | 87.2 |
| F-16 | 117.8 | 113.2 | 108.5 | 103.3 | 97.4 | 90.5 | 81.6 |
| FA-18* | 120.8 | 116.2 | 111.3 | 105.9 | 99.6 | 92.1 | 83.2 |
| AV-8 | 116.2 | 111.5 | 106.2 | 100.2 | 93.3 | 85.6 | 77.2 |
| **Helicopters** | | | | | | | |
| CH-47 | 99 | 94.6 | 90 | 85.1 | 79.6 | 73.4 | 66.1 |
| UH-60 | 99.7 | 95.3 | 90.9 | 86.1 | 80.9 | 75.1 | 68.1 |

Notes: Approximate sound exposure levels calculated using United States Air Force SELCAL model, assuming a direct overflight with a 0-degree slant angle, level flight, and 85 percent power. dBA = decibels, A-weighted. *The EA-18G Growler is an electronic combat version of the FA-18 E/F that will replace the EA-6B Prowler. As a replacement for existing aircraft, the introduction of this system would not result in substantially different noise levels from the FA-18.

Exposure to fixed-wing aircraft noise would be intermittent and brief (seconds) as an aircraft quickly passes overhead. The rate of increase in sound level, which is referred to as the onset rate, is sudden for jet aircraft flying at low altitudes and high airspeeds. The number of times an individual animal could be exposed to aircraft noise during a specific time period (day, month, year, etc.) would be highly variable based on factors such as specific training schedules, flight tracks, altitudes, number of participating aircraft, and biological factors such as diurnal and seasonal behavior. Given the number of annual sorties (about 1,668), the total annual flight time below 3,000 ft. (914.4 m) above ground level (about 2,049 hours), and a typical exercise duration of 1.5 hours, some individuals could be exposed to aircraft noise several times per day.

Figure 10 (in the Assessment) shows average day-night sound level (DNL) noise contours for fixed-wing aircraft under the Proposed Action. While the DNL metric and contours are intended to help describe potential impacts to humans, the 65 and 70 dB contours also indicate where potential exposure of Washington ground squirrels to noise from low-altitude overflights could be most frequent. The DNL contours indicate that Washington ground squirrels could be exposed to aircraft noise most frequently around the strafing pit and within a narrow corridor west of the Main Target Area.

Aircraft overflights are not expected to result in hearing loss in Washington ground squirrels based on the expected SELs (Table 14) and frequency of exposure. Based on responses of other animals (National Park Service 1994, Bowles 1995, Larkin 1996), it is likely that noise from at least some aircraft overflights would elicit physiological or behavioral responses in Washington ground squirrels. For example, overflights might cause a startle response, which includes a physiological component (e.g., rapid increase in heart rate, shutdown of nonessential functions, and mobilization of glucose reserves) and a behavioral component (Bowles 1995). The behavioral component could be similar to responses to predators or other natural threats, and might include alert behavior, alarm calls, or retreating underground. Squirrels would be expected to quickly recover from these short-term responses, and no long-term effects on the fitness of individuals would be expected.

In addition, it is likely that squirrels have habituated to current levels of aircraft overflight noise at NWSTF Boardman. Washington ground squirrels are known to occur at NWSTF Boardman and on adjacent undeveloped lands to the west. These areas are located under low-altitude flight tracks. Washington ground squirrel populations in these areas have been exposed to noise associated with military aircraft and other military readiness activities for more than 50 years. Washington ground squirrel population dynamics at NWSTF Boardman are not fully understood and the effects of aircraft overflights on squirrel populations have never been studied. Nonetheless, available data indicate that squirrel populations at NWSTF Boardman respond to factors such as precipitation and available forage as would be expected. There is no evidence that suggests current levels of aircraft overflights or other noise influence population dynamics at NWSTF Boardman.

Noise associated with aircraft overflights, under the Proposed Action, are likely to have some effects to Washington ground squirrels. The effects are expected to be limited to short-term physiological and behavioral responses, and no long-term effects on the fitness of individuals would be expected.

*.2.5 Helicopter Noise*

Helicopter overflights take place below 3,000 ft. (914.4 m) above ground level throughout the special use airspace (Figure 1 in the Assessment), but most helicopter activity occurs directly over the NWSTF Boardman land area. About 93 annual helicopter sorties would take place under the Proposed Action for a total of about 137 flight hours and typical flight durations of 1.5 hours. Approximately 33 percent of the flight hours would occur at night (Table 4). About 72 annual helicopter sorties currently take place at NWSTF Boardman for a total of 108 flight hours per year. Helicopters land and take off at NWSTF Boardman occasionally. Representative helicopter flight altitudes are less than 500 ft. (152 m) above ground level during training exercises. Some exercises might include hovering approximately 20 ft. (6.1 m) off the ground for several minutes. Washington ground squirrel exposure to helicopter noise would be intermittent and infrequent based on the annual number of sorties (93) that would occur under the Proposed Action. Table 14 provides representative helicopter noise levels that squirrels could be exposed to in the NWSTF Boardman Action Area. The duration of exposure to noise from a helicopter would be longer than a fixed-wing aircraft overflight because helicopters fly at slower airspeeds, and hover, land, and takeoff at NWSTF Boardman. Nonetheless, most exposures would still be brief (seconds to minutes). As noted above, most helicopter activity takes place over the NWSTF

Boardman land area and is less dispersed compared to fixed-wing aircraft overflights. Therefore, repeated exposure of an individual animal to helicopter noise during a given exercise is more likely than that of a fixed-wing aircraft overflight. The onset rate for helicopter noise is lower than that of a fixed-wing aircraft.

Similar to fixed-wing aircraft overflights, aircraft overflights are not expected to result in hearing loss in Washington ground squirrels based on the expected SELs (Table 14) and frequency of exposure. Low-altitude helicopter overflights are expected to elicit short-term physiological or behavioral responses in Washington ground squirrels, which may be triggered by noise, visual cues, the downwash from the rotor blade, or a combination of these stimuli. Washington ground squirrels would likely perceive low-flying or hovering helicopters as a threat and could temporarily retreat underground. Given the expected SELs and frequency of exposure, squirrels would be expected to quickly recover from these short-term responses, and no long-term effects on the fitness of individuals would be expected.

### *5.2.6 Unmanned Aerial Systems Noise*

UAS overflights take place at various altitudes and airspeeds throughout Restricted Areas 5701A-E and 5706 (Figure 6 in the Assessment). About 85 percent occur during the daytime (Table 7). The RQ-7 Shadow and RQ-11 Raven take off and land at NWSTF Boardman and typically fly below 3,000 ft. (914.4 m) above ground level. The ScanEagle is launched at facilities located outside of NWSTF Boardman and 85 percent of this platform's flight time is above 3,000 ft. (914.4 m) above ground level. Of the 1,709 annual UAS sorties, 1,475 are ScanEagle sorties. UAS are estimated to be significantly quieter than the manned fighter jets so, even though the UAS account for more than half of the total proposed aircraft sorties, their noise contribution to the overall aircraft noise is negligible. However, noise and visual cues associated with UASs taking off and landing could elicit short-term physiological or behavioral responses in Washington ground squirrels, but no long-term effects on the fitness of individuals would be expected.

### *5.2.7 Noise Associated with Training Activities on the Proposed Ranges*

**Overview**

The Proposed Action includes construction and operation of four new training ranges (Figure 1, Table 1):

- The MPMGR would be used for small arms (up to and including .50 caliber weapons) training
- The eastern CLFR would be used for small arms (up to and including .50 caliber weapons) training
- The western CLFR would be used for small arms (up to and including .50 caliber weapons) training
- The DTR would be used for high explosive charge (up to and including 200 lb. [90.7 kg] NEW charge) detonation training

Washington ground squirrel exposure to noise and potential responses to noise exposure depend on loudness of the weapons or munitions used, the number of days the range is used per year, the time interval between noise events (i.e., frequency of weapons firing during the training), seasonal use of the ranges, and the presence or absence of squirrels in the exposed habitats. Figure 9 shows the single-event 130 and 140 dBP noise contours for the MPMGR, eastern CLFR, and western CLFR based on the loudest weapon or munitions (.50 caliber) used on each of these ranges. The noise contours would be smaller when other weapons are fired on these ranges. These single-event noise contours depict the land area that could be exposed to the specified peak sound level and represent a composite of the sound fields surrounding all firing positions on the range. Table 15 provides a summary of range use for the MPMGR and CLFRs, and the land area within the 140 dBP noise contour. Portions of the MPMGR and western CLFR noise contours overlap; however, these contours would not actually overlap in time because the MPMGR and western CLFR would not be used simultaneously.

**Table 15. Summary of Range Use and Land Area within the 140 Decibel Peak Noise Contours for the Multi-Purpose Machine Gun Range and Convoy Live Fire Ranges Under the Proposed Action**

| Range | Days Used Per Year | Seasonal Use | Loudest Weapon | Land Area (acres) within the 140 Decibel Peak Noise Contours for Loudest Weapon |
|---|---|---|---|---|
| Multi-Purpose Machine Gun Range | 117 | Year Round | .50 caliber | 100 |
| Eastern Convoy Live Fire Range | 45 | Year Round | .50 caliber | 113 |
| Western Convoy Live Fire Range | 45 | Year Round | .50 caliber | 199 |

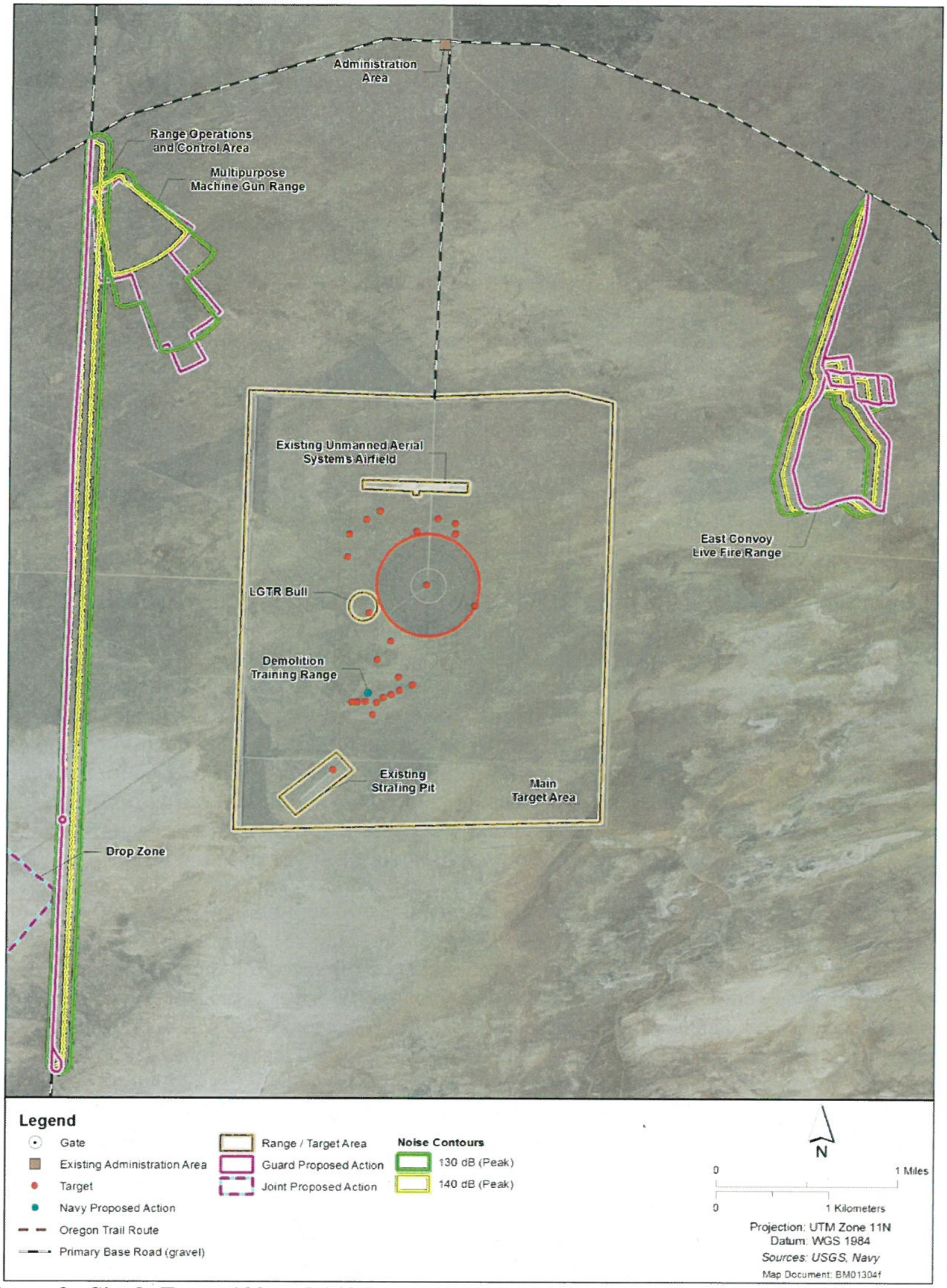


**Figure 9. Single Event 130 and 140 Decibel Peak Noise Contours (approximate) for the MPMGR and CLFRs**

**Multi-Purpose Machine Gun Range**

The MPMGR would be used year round, about 117 days per year, and primarily on weekends. The loudest weapon used on this range would be a .50 caliber machine gun or rifle. Training events on the MPMGR would take place in a deliberate progression that involves steps prior to firing weapons. For example, a representative event could include the following:

- Advance crews would arrive to place targets and ensure the range is clear of non-participants.
- Units and equipment would arrive and training plans, safety, and standard operating procedures would be reviewed.
- Weapons would be sighted with a few initial shots, after which feedback is obtained before firing the next series of shots.
- Firing would occur intermittently from about 9:00 a.m. to 6:00 p.m. during 20-minute blocks. Total firing time would be about 2 hours per day. Multiple rounds would be fired from weapons on up to 10 firing lanes during a 20-minute block. Some shots would be fired in rapid succession, but firing would not be continuous during a 20-minute firing block.

The entire MPMGR is historically occupied Washington ground squirrel habitat (Figure 7) based on known squirrel detections through 2009 (Figure 6). If Washington ground squirrels occupy habitats on or near the MPMGR following construction, individuals would be exposed to weapons firing noise approximately 2 days per week (estimate 29 –88 days of use per year during the above-ground period.[25%-75% of the days/yr.]). When the range is active, squirrels would be intermittently exposed to noise about 2 hours per day during six 20-minute blocks of firing time. Based on repeated exposures over a two-day training period and the information discussed above in the conceptual framework (Section 5.2.3), it is possible that squirrels within the 140 dBP noise contour could experience noise-induced threshold shift and associated negative effects on individual fitness. Behavioral and physiological responses of squirrels to noise within the 140 dBP contour could also result in reduced fitness of individuals.

The 140 dBP noise contour for the MPMGR covers about 100 ac. (40.5 ha), 97 ac. (39.3 ha) of which are located within the range footprint (Figure 9 and Table 15). The range footprint and most of the area within the 140 dBP contour would also be subjected to other disturbances during training, including general human activity, vehicle operations, target maintenance, projectiles impacting the ground, and small, training-caused wildfires. Some habitat within the 140 dBP contour would also be permanently lost and temporarily disturbed during construction (see Section 5.3 for detailed analysis of ground disturbing activities and habitat alteration). Although it is difficult to predict exactly how each of these stressors would affect Washington ground squirrels and their habitat, it is likely that the combined effects would result in long-term habitat degradation and a reduction in squirrel abundance in the affected area.

As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise. Although noise thresholds are not available for Washington ground squirrels, long-term effects are most likely to occur in areas within the 140 dBP contour. As discussed in Section 1.5, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the MPMGR range footprint and 140 dBP contour through habitat restoration and enhancement in other areas on NWSTF Boardman. The adaptive management and monitoring process described in Section 1.6 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contour.

**Eastern and Western Convoy Live Fire Ranges**

Convoy live fire training would be conducted about 45 days per year, primarily on weekends. The loudest weapon used on these ranges would be a .50 caliber machine gun. One or both of the CLFRs could be used during a training event, but firing would not occur simultaneously on both ranges. Approximately 50 percent of the total annual CLFR training time would be spent on each range. Up to platoon-sized (25 to 50 personnel) convoys would navigate the CLFR within vehicles armed with a machine gun. When units within a vehicle detect an activated target, they would engage the target with bursts of fire (typically seven to nine rounds) from one or more machine guns. Firing on an individual target may occur intermittently for a period of less than a minute. Units would then continue to navigate the CLFR, and detect and engage targets until the training event is concluded. Targets would be within about 328 ft. (100 m) of the CLFR roads and oriented so that firing is directed toward the center of NWSTF Boardman. Specific target locations and the number of targets activated and engaged could vary for each training event to increase training realism. A representative CLFR training event would include multiple scenarios, and multiple runs through the course. Approximately 16 training events could occur per representative 24-hour period. Three to six targets could be engaged per day and total firing time would be approximately 30 minutes within a 24-hour period.

Most of the land on and around the CLFRs is historically occupied Washington ground squirrel habitat (Figure 7) based on known squirrel detections through 2009 (Figure 6). If Washington ground squirrels occupy habitats on or near the CLFRs following construction, individuals would be exposed to weapons firing noise approximately 45 days per year (approximately 11 - 34 days during the above-ground activity period [25%-75% of the days/yr.]), primarily during 2-day training events. When the range is active, squirrels near active targets would be briefly (up to a few minutes) exposed to weapons firing noise while units engage the target. The potential for squirrels to be repeatedly exposed to weapons firing noise during a training event would depend on specific target placements. For example, if two targets were within approximately 200 ft. (61 m) of each other, their associated 140 dBP contours would overlap. In most cases the distance between targets would be more than 200 ft. (61 m), particularly on the western CLFR because of its linear layout. The layout of the eastern CLFR is non-linear; therefore, the potential for the sound fields associated with individual targets is more likely to overlap. As discussed above for the MPMGR, it is possible that squirrels within the 140 dBP noise contours of the CLFRs could experience noise-induced threshold shift and associated negative effects on individual fitness. Behavioral and physiological responses of squirrels to noise within the 140 dBP contour could also result in reduced fitness of individuals. However, the likelihood that these effects would occur on the CLFRs is lower than that of the MPMGR because the CLFRs would be used less frequently and the possibility of repeated exposure is less likely.

The 140 dBP noise contour for the eastern CLFR covers about 113 ac. (46 ha), which is located east of the range footprint, since this range would be located along an existing road for the majority of the range footprint (Figure 10 and Table 15). The 140 dBP noise contour for the western CLFR covers about 199 ac. (80.5 ha), 176 ac. (71.2 ha) of which are located within the range footprint. The CLFR noise contours presented in Figure 10 and the area within the 140 dBP contours presented in Table 15 assume that targets could be placed along the entire length of the CLFRs. Therefore, Figure 10 depicts continuous noise footprints along the length of the CLFRs to provide a worst-case, conservative estimate of the area potentially affected by noise. The actual noise footprint during a training event would not be continuous because discrete target locations would be established.

The range footprint and most of the area within the 140 dBP contours would also be subjected to other disturbances during training, including general human activity, vehicle operations, target maintenance, projectiles impacting the ground, and small, training-caused wildfires (see Section 5.3 for detailed analysis of ground disturbing activities and habitat alteration). Although it is difficult to predict exactly how each of these stressors would affect Washington ground squirrels and their habitat, it is likely that the combined effects would result in long-term habitat degradation and a reduction in squirrel abundance in the affected area.

As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise. Although noise thresholds are not available for Washington ground squirrels, long-term effects are most likely to occur in areas within the 140 dBP contour. As discussed in Section 1.5, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the CLFR range footprints and 140 dBP contours through habitat restoration and enhancement in other areas on NWSTF Boardman. The adaptive management and monitoring process described in Section 1.6 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contours.

**Demolition Training Range**

Figure 10 shows the single-event 130 and 140 dBP noise contours for the DTR based on a 200 lb. (90.7 kg) NEW charge (conservatively modeled as a 220 lb. [99.8 kg] NEW charge). The largest area of impact from the DTR would be when using a charge of 200 lb. NEW. Any charge size smaller than 200 lb. NEW would produce a smaller area of impact. Detonations on the DTR could be conducted any day of the week between the hours of 10:00 a.m. and 4:00 p.m. Explosive demolition training is not normally planned to occur in the June to September time frame to help mitigate wildland fire potential, though seasonal conditions and training times may vary. DTR training includes additional BMPs to help reduce noise levels for training with charges greater than 100lbs (45.4 kg) NEW. These could include: training during times with optimal weather conditions to attenuate noise, burying the explosive charge, or bunkering the charge with sand bags. A representative annual training scenario for explosive detonation training on the DTR is provided in Table 16.

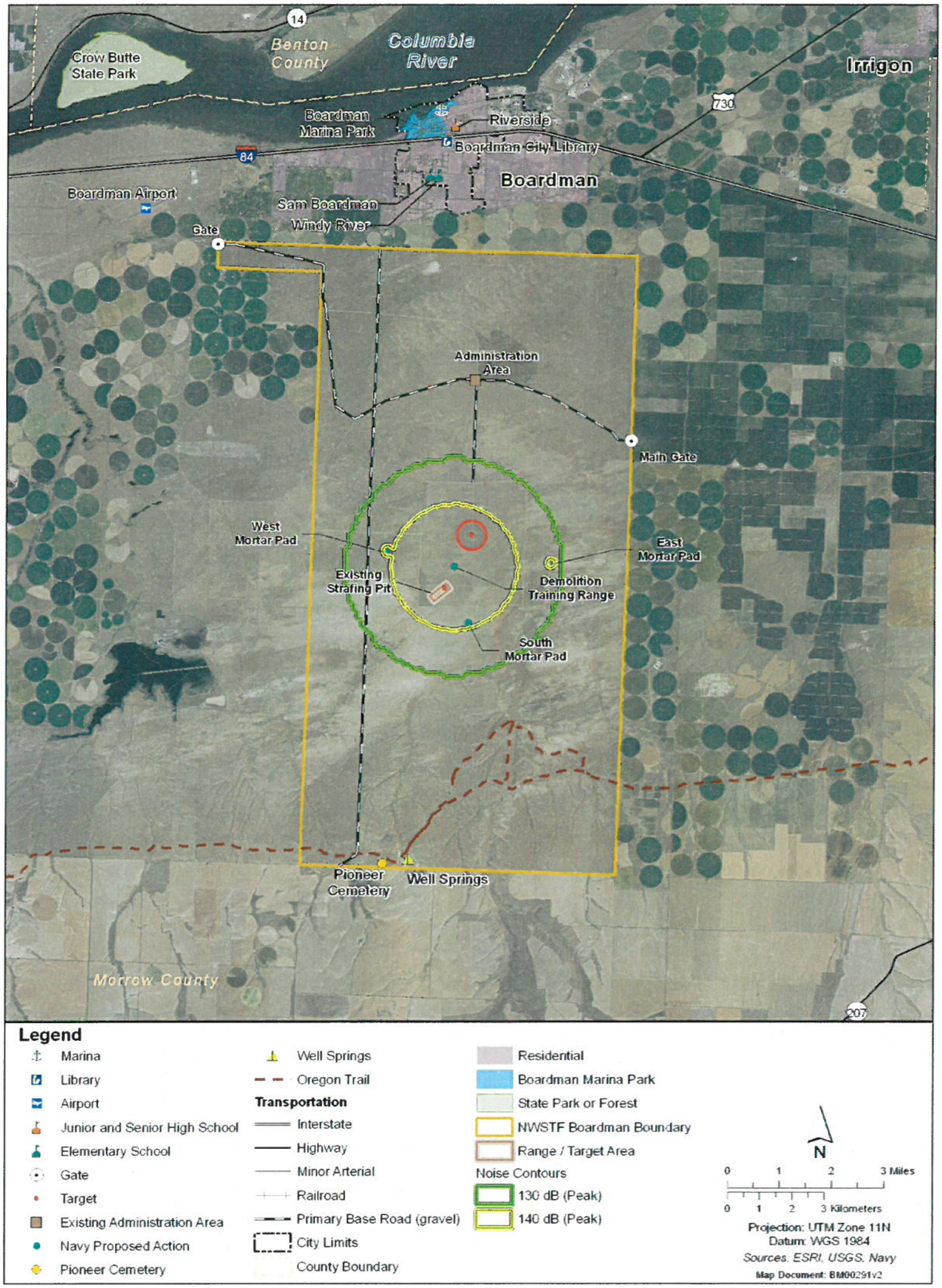


**Figure 10. Projected Single Event Noise Contours for Ordnance Activities Associated with the Main Target Area, Strafe Pit, and Demolition Training Range under the Proposed Action**

**Table 16. Representative Annual Training Scenario for the Proposed Demolition Training Range**

| Net Explosive Weight | Events Per Year (Days) | Detonations Per Event | Total Detonations Per Year |
|---|---|---|---|
| 200 lb. | 2 | 1 | 2 |
| 100 lb. | 3 | 1 or 2 | 5 |
| 50 lb. | 3 | 1 to 6 | 10 |
| 25 lb. | 4 | 1 to 6 | 20 |
| <25 lb. | 3 | 1 to 6 | 13 |
| **Total =** | **15** | | **50** |

Notes: lb. = pounds, < = less than

While the noise footprint associated with the DTR would be large, this range would be used relatively infrequently. Washington ground squirrels within the 140 dBP contours associated with the DTR would be expected to exhibit short-term behavioral and physiological responses to noise, but the time interval between detonations would likely allow for recovery. Seasonal restrictions on the use of charges over 50 lb. NEW would also help to minimize negative effects to active Washington ground squirrels. Based on the relatively infrequent use of the DTR and the limited potential for repeated exposure over short periods of time, noise associated with use of the DTR is not expected to result in long-term habitat degradation or a reduction in squirrel abundance in the affected area. The adaptive management and monitoring process described in Section 1.6 would be used to reduce uncertainty associated with potential effects of noise associated with the DTR.

Based on the above, noise associated with weapons firing and detonation of high explosive training activities on the proposed ranges may cause some short-term adverse effects to Washington ground squirrels.

### *5.2.8 Non-explosive Practice Munitions Noise*

Air-to-Ground Bombing Exercises at NWSTF Boardman involve dropping various non-explosive practice bombs from fixed-wing aircraft within the Main Target Area (Table 1 and Table 3). A typical exercise might involve dropping two to six non-explosive practice bombs in successive target runs. Though non-explosive practice munitions do not contain a high-explosive charge that detonates on impact, most practice munitions contain a small spotting charge that allows the unit conducting the training to see the impact location through a flash and puff of smoke generated by the spotting change on impact. When a non-explosive practice bomb makes contact with the target, kinetic energy would be transferred and sound would be generated. Sound associated with the impact event is typically of low frequency (less than 250 Hertz) and of a short enough duration (i.e., impulsive sound) that it produces negligible amounts of acoustic energy. This noise would co-occur with aircraft overflight noise. While wildlife near the impact point would likely respond to the overall noise event, it would be difficult to distinguish between responses to the impact noise and the overflight noise, which has a larger footprint. Noise associated with a non-explosive practice bomb impacting the target was not addressed as an independent noise stressor because noise from practice bombs striking the target would co-occur with aircraft noise. Noise associated with non-explosive practice bombs is not addressed in further detail.

### *5.2.9 Vehicle and Equipment Noise*

Vehicles and equipment used during construction and ground-based training activities would produce noise intermittently. Individual pieces of commonly used construction equipment typically generate noise levels of 80 to 88 dBA (U.S. Department of Transportation, Federal Highway Administration 2006). During the peak construction activities multiple pieces of equipment could be operating simultaneously and noise levels could be elevated during daytime periods at locations near the construction site. Washington ground squirrels would likely respond to construction equipment by exhibiting alert behavior, making alarm calls, or retreating underground. These responses may be generated by visual cues, noise, or a combination of visual cues and noise. Washington ground squirrels in the vicinity of persistent equipment operation could be displaced and become more susceptible to predation.

Vehicle and equipment use during ground-based training would include transport of Soldiers to and from the range in buses or vans and operation of tactical equipment such as high-mobility multipurpose wheeled vehicles. In addition to traveling to and from the range, tactical equipment would be operated on the eastern and western CLFRs, which would be used about 45 days per year. A high-mobility multipurpose wheeled vehicle generates noise levels of less than 85 dBA at the crew positions when traveling at 30 miles per hour (U.S. Department of the Army 2013). Unlike construction activities where equipment may be operated in one area for several hours, training activities would primarily involve vehicle pass-by events. Washington ground squirrels would likely respond to visual cues and noise from a passing vehicle by exhibiting alert behavior, making alarm calls, or retreating underground. Squirrels would be expected to return to normal behavior soon after a vehicle or series of vehicles pass.

In summary, construction equipment operation has the potential to temporarily displace Washington ground squirrels and increase their susceptibility to predation. Vehicle and equipment operation during training activities is expected to result in short-term behavioral responses, but no long-term effects to Washington ground squirrel fitness would be expected. These effects would likely be attributable to both visual cues and noise.

### *5.2.10 Summary of Effects from Noise*

A relatively small portion of NWSTF Boardman would be exposed to noise levels that could cause physiological and behavioral responses in Washington ground squirrels. Individuals within the 140 dBP noise contours for MPMGR (235 acres within the range footprint and noise contour is approximately 0.4% of the total NSWTF Boardman property) would be repeatedly exposed to loud noise on most weekends, and could experience reduced fitness from hearing threshold shift or behavioral and physiological responses. Squirrels could also be repeatedly exposed in the 140 dBP contours for the CLFRs, but the frequency of exposure would be much lower than the MPMGR.

As previously discussed, well-established thresholds or criteria for predicting impacts of noise on terrestrial wildlife do not exist. While a specific noise threshold cannot be defined to predict long-term impacts to Washington ground squirrel fitness based on available data, the Navy and ORNG used 140 dBP to estimate the area where long-term Washington ground squirrel habitat degradation could occur as a result of weapons firing noise on the proposed MPMGR and CLFRs. This value was used because squirrels repeatedly exposed to 140 dBP could experience hearing threshold shifts based on available data for chinchillas and humans (e.g., Hamernik *et al.* 1987, Humes *et al.* 2005, U.S. Army Public Health Command 2010). Given the potential for threshold shift, it is also logical to assume that squirrels would exhibit a strong and consistent behavioral and stress response to 140 dBP. It is also likely that squirrels would be exposed to visual and other cues within the 140 dBP contours, making it more likely that squirrels would perceive the loud noise as a threat. When loud noises are perceived as a threat, animals are less likely to habituate to the noise. With repeated exposure to 140 dBP over a two-day training period, which could occur on the MPMGR and CLFRs, it appears likely that squirrels could experience reduced fitness, even if threshold shift did not occur. As discussed in Section 1.5, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the MPMGR and CLFR range footprints and their associated 140 dBP contours through habitat restoration and enhancement in other areas on NWSTF Boardman.

The Navy and ORNG acknowledge that Washington ground squirrels would respond to some sound levels below 140 dBP. In addition, it is possible that sound levels below 140 dBP could contribute to long-term habitat degradation when accompanied by visual cues, human activity, ground disturbance, wildfire, or other stressors. As discussed in Section 5.3, these other stressors would be expected to occur within the range footprints. Therefore, the area within the range footprints, plus the area of the 140 dBP noise contours for the MPMGR and CLFRs outside the range footprints, was defined as the area of long-term habitat degradation for mitigation planning purposes. As depicted in Figure 10, most of the 140 dBP contours for the MPMGR and CLFRs and a substantial portion of the 130 dBP contour for the MPMGR are within the range footprints. Sound levels below 140 dBP occurring outside the range footprints were not considered as long-term habitat degradation for mitigation planning purposes because:

- As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise.
- The MPMGR and CLFRs would primarily be used on weekends, providing squirrels the opportunity to recover from noise exposures.
- Although studies conducted at Orchard Training Area did not specifically evaluate Piute ground squirrel responses to noise, long-term monitoring data suggest that noise and other potential stressors associated with military training do not appear to be impacting Piute ground squirrel populations at the training area.
- Monitoring and adaptive management measures will be developed and implemented to help reduce uncertainty.

Proposed compensatory mitigation for unavoidable effects on Washington ground squirrel habitat is discussed in detail in Section 1.5. The adaptive management and monitoring process described in Section 1.6 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contours. Noise associated with portions of the Proposed Action is likely to cause adverse effects to Washington ground squirrels.

## *5.3 Ground Disturbing Activities and Habitat Alteration*

### *5.3.1 Introduction*

This section analyzes potential effects of ground disturbing activities on Washington ground squirrel habitat, as well as other stressors that could alter habitat. Proposed activities that would result in ground disturbance include construction, training (non-explosive practice munitions striking the ground and vehicle and equipment operations), and maintenance (fire break and target maintenance). The potential for these activities to directly injure Washington ground squirrels is addressed separately in Section 5.4, *Physical Strikes*, and effects of noise and general disturbance associated with these activities were addressed in Section 5.2, *Noise*. Other stressors analyzed in this section that could alter habitat include invasive plants and wildfire.

### *5.3.2 Construction Activities*

Site excavation, grading, and equipment operations during construction of the proposed range enhancements would result in temporary disturbances to the ground surface. The area of disturbance for individual construction projects would range from less than 1 to 30 ac. (0.4 to 12 ha). The total area of disturbance would be 65 ac. (26 ha), 25 ac. (10 ha) of which are previously disturbed (mostly consisting of existing gravel or dirt roads). Approximately 40 ac. (16 ha) of previously undisturbed area would be affected, about 25 ac. (10 ha) would be permanently converted to development, and about 15 ac. (6 ha) would be temporarily disturbed and revegetated in accordance with the post-construction revegetation plan (Appendix A). Construction activities for the range enhancements would be spaced over a period of several years as funding becomes available. Therefore, the total area of disturbance at any given time during construction would be much less than 65 ac. (26 ha).

Annual grass/forb, bunchgrass, and open-low shrub communities would be affected by construction based on 1997 vegetation survey data. Ecological condition classifications for the area of disturbance range from medium to low based on data collected in 2013. With the exception of the UAS Airfield and Maintenance Facility and the Range Operations Control Center, the area of disturbance is historically occupied Washington ground squirrel habitat (Figure 7) based on known detections recorded through 2009 (Figure 6). As previously discussed, a systematic Washington ground squirrel survey of the entire NWSTF Boardman property has not been conducted. Therefore, the distributions of squirrel detections and historically-occupied habitat presented in Figures 6 and 7 are, in part, a reflection of variable survey effort. As discussed in Section 1.6.4 *Monitoring*, systematic surveys would be conducted prior to construction to support micrositing decisions. Micrositing would involve looking at proposed construction sites at a "micro" level to identify sensitive features that should be avoided to the extent practicable. Occupied Washington ground squirrel habitat and areas with higher ecological condition classifications (e.g., undisturbed areas with a relatively high percentage of native plant cover) would be avoided in favor of unoccupied habitat with lower ecological condition classifications (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable. Micrositing efforts would primarily be aimed at the UAS Airfield and Maintenance Facility and the Range Operations Control Center. The ability to microsite ranges would be limited based on safety constraints.

As noted above, approximately 25 ac. (10 ha) would be permanently converted to development. Washington ground squirrel habitat in these areas would be permanently lost. The area of permanently lost habitat would be small relative to the total land area at NWSTF Boardman (0.05 percent). Approximately 15 ac. (6 ha) temporarily disturbed during construction would be revegetated and maintained in accordance with the proposed post-construction revegetation plan (Appendix A). After restoration, disturbed areas could provide foraging habitat for Washington ground squirrels. Restoration efforts would include establishment of native plants. Foraging habitat quality could be improved in temporarily disturbed areas that were dominated by invasive plants prior to disturbance, if these areas are not subject to further disturbance during operation of the ranges (see analysis below for training and maintenance activities). The suitability of temporarily disturbed and restored areas for burrowing habitat would depend on the level of disturbance. For example, the natural soil profile would be altered in areas subject to grading or trenching activities. It is unlikely that these areas would be suitable for burrowing for several years following construction. Therefore, a long-term, but not permanent, loss of Washington ground squirrel habitat would occur in temporarily disturbed and restored areas (15 ac.).

### *5.3.3 Training Activities*

Training activities on the proposed new ranges would result in increased ground disturbance and habitat alteration. Habitat around targets on the new ranges would be disturbed by non-explosive practice munitions striking the ground and during target maintenance. Some of the areas affected would coincide with areas temporarily disturbed during construction, thus hampering restoration efforts. Areas disturbed by projectile impacts would likely be colonized by invasive plants, which would further reduce habitat quality. Invasive plants are discussed in more detail in Section 5.6.5.

Training activities conducted under the Proposed Action would increase the risk of wildfire at NWSTF Boardman. Effects of training-caused wildfires are analyzed in more detail in Section 5.6.6.

Vehicle and equipment use would increase substantially (over the current use) under the Proposed Action during ground-based training events. However, vehicles, including tracked vehicles, would continue to use existing roads or new gravel roads constructed under the Proposed Action. No off-road maneuver training is proposed. Vehicle and equipment use during training activities would not result in ground disturbance, but would provide pathways for invasive plant seed dispersal. As discussed in other sections, vehicle strikes, noise, and general disturbance associated with vehicles and equipment used during training could affect Washington ground squirrels.

### *5.3.4 Maintenance Activities*

Target and fire break maintenance would result in ground disturbance under the Proposed Action. Current target maintenance within the Main Target Area would continue under the Proposed Action. The Main Target Area includes the main bull's eye, the strafing pit, the laser-guided training range bull's eye, and several single targets or grouped target sets (e.g., old vehicles, tanks, etc.). The vegetation in and around each of these targets must be maintained or removed for fire safety and to provide a viable visual cue to pilots. This is accomplished by mechanical disturbance (i.e., plowing or disking) with a tractor one time per year. Approximately 23 ac. (9.3 ha) in the Main Target Area would continue to be subjected to this maintenance under the Proposed Action.

Maintenance activities on the MPMGR and the CLFRs would include periodic maintenance, repair, and replacement of targets and target support mechanisms. Gravel roads associated with the CLFRs would be graded or could include placement of additional gravel. Periodic vegetation control may be required to reduce fire fuel loading or manage exotic vegetation and would be conducted as authorized in approved natural resource and fire management plans. Targets on the CLFRs would be relocated periodically to vary the training, and former target locations would be revegetated with native species.

Currently, approximately 462 ac. (187 ha) of fire breaks throughout NWSTF Boardman are maintained annually by mechanical disturbance (e.g., plowing or disking) with a tractor. The Draft Integrated Wildland Fire Management Plan (Appendix H of the DEIS) includes proposed modifications to the existing system of fire breaks. The width of some fire breaks would be reduced to the width of the adjacent road, some fire breaks that do not follow roads would be eliminated, and two new fire breaks totaling about 19 ac. (7.7 ha) would be created (Figure 11). The total area of fire breaks that would be maintained annually by mechanical disturbance (plowing or disking with a tractor) would decrease from 462 ac. (187 ha) to 243 ac. (98 ha).

Establishment and maintenance of the two new fire breaks would alter 19 ac. (7.7 ha) of potentially suitable Washington ground squirrel habitat. However, a long-term revegetation plan (Appendix A) would be implemented to restore the areas removed from mechanical maintenance. These areas would be re-vegetated with native bunchgrasses, primarily Sandberg's bluegrass with some needle and thread or bluebunch wheatgrass, to provide a low-structure and low-fuel load area next to the road/fire break, and also provide some wildlife habitat value. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80 percent density of a representative bunchgrass stand area within two to three years of seeding. Selective herbicide treatments or other appropriate management actions would be used to control invasive plants until these areas are completely restored.

The proposed modifications to the fire break system would result in long-term benefits to vegetation communities at NWSTF Boardman by restoring approximately 219 ac (89 ha) of mechanically-disturbed land to native plant communities, which would also reduce the potential for soil erosion, reduce the likelihood of invasive plant infestations, and improve Washington ground squirrel foraging habitat. Native plants appear important to Washington ground squirrels, with Sandberg bluegrass playing a key role in their diets (Tarifa and Yensen 2004a,b). Restoration would also allow natural soil profiles to begin to naturally recover in these areas. While these areas might eventually provide suitable Washington ground squirrel burrowing habitat, the soil recovery process could take several years to decades. Long-term benefits associated with fire break restoration (219 ac. [89 ha]) would help to offset impacts to Washington ground squirrel habitat from construction activities. Nonetheless, about 25 ac. (10

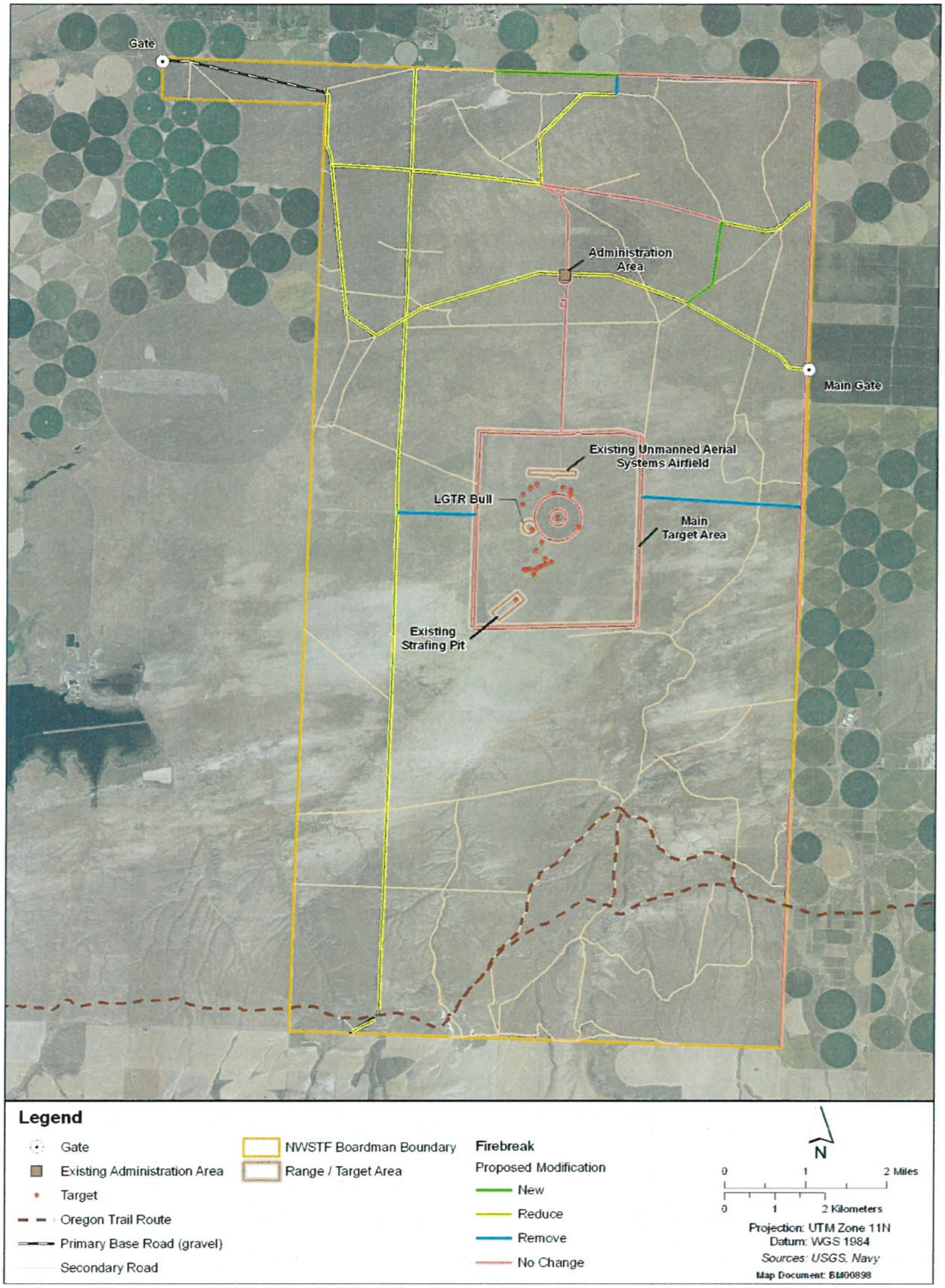


**Figure 11. Proposed Fire Break Modifications at Naval Weapons Systems Training Facility Boardman**

ha) of potential Washington ground squirrel habitat would be permanently converted to development under the Proposed Action.

### *5.3.5 Invasive Plants*

Vegetation communities and Washington ground squirrel habitat at NWSTF Boardman would continue to be affected by invasive plants under the Proposed Action. Non-native invasive plants, including cheatgrass, threaten squirrels by competing with native plants that are important for ground squirrel diets. Exotic annual plant species provide an unstable food resource for ground squirrels because their productivity fluctuates with annual precipitation (Yensen *et al.* 1992). Washington ground squirrels do eat non-native species, including cheatgrass (Tarifa and Yensen 2004a, Tarifa and Yensen 2004b), but native perennial plant species are more drought-tolerant than annuals. When annual plants dominate the landscape, there is less forage for ground squirrels during drought years and it is available for a shorter period of time (Yensen *et al.* 1992). Further, plant communities dominated by exotic annuals have lower diversity, reducing dietary choices and probably the ability to avoid toxic secondary compounds (Quade 1994). Exotic-dominated communities are also far more likely to burn than native vegetation (Whisenant 1990).

Ground-disturbing activities described above would continue to indirectly affect native plant communities by creating favorable conditions for establishment of invasive plants and providing pathways for seed dispersal. Construction and operation of the proposed new ranges would exacerbate existing invasive plant problems. Construction and military vehicles and equipment coming from offsite would provide a new pathway for introduction of invasive plants and would be a dispersal mechanism for seeds at NWSTF Boardman.

As discussed in Section 1.4, several BMPs would be implemented to avoid invasive plant infestations, monitor invasive plants, and adaptively manage invasive plants during construction and over the life of the proposed training ranges. In addition to project specific mitigations, NWSTF Boardman-wide invasive plant and noxious weed management actions would be implemented as part of the *NWSTF Boardman INRMP*, with increased efforts to reflect new threats introduced by the Proposed Action. The invasive plant and noxious weed management actions, developed in cooperation with the Service and ODFW, would be reviewed annually and updated as necessary. Key elements of the plan include the following:

- Standard operating procedures for preventing and minimizing the introduction and spread of invasive plants
- Updates of the invasive plant inventory and mapping prior to implementing the Proposed Action
- Responsibilities and procedures for integrating efforts of the Navy, ORNG, and The Nature Conservancy
- Criteria for prioritizing management actions
- Short- and long-term monitoring programs
- Annual work plans, including funding requirements and funding sources

### *5.3.6 Wildfire*

Wildfire, in combination with invasive plants, has affected vegetation and Washington ground squirrel habitat at NWSTF Boardman in recent years. Since 1998, wildfires burned more than 85 percent of NWSTF Boardman causing short- and long-term habitat alterations. Large fires swept portions of the installation in 1998 (17,514 ac. [7,088 ha]), 2007 (11,664 ac. [4,720 ha]), and 2008 (30,612 ac. [12,388 ha]), while smaller areas burned in 2002 (1,639 ac. [663 ha]) and 2009 (618 ac. [250 ha]) (Figure 13). With the exception of the 2009 fire, all of these fires were started by lightning strikes. The cause of the 2009 fire is unknown (U.S. Department of the Navy 2012a). Training-related wildfires also occur occasionally at NWSTF Boardman. Range safety monitoring by participating military units allows for early detection of training-related fires and rapid response. Therefore, fires that start during training activities are typically contained to relatively small areas compared to lightning-caused fires, which might go undetected for a period of time after ignition.

Historically, the area was comprised of fire-adapted vegetation communities with fire return intervals that likely ranged from about 20 to 70 years based on information for similar habitats (Leenhouts 1998, Paysen *et al.* 2000). With the widespread introduction of invasive, non-native annual grasses such as cheatgrass, the amount of fuel for wildfires has increased. Wildfires now tend to be more frequent and more severe (burn hotter), and can be long-term or permanent habitat altering events. Frequent and hot burning fires like those that have occurred at NWSTF Boardman favor a shift from shrublands to grasslands. Humple and Holmes (2001) documented decreases in sagebrush cover and increases in cover of grass, primarily cheatgrass, in study plots following the 1998 fire at NWSTF Boardman.

Increases in training under the Proposed Action would increase the risk of wildfire at NWSTF Boardman. Fires resulting from training activities would be expected to occur on the MPMGR and CLFRs, particularly during dry periods. To address these issues the Navy and ORNG prepared a Draft Integrated Wildland Fire Management Plan which contains a Fire Danger Rating and Wildland Fire Risk Management Matrix (Appendix H of the DEIS). The Plan would be finalized prior to implementing the Proposed Action and includes measures to prevent, monitor, and respond to wildfires. The Navy, ORNG, and other range users would implement the Plan.

While preventive measures are expected to reduce the incidence of training-caused fires, it is possible that one or more fires could occur on the ranges each year. Monitoring conducted during training exercises and onsite firefighting assets would ensure rapid response to training-caused fires, and would help to contain the fires to relatively small areas (e.g., less than 100 ac.). While the total area affected by training-caused fires cannot be quantified, long-term adverse effects on vegetation and habitat are likely. A mosaic of recently burned areas, unburned areas, and areas in various stages of recovery would likely develop as the ranges become operational and frequent, small fires occur. Vegetative cover would decrease and bare ground would increase. Conditions would be favorable for establishment and spread of non-native annual grasses such as cheatgrass, although cheatgrass already dominates portions of the proposed ranges. Washington ground squirrels would be more susceptible to predation in areas of bare ground and their available food supply would decrease. Shifts from native grasses to cheatgrass or other invasive plants could

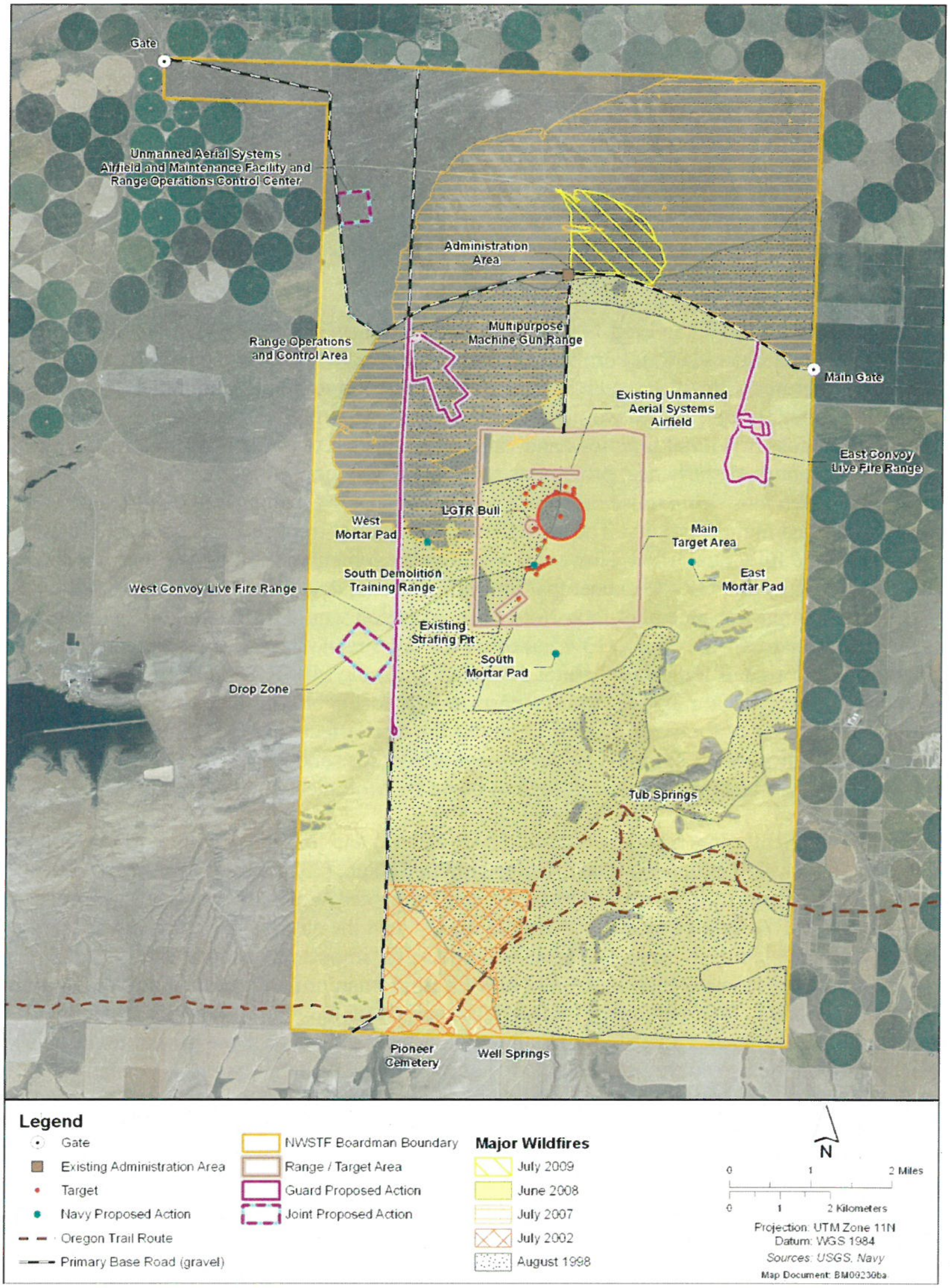


**Figure 12. Extent of Major Wildfires at NWSTF Boardman**

also reduce the quality of available forage. For these reasons, training-caused wildfire is expected to have long-term adverse effects on Washington ground squirrel habitat.

*5.3.7 Summary and Combined Effects on Washington Ground Squirrel Habitat*

This section provides a summary of the analyses presented above and synthesizes this information to consider the overall effects of the Proposed Action on Washington ground squirrel habitat. Consideration of the combined effects on habitat provides a better understanding of potential population-level effects and helps to define the scope of proposed habitat restoration and enhancement efforts to mitigation adverse effects.

As summarized in Table 17, the Proposed Action would result in some permanent habitat loss and long-term habitat degradation. Permanently lost habitat includes areas that would be converted to structures or facilities such as the UAS airfield, gravel roads, and targets. Complete loss of habitat functions and values would occur in these areas. Long-term habitat degradation, but not complete loss of habitat functions and values, is expected to occur in areas affected by temporary construction disturbance, projectiles striking the ground, training-caused wildfires, invasive plants, weapons firing noise on the MPMGR and CLFRs, and general disturbance caused by increased human activity. The spatial extent of habitat impacts associated with these stressors cannot be fully quantified. However, based on implementation of BMPs discussed in Section 1.4, the Navy and ORNG expect that long-term habitat degradation would primarily occur within the range enhancement footprints. One exception would be the 140 dBP contours for the MPMGR and CLFRs, 33 ac. (13.4 ha) of which fall outside the range footprints (Figure 13). Therefore, the area of long-term habitat degradation for the MPMGR and CLFRs was calculated as follows: (total range footprint – permanently lost habitat) + area of 140 dBP contour outside the range footprint. Figure 13 shows the total affected area for the MPMGR and CLFRs. Table 17 provides a summary of permanent habitat loss and long-term habitat degradation for each range enhancement, broken down by ecological condition class.

The area of permanently lost habitat would be 25 ac. (10 ha) and long-term habitat degradation is expected on 561 ac. (227 ha), for a total affected area of 586 ac. (237 ha). Approximately 90 percent of the affected area is known to be historically occupied Washington ground squirrels. However, based on the lack of recent, systematic survey data the entire affected area was assumed to be occupied by Washington ground squirrels for impact assessment and mitigation planning purposes. Assuming that the entire NSWTF Boardman property is suitable Washington ground squirrel habitat, 0.05 percent of the available habitat would be permanently lost and 1.7 percent would be degraded. Quantifying the population-level effects of these habitat impacts is not possible given the current limited knowledge of Washington ground squirrel population dynamics. While squirrel numbers could decline in response to lost and degraded habitat, the area affected would be relatively small compared to the total habitat available at NWSTF Boardman. Therefore, it is unlikely that the viability of the population would be threatened. Large areas of historically-occupied habitat would be unaffected by the action and some existing fire breaks (219 acres) would be restored. In addition, the proposed habitat mitigation measures discussed in Section 1.5 would help to ensure no net loss of habitat quantity or quality and a potential net benefit to Washington ground squirrel habitat. Proposed activities that would result in habitat loss or degradation will adversely affect the Washington ground squirrel.

**Table 17. Summary of Habitat Impacts for Proposed Range Enhancements at NWSTF Boardman**

| Range Enhancement and Ecological Condition Classification of Affected Habitat | Permanent Habitat Loss (acres) | Long-term Habitat Degradation (acres) | Total (acres) |
|---|---|---|---|
| **Multi-Purpose Machine Gun Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 8 | 193 | 201 |
| Medium-low | 8 | 6 | 14 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 20 | 20 |
| Subtotal = | 16 | 219 | 235 |
| **Eastern Convoy Live Fire Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 8 | 8 |
| Medium | 0 | 97 | 97 |
| Medium-low | 0 | 6 | 6 |
| Low | 0 | 2 | 2 |
| Unclassified | 0 | 2 | 2 |
| Subtotal = | 0 | 113 | 113 |
| **Western Convoy Live Fire Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 5 | 5 |
| Medium | 0 | 146 | 146 |
| Medium-low | 0 | 14 | 14 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 63 | 63 |
| Subtotal = | 0 | 228 | 228 |
| **Demolition Training Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 1 | 0 | 1 |
| Medium-low | 0 | 0 | 0 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 0 | 0 |
| Subtotal = | 1 | 0 | 1 |
| **Unmanned Aerial Systems Airfield and Maintenance Facility and Range Operations and Control Center** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 0 | 0 | 0 |
| Medium-low | 0 | 0 | 0 |
| Low | 8 | 1 | 9 |
| Unclassified | 0 | 0 | 0 |
| Subtotal = | 8 | 1 | 9 |
| **Total for All Range Enhancements** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 13 | 13 |
| Medium | 9 | 435 | 444 |
| Medium-low | 8 | 26 | 34 |
| Low | 8 | 3 | 11 |
| Unclassified | 0 | 84 | 84 |
| Total = | 25 | 561 | 586 |

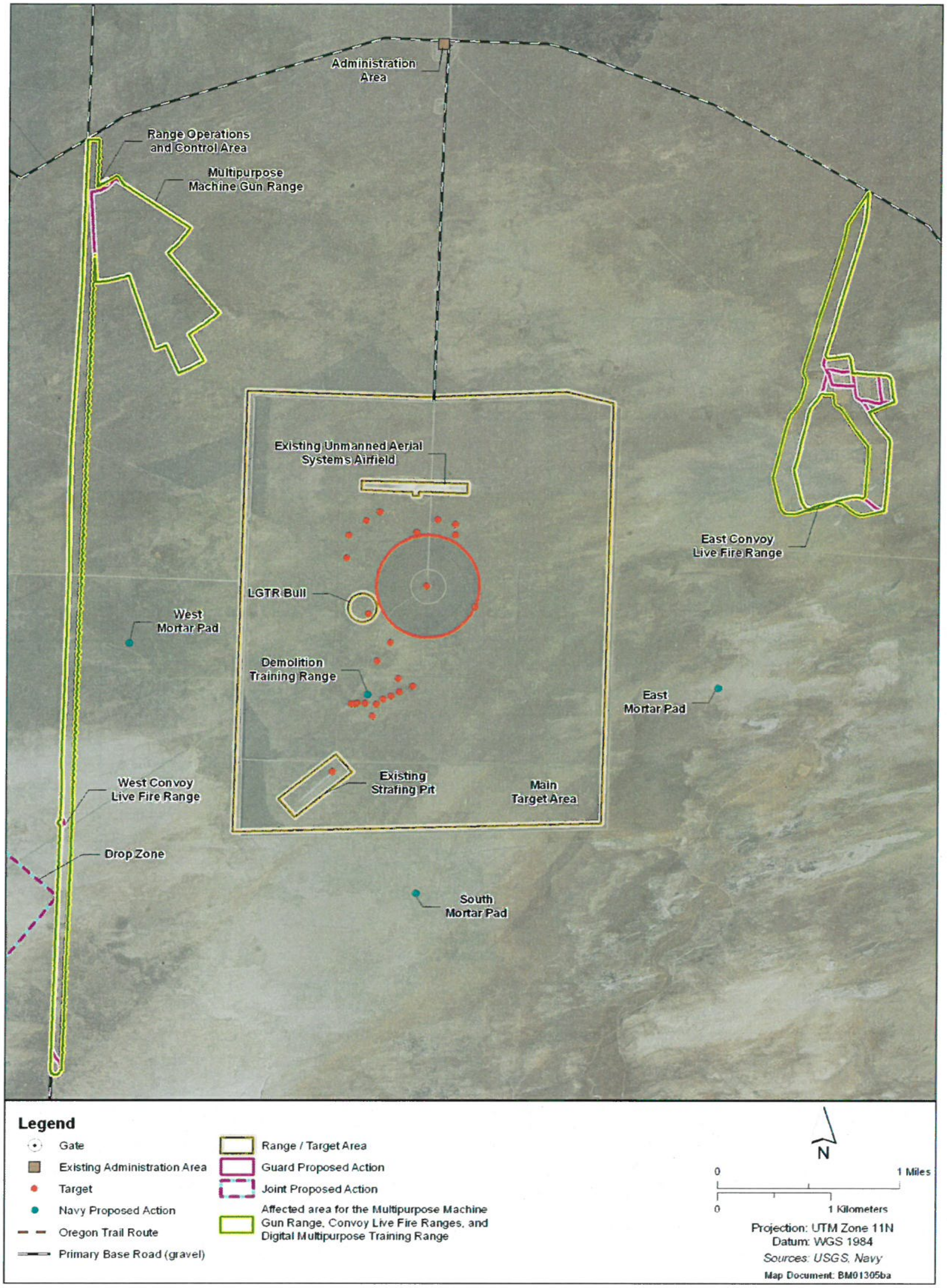


**Figure 13. Area of Habitat Affected by the MPMGR and CLFR**

### *5.4 Physical Strikes*

#### *5.4.1 Non-explosive Practice Munitions Strikes*

Various types of non-explosive practice munitions (e.g., bullets and practice bombs) would be fired at or dropped on targets (Tables 2, 3, and 4) under the Proposed Action. Most projectiles would make contact at or near the designated target, with an occasional round landing within the larger surface or weapons danger zones. A Washington ground squirrel could be struck and killed in the unlikely event that the animal was at the point of physical impact at the time of projectile delivery.

Portions of the Main Target Area are highly disturbed from decades of use. Nonetheless, Washington ground squirrels have been detected in the area. Vegetation around target emplacements in the Main Target Area, where most projectiles would make contact, is periodically maintained by disking or plowing for fire safety and to provide visual cues to pilots. Vegetation around targets on the MPMGR and CLFRs would not be disked, but some level of habitat disturbance would result from projectile impacts. Washington ground squirrels are less likely to use these disturbed areas, reducing the likelihood of a strike. Noise is associated with non-explosive practice munitions use and a noise event often occurs prior to weapons firing. For example, pilots fly over the target area to make safety checks before dropping or firing ordnance during air-to-ground bombing and gunnery exercises. Squirrels might flee the immediate area or take cover underground in response to the fly over, reducing the likelihood of a strike. In addition, other weapons firing exercises take place in a deliberate progression, with target placement being followed by a few initial shots, after which feedback is obtained before firing the next series of shots. Again, the likelihood of a strike might be reduced by squirrels responding to the initial stages of an exercise. Also, the likelihood of a relatively small projectile and an animal co-occurring in time and space within the target area is low. Based on these factors, the risk of non-explosive practice munitions striking a Washington ground squirrel would be low. If strikes did occur, a limited number of individuals would be affected, and no population-level effects would be expected. For compliance purposes, the Navy and ORNG estimate that up to six Washington ground squirrel incidental mortalities could occur per year from a combination of non-explosive practice munitions strikes and vehicle strikes. As discussed in Section 1.6.4, *Monitoring*, range control personnel would inspect the target areas at the conclusion of a firing exercise to record and report any mortality. Non-explosive practice munitions strikes under the Proposed Action may have adverse effects to the Washington ground squirrel.

#### *5.4.2 Vehicle and Equipment Strikes*

Vehicle and equipment use at NWSTF Boardman would increase substantially under the Proposed Action during ground-based training events and during construction. During training activities, vehicles and military equipment would be driven on existing roads or new gravel roads constructed under the Proposed Action. No off-road maneuver training is proposed. Maximum travel speeds would be limited during training, but the potential exists for Washington ground squirrels to be struck along roads used during training. During construction, vehicle use would be confined to existing roads to the extent possible, but construction equipment would require access to off-road areas to accomplish the work. The potential for squirrel strikes also exists during fire break and target maintenance activities. As discussed in Section 5.3.4, fire break maintenance activities would decrease substantially under the Proposed Action. The following measures would be implemented to avoid and minimize the risk of strikes:

- Washington ground squirrel locations would be identified during pre-construction surveys and monitoring would be conducted during construction to avoid strikes by construction equipment.
- Data from long-term Washington ground squirrel monitoring would be used, in part, to identify areas along heavily traveled roads and maintained fire breaks where squirrel encounters would be most likely. This information would be used to increase awareness and vigilance of range users and equipment operators.
- On NWSTF Boardman, to improve vehicle operation safety, be protective of wildlife, and reduce dust emissions, the vehicle speed limit for the range is 25 mph unless otherwise posted; however, emergency situations, operational necessities and certain training events may require vehicle speeds to exceed this standard speed limit. At all times on the range, vehicle operators shall use extreme caution and operate at a slow, safe speed consistent with the mission, safety, and current road and environmental conditions. Vehicle operators shall be cognizant and protective of pedestrians and wildlife while conducting all range activities.
    - The only road posted above 25 mph is the Admin Main road from the main gate access to the range from Bombing Range Road to the on-range road known as "The Interstate". Speed limit on the Admin Main Road is 30 mph.
    - It is not expected that training requirements will require speeds in excess of 25 mph on a routine basis; however in some training events, vehicles need to be able to react to changing tactical situations in training as they would in actual combat. Training differently than that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities. During these activities, the 25 mph speed limit may need to be exceeded for brief periods.

Although the risk of vehicles or equipment striking a Washington ground squirrel cannot be eliminated, the measures listed above would minimize risk. If strikes did occur, a limited number of individuals would be affected, and no population level effects would be expected. For compliance purposes, the Navy and ORNG estimate that up to six Washington ground squirrel incidental mortalities could occur per year from a combination of non-explosive practice munitions strikes and vehicle strikes. As discussed in Section 1.6.4, *Monitoring*, range control personnel would inspect the training area, including target areas and heavily travelled roads, at the conclusion of a ground-based training exercise to record and report any mortality. Vehicle and equipment strikes are likely to cause adverse effects to Washington ground squirrels under the Proposed Action.

## *5.5 Electromagnetic Radiation*

Electromagnetic radiation is a form of environmental pollution that may impact wildlife in various ways depending on type of radiation, duration of exposure, and the species of the receiving animal. Effects on birds may include reduced nesting success (Fernie and Reynolds 2005, Balmori 2009) and various behavioral and physiological responses to electromagnetic fields (Fernie *et al.* 2000, Fernie and Bird 2001), such as disruption of normal sleep-wake cycles through interference with pineal gland and hormonal imbalance. Salford *et al.* (2003) and Marks *et al.* (1995) report various effects on mammals from electromagnetic exposure, including changes in alarm and aversion behavior, deterioration of health, reproductive problems, and changes in normal sleep wake patterns. Nishimura *et al.* (2010) reported response in lizards to low-frequency electromagnetic fields.

Experiments and field observations in these studies were based on continual and long-duration exposure. For instance, Balmori (2009) reports reduced bird activity (breeding and foraging) followed by extirpation within areas saturated with high microwave radiation (greater than 2 Volts/meter [V/m]). The same study reported anomalies in magpies (*Pica pica*), such as plumage deterioration, limps and deformities in limbs, partial albinism. In another study by Balmori and Halberg (2007), significant declines of house sparrow densities were observed in areas of high electromagnetic field strength. The study predicted that no sparrows would be expected in an electromagnetic field of greater than 4 V/m of long-term constant exposure.

Various forms of electromagnetic sources are used at NWSTF Boardman including radar, threat emitters, communications equipment, and electronic detection equipment, primarily during electronic combat training events. The likelihood of a Washington ground squirrel being exposed to a harmful dose of electromagnetic radiation is extremely low for the following reasons: (1) the sources of electromagnetic radiation are used at high altitudes in the NWSTF Boardman airspace or the source is directed into the airspace and (2) the sources of electromagnetic radiation would not expose squirrels to constant radiation; in other words, no area of NWSTF Boardman would be continuously saturated with electromagnetic fields. Electromagnetic radiation is not likely to cause any adverse effects to Washington ground squirrels.

### *5.6 Lasers*

Military uses of lasers include applications such as target designation and ranging, defensive countermeasures, communications, and directed energy weapons. Targeting and ranging lasers are the only laser applications used during training and testing on the ground at NWSTF Boardman and within the airspace. These platforms and devices are described in Section 1, Description of Proposed Action. Target designation and ranging laser types are relatively low power lasers (compared to directed energy lasers or lasers used for defensive countermeasures). A targeting laser is a low-power laser pointer used to indicate a target for a precision-guided munition, typically launched from an aircraft. The guided munition adjusts its flight-path to home in to the laser light reflected by the target, enabling a great precision in aiming. The beam of the laser target designator is set to a pulse rate that matches that set on the guided munition to ensure munitions strike their designated targets and do not follow other laser beams which may be in use in the area (Northrop-Grumman 2010). The laser designator can be shone onto the target by an aircraft or ground-based personnel. Lasers used for this purpose are usually infrared lasers, so the enemy cannot easily detect the guiding laser light.

Vision damage is the primary concern for wildlife species for the lasers used at NWSTF Boardman. Most studies of the effects of lasers on terrestrial animals involve birds because of the interest in developing deterrents to minimize bird-aircraft strike hazards at airports and wind developments (Baxter 2007, Burton *et al.* 2011). Fewer studies are available for other species groups, such as terrestrial mammals and reptiles, but the same range of responses (none to avoidance behavior) are expected.

Lustick (1973) conducted an experiment using pulsing light, which indicated that starlings and gulls were able to look directly into the laser beam and not change their behavior. A later study conducted through the National Wildlife Research Center's Mississippi Field Station demonstrated that there was no eye damage to double-crested cormorants (*Phalacrocorax auritus*) that had been exposed to a moderate-power red laser as close as 3 ft. (0.9 m) (Glahn *et al.* 2000). Furthermore, the bird eye is protected from thermal damage to retinal tissue associated with concentrated laser radiation (U.S. Department of Agriculture 2003).

For several decades, pulsing light has been used on aircraft, aircraft hangers, and high towers as a means of avian management or bird control. In 2001, the U.S. Department of Agriculture's National Wildlife Research Center conducted research on low- to moderate-power, long-wavelength lasers (630–650 nanometers) as an effective, environmentally safe means of dispersing specific bird species under low-light (sunset to dusk) conditions (Blackwell *et al.* 2002). Results of the U.S. Department of Agriculture research concluded that waterfowl species, wading birds, gulls, vultures, and American crows (*Corvus brachyrhynchos*) have all exhibited avoidance of laser beams during field trials (Blackwell *et al.* 2002, U.S. Department of Agriculture 2003). However, avoidance reaction times and duration are dependent upon context and species (Blackwell *et al.* 2002). In general, diurnal birds (active during the day and resting during the night) are not sensitive to extremely intense laser light and elicit a slow avoidance response to lasers. In contrast, nocturnal birds (active during the night and resting during the day) are more sensitive to light and react more quickly to avoid intense light (Blackwell *et al.* 2002). Blackwell and Bernhardt (2004) found that the avoidance response to pulsed white and wavelength-specific aircraft-mounted light was inconsistent across experiments with cowbirds (*Molothrus* spp.), and there was little or no avoidance behavior in experiments with other species. Also, some studies on the use of lasers for bird control have shown that birds may become habituated to light quickly, and there is a loss of effect as the distance increases from the bird and the laser (U.S. Department of Agriculture 2003).

Laser guided munitions are used during Air-to-Ground Bombing Exercises within the Main Target Area. There are 133 events of this type per year, but only 20 laser guided bombs are allocated for use (Tables 2, 3, and 4). Lasers used at NWSTF Boardman and in the airspace would be similar to the moderate-powered lasers from the studies cited above, and therefore no damaging effects on vision would be anticipated.

A Washington ground squirrel may experience a detectable response to a laser beam, but would recover after the exposure. The fitness of individual animals would not be affected by this temporary effect (the duration of the laser beam directly sighted on an animal's eyes) from lasers. The use of lasers may have some effect on Washington ground squirrels under the Proposed Action but any effects would be insignificant.

### *5.7 Soil Contamination*

This section analyzes the potential effects of soil lead contamination on Washington ground squirrels. Some ammunition (5.56 mm, 7.63 mm, and .50 caliber tracer rounds) used in the Main

Target Area and on the MPMGR and CLFRs contain lead. These projectiles would accumulate in soil over time and lead is a constituent of concern because of its toxicity and its ability to persist in the environment (U.S. Army Environmental Center 1998).

Several factors influence the fate and transport of lead on a training range, including soil type, soil pH, annual precipitation rate, and topographic slope (U.S. Environmental Protection Agency 2005). Lead oxidizes when exposed to air and dissolves when exposed to acidic water or soil, but is generally insoluble and immobile under neutral or basic pH conditions (U.S. Environmental Protection Agency 2005). The corrosion products of lead bullets in soil environments consist primarily of hydrocerussite, which is relatively insoluble (Chen and Daroub 2002). However, Dermatas *et al.* (2004) demonstrated that, in the case of a lead bullet with a copper jacket, the presence of copper increased the solubility of lead significantly, due to a galvanic corrosion reaction. Lead and copper concentrations were highly elevated in surface soils at two small arms ranges on Fort Irwin, California, but quickly decreased as a function of increasing depth from the ground surface. Despite the galvanic corrosion reaction, the mobility of both metals was significantly reduced within the first 10 to 20 in. (25.4 to 50.8 cm) below the surface. The limited mobility was attributed to the alkaline characteristics of the soils (pH 7.48 to 7.65 on one range and 8.03 to 8.30 on the other) and the formation of secondary minerals such as hydrocerussite (Dermatas *et al.* 2004).

Ideal soil pH for firing ranges is 6.5 to 8.5 because the lead precipitates out of solution and binds to the soil within this pH range (U.S. Environmental Protection Agency 2005). This binding effect prevents the lead from migrating to the subsurface. Koehler and Quincy soils are found within and around the Main Target Area. The proposed MPMGR would be constructed on Koehler and Quincy soils, with pH values in the range of 7.3 to 7.9. The eastern CLFR would be sited on Koehler, Quincy, Royal, Ellum, and Sagehill soils, with pH values in the range of 7.2 to 7.9. Lead precipitates out of solution and binds to the soil within these pH ranges, preventing or limiting migration to the subsurface (Dermatas *et al.* 2004, U.S. Environmental Protection Agency 2005). Lead mobility would also be limited by the low annual precipitation rate at NWSTF Boardman (9 to 11 in. per year [23 to 28 cm]). Lead would weather slowly under these arid conditions because it would have limited contact with water. Low precipitation coupled with the flat terrain also makes it unlikely that lead would be transported outside the immediate target area by storm water runoff (U.S. Environmental Protection Agency 2005).

Spent projectiles and projectile fragments would accumulate over time in the vicinity of targets. Lead concentrations in surface soils would be expected to increase as the projectiles slowly corrode. Washington ground squirrels could be exposed to lead via the following pathways:

- Incidental ingestion of lead-contaminated soils while foraging or grooming
- Ingestion of plant materials covered in lead-contaminated soil dust
- Ingestion of plant materials that have accumulated lead from the soil
- Inhalation of lead-contaminated dust
- Incidental ingestion of projectile fragments

### *5.8 Interrelated/Interdependent Effects*

Interrelated actions are those that are a part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. Both interdependent and interrelated activities are assessed by applying the "but for" test, which asks whether any action and its associated impacts would occur "but for" the proposed action. The proposed project is not anticipated to have any interrelated or interdependent effects.

## 6. Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this Conference Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

A list of reasonably foreseeable future actions was compiled for NWSTF Boardman and surrounding areas based on the Navy's scoping process, communications with other agencies, state and local officials, a review of other military activities, literature review, and other available information. Table 18 lists the other actions and other environmental considerations that were identified for the cumulative effects analysis and Figure 16 (in the Assessment) provides each project's geographic relation to NWSTF Boardman. The expected impacts may include temporary disturbance, habitat loss and degradation, habitat fragmentation, and incidental mortality.

**Table 18: Other Actions Identified for the Cumulative Effects Analysis**

| Name of Action | Lead Agency or Proponent | Location | Timeframe |
|---|---|---|---|
| Leaning Juniper Wind Power Facility | Iberdrola Renewables, Inc. | Gilliam County | Past, Ongoing, Future |
| Montague Wind Power Facility | Iberdrola Renewables, Inc. | Gilliam County | Past, Ongoing, Future |
| Saddle Butte Wind Power Facilities | Saddle Butte Wind LLC | Morrow County and Gilliam County | Ongoing, Future |
| Baseline Wind Energy Facility | First Wind | Gilliam County | Future |
| Rock Creek Wind Power Facility | Rock Creek Wind Power, LLC | Gilliam County | Future |
| Echo Wind Farm (eight built inside 5701) | Oregon Wind Farms, LLC | Morrow and Umatilla County | Past |

| Name of Action | Lead Agency or Proponent | Location | Timeframe |
|---|---|---|---|
| Threemile Canyon Wind Farm | John Deere Wind Energy | Morrow County | Past, Ongoing, Future |
| Poplar Wind Farm | First Wind | Morrow County | Ongoing, Future |
| Perennial Wind Chaser Station | Perennial Power Holdings, Inc. | Umatilla | Future |
| Wheatridge Wind Energy Facility | Wheatridge Wind Energy, LLC | Morrow and Umatilla County | Future |
| Ward Butte Wind Farm | American Wind | Umatilla County | Future |
| Sullivan's Wind Farm (Horned Butte) | Invenergy | Gilliam County | Ongoing, Future |
| Butter Creek Projects (1-9) | Intelligent Wind Energy | Morrow and Umatilla County | Past, Ongoing, Future |
| Multi- Species Candidate Conservation Agreement – Habitat Conservation | Threemile Canyon Farms, Portland General Electric, The Nature Conservancy, and the Oregon Department of Fish and Wildlife | Morrow County | Past, Ongoing, Future |

Future development, consisting of the specific projects listed in Table 18, along with regional growth of urban areas and regional increases in wind energy development would incrementally increase average sound levels during construction as well as during operation (e.g., wind turbines). Construction related to new development would result in short-term increases in daytime sound levels in the vicinity of those projects. In rural portions of Morrow, Gilliam, and Umatilla Counties, vehicle noise from increased traffic on local roads and regional highways would be the largest sources of increased noise. Daytime sound levels would likely increase more than nighttime sound levels. Substantial increases in sources of intrusive sound are not expected.

Johnson and Erickson (2011) evaluated the cumulative impacts of wind energy development projected to occur within the Columbia Plateau Ecoregion of eastern Washington and Oregon through 2015. Approximately 2,578 ac. (1,043 ha) of non-agricultural vegetation types, primarily grassland and shrub- steppe vegetation, would be lost in the Columbia Plateau Ecoregion to existing and proposed wind energy development through 2015. This loss of vegetation corresponds to a loss of wildlife habitat but it is unclear how much of this is Washington ground squirrel habitat. Impact estimates for the other projects are not yet available. All of these projects are subject to established environmental planning and review processes. Therefore, it is expected that all of these projects will include measures to avoid and minimize impacts to wildlife, and restore wildlife habitat.

Several ongoing and future State or local actions in the region would also provide long-term benefits for shrub-steppe and grassland communities:

- The Multi- Species Candidate Conservation Agreement – Habitat Conservation is protecting and enhancing shrub-steppe and grassland communities at the Boardman Conservation Area adjacent to NWSTF Boardman. The Nature Conservancy is currently implementing a restoration plan for the Boardman Conservation Area, which includes eradicating invasive plants in degraded habitats and revegetating the areas with native plants.
- Continued management of lands at the Lindsay Prairie Preserve by The Nature Conservancy would protect and enhance shrub-steppe and grassland communities.
- Continued management of lands at the Horn Butte Area of Critical Environmental Concern by the Bureau of Land Management would protect and enhance shrub-steppe and grassland communities.

Future actions outside the boundaries of NWSTF Boardman, including wind energy projects and reuse development at UCD are expected to impact wildlife and wildlife habitat in the vicinity of NWSTF Boardman and in the region. Estimating the area of Washington ground squirrel habitat that would be impacted by other actions is not possible based on available information. However, it is expected that wind energy projects would create small patches (component footprints) of permanently lost habitat. Complete loss of habitat functions and values would occur in these areas. Additionally, long-term habitat degradation, but not complete loss of habitat functions and values, is expected to occur in areas affected by temporary construction disturbance and general disturbance caused by increased human activity. The spatial extent of habitat impacts associated with these stressors cannot be fully quantified. Quantifying the population-level effects of these habitat impacts is not possible given the current limited knowledge of Washington ground squirrel population dynamics. While squirrel numbers could decline in response to lost and degraded habitat, the area affected would be relatively small compared to the total habitat available. Proposed activities that would result in habitat loss or degradation would have adverse effects to the Washington ground squirrel.

## 7. Conclusion

After reviewing the current status of Washington ground squirrel, the environmental baseline for the action area, the effects of the proposed project activities, and anticipated cumulative effects, it is the Service's conference opinion that the action, as proposed, is not likely to jeopardize the continued existence of the Washington ground squirrel. The Service reached this conclusion for the following reasons:

- Although the NWSTF Boardman is a key area for Washington ground squirrel conservation, the proposed action will occur over a relatively small area and the permanent loss of habitat (habitat removal and habitat degradation due to noise effects) is anticipated to be less than two percent of the total area of the Range. Large areas of the currently and historically occupied habitat on NWSTF Boardman would be unaffected by the proposed action. Therefore, it is unlikely that the viability of the population would be threatened.

- Although there will be some reduced fitness of individuals and a reduction in the distribution of Washington ground squirrels in some areas on NWSTF Boardman, the NWSTF will still contain large blocks of unaffected habitat and the area's contribution as the main connection between smaller sites to the west of this area and possible movement east and south should be maintained.
- Best Management Practices (Conservation Measures) have been added to minimize or eliminate effects.
- Mitigation has been established to meet a "no net loss- net gain" condition for habitat loss (for both direct and indirect)
- Because of uncertainty, the Navy will implement an adaptive management and monitoring strategy so that adjustments/mitigation can be made if currently anticipated effects or the outcome of restoration efforts are different than analyzed or expected.

The project is not expected to appreciably reduce either the survival or recovery of Washington ground squirrel.

## 8. Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of Section 7 (b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of this project is not considered to be prohibited taking under the ESA provided that such taking is in compliance with this Incidental Take Statement.

The prohibitions against taking the species found in section 9 of the ESA do not apply until the species is listed. However, the Service advises the Navy to consider implementing the following reasonable and prudent measures. If this Conference Opinion is adopted as a Biological Opinion should the Washington ground squirrel be listed, these measures, with their implementing terms and conditions, will be non-discretionary.

### *8.1 Amount/Extent of Take Anticipated*

The Service anticipates that take of the Washington ground squirrel is likely to occur in the form of harm caused by implementation of the proposed action. Incidental take of individual Washington ground squirrels, in most situations, will be difficult to detect or quantify for the following reasons: l) the low likelihood of finding dead or injured adults or juveniles; 2) delayed injury (i.e., reduced fitness) or mortality; and, 3) the relationship between habitat conditions and the distribution and abundance of individuals is imprecise such that a specific number of affected individuals cannot be practically obtained with one exception discussed below. For that reason, the Service is using the amount of Washington ground squirrel-occupied habitat that is likely to be affected in a manner that causes the death or injury of affected squirrels as a surrogate to express the amount or extent of take of the squirrel and for purposes of monitoring take-related impacts, with the one exception discussed below. Based on our analysis of the *Effects of the Proposed Action* above, the Service anticipates the following forms and level of take are likely to occur as a result of activities associated with the project:

- Approximately 561 acres of Washington ground squirrel-occupied habitat (Figure 10) are likely to be subject to noise levels >140dBP that is likely to cause a hearing threshold shift in squirrels occupying those acres. Over the term of the proposed action, the Service anticipates these 561 acres are not likely to be occupied by the Washington ground squirrel due to these harm-related take impacts.

- Approximately 40 acres of Washington ground squirrel-occupied habitat (Figure 1; Table 5) are likely to be destroyed (25 acres permanently; 15 acres will be restored) due to construction of the MPMGR, Demolition Training Range, and UAS Airfield, Maintenance Facility, and Range Operations and Control Center. The Service anticipates the 25 acres of permanent lost habitat are not likely to be occupied by the Washington ground squirrel due to these harm-related take impacts and there will be a delay in re-occupation for the 15 acres of restored habitat.

- No more than six squirrels per year (see Section 5.4, *Physical Strikes*, above) are likely to be killed or wounded due to vehicle and equipment strikes and munitions strikes.

If it is determined that any of these activities are adversely affecting Washington ground squirrels beyond the extent identified above, then consultation will need to be reinitiated on that activity.

### *8.2 Effect of Take*

In the accompanying Conference Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the Washington ground squirrel.

### *8.3 Reasonable and Prudent Measures*

The Service believes that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impacts of incidental take of the Washington ground squirrel caused by the proposed action:

1. Design construction footprints to minimize direct impacts to Washington ground squirrel-occupied habitat.

2. Establish the schedule for construction activities outside of the above-ground activity period for Washington ground squirrels to the maximum extent possible.

3. Establish vehicular speed limits, road signage, and education of on-site personnel and training personnel on NWSTF Boardman to reduce the potential for collisions between vehicles and squirrels.

4. Develop and implement a take impact monitoring program.

### *8.4 Terms and Conditions*

In order to be exempt from the prohibitions of section 9 of the Act, the Navy must comply with the following terms and conditions, which will implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. If this Conference Opinion is adopted as a Biological Opinion, these terms and conditions become non-discretionary.

1. The following terms and conditions are necessary for the implementation of RPM 1:

    a. Conduct habitat surveys during the project design phase to identify existing Washington ground squirrel habitat, and evaluate the quality of that habitat. This information shall be used during project design to support micro-siting decisions such that areas of higher quality squirrel habitat (e.g., undisturbed areas with a relatively high percentage of native plant cover) or existing Washington ground squirrel burrows would be avoided in favor of areas of lower quality habitat (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable.

2. The following term and condition is necessary for the implementation of RPM 2:

    a. Conduct construction activities, to the extent practicable, outside the above-ground period for Washington ground squirrels (January 1 through June 30). If construction must occur within this time period, avoid the key breeding period (mid-January through the 3$^{rd}$ week in February).

3. The following terms and conditions are necessary for the implementation of RPM 3:
    a. Establish a vehicle speed limit of 25 mph for the range to reduce potential vehicle strikes of Washington ground squirrels. The 25 mph speed limit may be exceeded for brief periods during some training events where vehicles need to be able to react to changing tactical situations in training as they would in actual combat.
    b. Avoid off-road vehicular travel, as much as practicable, in areas identified as suitable Washington ground squirrel habitat.
    c. Provide education on Washington ground squirrels, their habitat, and procedures for collecting dead Washington ground squirrels to on-site personnel and Navy and ORNG personnel utilizing the range.

4. The following term and condition is necessary for the implementation of RPM 4:

a. By July 1, 2014, prepare a take impact monitoring plan, in coordination with the Service, ODFW, and The Nature Conservancy (based on the framework described in Section 1.6 above) to address each of the take findings described above under the ***Amount/Extent of Take Anticipated*** section.

### *8.5 Reporting Requirements*

If a dead, injured, or sick Washington ground squirrel is located, initial notification must be made to the Service Law Enforcement Office, located at 9025 SW Hillman Court, Suite 3134, Wilsonville, OR 97070; phone: 503-682-6131. The Service's La Grande Field Office, located at 3502 Highway 30, La Grande, OR 97850; phone 541-962-8584) should also be notified. Care should be taken in handling sick or injured Washington ground squirrels to ensure effective treatment or the handling of dead specimens to preserve biological material in the best possible state for later analysis of cause of death. Dead squirrels should be collected as soon as possible, put in a plastic bag and then put in a freezer. Record the date, time of collection, location (GPS coordinates), and cause of death, if known. This information should accompany each carcass. The Service's La Grande Field Office will retrieve the collected carcasses from NWSTF Boardman.

*Review Requirement:* The Reasonable and Prudent Measures, with their implementing Terms and Conditions, are designed to minimize incidental take that might otherwise result from the proposed action. These measures should decrease the level of take of Washington ground squirrel to the degree possible, given the circumstances surrounding the proposed action. With implementation of these measures, the Service believes that some Washington ground squirrels may be incidentally taken as quantified above. If, during the course of the action, this minimized level of incidental take is exceeded, such incidental take would represent new information requiring review of the reasonable and prudent measures provided, the Navy must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

## 9. Conservation Recommendations

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Continue to work collaboratively with partners (i.e., The Nature Conservancy, ODFW, Defenders of Wildlife, the Service, etc.) to implement conservation actions to benefit Washington ground squirrels in the Columbia Basin of Oregon.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

## 10. Reinitiation – Closing Statement

This concludes the conference for the Navy's Military Readiness Activities at the NWSTF Boardman. You may ask the Service to confirm the conference opinion as a biological opinion issued through formal consultation should the Washington ground squirrel be listed. The request must be in writing. If the Service reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, the Service will confirm the conference opinion as the biological opinion on the project and no further section 7 consultation will be necessary.

After listing of the Washington ground squirrel as endangered/threatened and/or designation of critical habitat for the Washington ground squirrel and any subsequent adoption of this conference opinion, the Federal agency shall request Reinitiation of consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect the species or critical habitat in a manner or to an extent not considered in this conference opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the species or critical habitat that was not considered in this conference opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

The incidental take statement provided in this Conference Opinion does not become effective until the species is listed and the conference opinion is adopted as the biological opinion issued through formal consultation. At that time, the project will be reviewed to determine whether any take of the Washington ground squirrel has occurred. Modifications of the opinion and incidental take statement may be appropriate to reflect that take. No take of the Washington ground squirrel may occur between the listing of the Washington ground squirrel and the adoption of the conference opinion through formal consultation, or the completion of a subsequent formal consultation.

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# Appendix A

## Revegetation Plan for Areas Disturbed by Construction and Operation Of Weapons Training Ranges and Other Facilities on Naval Weapons Systems Training Facility Boardman

**DRAFT - Revegetation Plan for Areas Disturbed by Construction and Operation of Weapons Training Ranges and Other Facilities on Naval Weapons Systems Training Facility Boardman**

Prepared by Jeff Mach, Oregon Military Department
August 2011

**Species.** Revegetation of disturbed areas on NWSTF Boardman would consist of three actions:

1. Cryptogammic crust (aka biological soil crust) would be collected from facility sites prior to construction and stored. Collected crust material would be screened to produce a homogenous material that would be applied to disturbed areas after completion of construction, either dry or in slurry, to innoculate the soil.

2. A mixture of the following grass would be broadcast onto disturbed sites, at a rate of 12.71 pounds pure live seed per acre:

| Species | Native? (y/n) | Noxious? (y/n) | Wildlife value (cover/forage) | Mature height (cm) | Life cycle | # Pure Live Seeds per square meter (PLS/m$^2$) | Seeding rate in grams/hectare (g/ha) | Seeding rate in pounds PLS per acre (lbs/ac) |
|---|---|---|---|---|---|---|---|---|
| bluebunch wheatgrass, *Pseudoroegneria spicatum* (= *Agropyron spicatum*) | Y | N | C/F | 30-60 | Perennial | 100 | 4,097 | 3.61 |
| Sandberg bluegrass, *Poa secunda* (= *Poa Sandbergii*) | Y | N | C/F | 30-60 | Perennial | 100 | 715 | 0.63 |
| *Festuca idahoensis* (Idaho fescue) | Y | N | C/F | 60+ | Perennial | 125 | 1,703 | 1.50 |
| needle and thread grass, *Hesperostipa comata* (= *Stipa comate*) | Y | N | C | 60+ | Perennial | 25 | 1,668 | 1.47 |
| bottlebrush squirrel-tail grass, *Elymus elymoides* (= *Sitanion hystrix*) | Y | N | C/F | 30-60 | Perennial | 50 | 1,589 | 1.40 |
| Indian ricegrass, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*) | Y | N | C/F | 30-60 | Perennial | 100 | 4,654 | 4.10 |
| TOTALS | | | | | | 500 PLS/m$^2$ coverage | 14,426 g PLS/ha | 12.71 lbs PLS /ac |

3. Basin big sagebrush (*Artemesia tridentata* ssp *tridentata*) seed would be broadcast on selected focus areas, typically upwind and outside of weapons training range areas which have a higher potential to burn, at a rate of 1.6 pound per acre (lb/ac).

**Site Preparation and Application:** Preparation of areas for cryptogam inoculation and grass seeding will consist of finish soil grading. No site preparation is planned for basin big sagebrush seeding focus areas. Cyptogam innoculation would be accomplished by direct application of cryptogam material either in a dry form or in a slurry. Grass seed would be applied using a hydroseeder. The grass seed would be applied with SOIL-GUARD™ or cellulose mulch with tackifier. Fertilizer would not be used with this seed mixture. Basin big sagebrush seed would be hand broadcast onto firm, but not compacted, ground and pressed, rolled or dragged to improve seed-to-soil contact, with the goal of leaving the seed at a depth of about 1/16 inch. Fertilizer would not be applied to basin big sagebrush seeding areas.

**Schedule:** Cryptogam inoculation and grass seeding would be conducted between October 1 and January 31. Cryptogam inoculation would be conducted before grass seeding. Sagebrush seeding would be conducted between November 1 and December 31.

**Revegetation Success Criteria:** Cryptogam inoculation will be considered successful upon completion of the action. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80% density of a representative bunchgrass stand area within two to three years of seeding. If an acceptable stand of grass is not achieved, then the area would be re-seeded between October 1 and January 31. Sagebrush revegetation would be considered successful if one seedling per square meter is established over a 10 square meter area in each seeding focus area after one year. Seeding will be repeated if needed to meet the success criteria.

# Appendix B

## Summary of Commitments in the NWSTF Boardman INRMP and Additional Procedures, Mitigation, and Monitoring Described in the Proposed Action

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| NOISE | | | |
| NONE | | | |
| | | From January through August, charges greater than 50 lb. NEW would not be detonated to avoid and minimize noise impacts on Washington ground squirrels and nesting birds, unless necessitated by operational or disposal requirements. | Mitigation |
| | | Public notice would be given prior to detonation of 100 lb. NEW or greater. | Mitigation |
| | | To the maximum extent possible, detonation training would be conducted only during days when the weather is favorable. Studies have shown that variation of temperature and wind velocity with altitude can cause a noise event to be inaudible at one time (favorable) and audible at another time (unfavorable). A number of factors affect noise propagation during training events, and are considered by range managers and users when planning and conducting activities to help mitigate noise impacts. Conditions that can enhance the propagation of sound include steady winds; clear days on which 'layering' of smoke, fog, or clouds are observed; cold, hazy or foggy mornings; large temperature swings on the previous day; and high barometer/low temperatures. | BMP |
| | | Explosive Ordnance Disposal measures for reducing noise impacts during land detonation training include conducting detonation training only during normal working hours (10:00 a.m.–4:00 p.m.). | BMP |
| | | DTR training includes additional BMPs to help reduce noise levels for training with charges of 100 lb. (45.4 kg) NEW or greater. These could include: training during times with optimal weather conditions to attenuate noise, burying the explosive charge, or bunkering the charge with sand bags. | BMP |
| VEGETATION | | | |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| All training and facility operation actions at NWSTF Boardman are reviewed by the Naval Air Station Whidbey Island/NWSTF Boardman Natural Resources Manager for potential invasive plant and noxious weed issues. | FY 2012 – FY 2016 | | |
| **V-1: Monitor and control noxious weeds and invasive, non-native plants.** The annual monitoring component of this project is used to identify priority areas for invasive plant control actions. Similar annual monitoring would continue following implementation of the Proposed Action, with appropriate modifications to address conditions resulting from construction and operation of the new ranges. | FY 2012 – FY 2016 | Invasive plants would continue to be managed and controlled under the *NWSTF Boardman INRMP*, with an increase in control effort to reflect new threats introduced by the Proposed Action. The Plan would be updated in cooperation with ORNG, USFWS, ODFW, and The Nature Conservancy during routine annual reviews to reflect the evolving invasive plant management situation associated with construction and operation of the new ranges. Updates to the Plan would include provisions for short- and long-term monitoring of invasive plants; responsibilities and procedures for integrating efforts of the Navy, ORNG, and The Nature Conservancy; criteria for prioritizing management actions and adaptive management strategies to control invasive plants; and annual work plans, including funding requirements and funding sources. After range becomes operational, qualitative surveys would be conducted annually within the range footprint to detect noxious weeds (Morrow County list of noxious weeds) within the identified affected areas. The purpose of these surveys is to detect noxious weeds so that they can be controlled immediately, most likely through targeted application of a glyphosate herbicide. Surveys would continue indefinitely, and controls would be implemented as necessary. | Monitoring/BMP |
| **V-3: Use high-resolution aerial photography to map all vegetation; produce GIS-based vegetation map.** This project is currently programmed for fiscal year 2014 to update vegetation mapping that is more than 10 years old and to document changes in vegetation communities resulting from wildfires and changes that have occurred since grazing leases were | FY 2014 | | |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| terminated. This project will also provide new baseline data prior to implementing the Proposed Action and information to support micrositing decisions. | | | |
| **V-4: Recover monumented vegetation plots and resurvey vegetation using established protocol; produce GIS data layers.** This project will resurvey plots established in the 1980s to provide ground truthing for the V-3 project above, trend analysis for vegetation change, and permanent locations to measure future vegetation change or stability. Plots located within the area of disturbance for the Proposed Action will provide new baseline data. | FY 2012, FY 2014, FY 2016 | | |
| **V-5: Monitor previously burned areas for vegetation recovery.** Pedestrian surveys conducted under this project will assist in evaluating natural recovery to pre-fire habitat types and identify priority areas for potential post-fire restoration measures. Information obtained during this project will also be used to identify potential restoration sites in the southern portion of NWSTF Boardman to mitigate impacts of the Proposed Action. Similar monitoring would be conducted in the area of disturbance for the Proposed Action to evaluate success of post-construction restoration efforts. | FY 2012, FY 2013 | | |
| **V-7: Move RNA-A.** The Navy, in cooperation with The Nature Conservancy, is proposing to relocate Research Natural Area (RNA)-A to a more suitable location. Three RNAs (A, B, and C; Figure 1-5 in the EIS) were established on NWSTF Boardman in 1978 and are co-managed by The Nature Conservancy. RNA-A encompasses the | FY 2014 | | |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| Main Target Area, which must be used and maintained to meet mission requirements. Portions of the Main Target Area are highly disturbed by military use, and this area is not currently functioning as an RNA (not providing the intended scientific and educational benefits of an RNA). The new RNA would be sited to avoid possible conflicts with military activities and would be more representative of the unique habitat types RNAs are designed to protect. Similar to existing RNAs B and C, access to the relocated RNA would be limited to research activities, invasive plant control, and emergency response. Vegetation communities would benefit from the increased protection and management provided by relocating RNA-A to a more suitable location. | | | |
| **V-8: Map noxious weeds and invasive, non-native plants.** This project is currently programmed for fiscal year 2014 to update the NWSTF Boardman-wide invasive plant survey conducted in 1997 and to help prioritize control. This project will also provide new baseline data prior to implementing the Proposed Action, information to support micrositing decisions, and help identify potential restoration sites in the southern portion of NWSTF Boardman to mitigate impacts of the Proposed Action. | FY 2014 | | |
| | | Vegetation temporarily disturbed during construction would be restored in accordance with the proposed post-construction restoration plan. | BMP |
| | | Explosive detonations are not conducted when the fire danger rating is unacceptable based on the Fire Danger Rating and Wildland Fire Risk Management Matrix contained in the *NWSTF Boardman Draft* | BMP |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | *Integrated Wildland Fire Management Plan*, unless approved by the Commanding Officer, Naval Air Station Whidbey Island. | |
| **FM-1: Fire break analysis for relocation.** Develop a comprehensive assessment of fire breaks for the installation. Include the results of fire break success from the 2008 fire and alternative techniques such as "green stripping" with herbicide or fire resistant vegetation. | FY 2013 - COMPLETED | The *NWSTF Boardman Draft Integrated Wildland Fire Management Plan* would be finalized and implemented. In addition to other fire protection measures, the Plan includes proposed modifications to the existing system of fire breaks. The width of some fire breaks would be reduced to the width of the adjacent road, some fire breaks that do not follow roads would be eliminated, and some new fire breaks would be created. The total area of fire breaks that would be maintained annually by mechanical disturbance (plowing or disking with a tractor) would decrease from 462 acres (ac.) (187 hectares [ha]) to 243 ac. (98 ha). A long-term revegetation plan would be implemented to restore the areas removed from mechanical maintenance. These areas would be re-vegetated with native bunchgrasses, primarily Sandberg's bluegrass with some needle and thread or bluebunch wheatgrass, to provide a low-structure and low-fuel load area next to the road/fire break. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80% density of a representative bunchgrass stand area within 2 to 3 years of seeding. Selective herbicide treatments or other appropriate management actions would be used to control invasive plants until these areas are completely restored. | BMP |
| WILDLIFE | | | |
| | | Applicable erosion control measures would be implemented during construction to avoid and minimize the potential for wind and water erosion in accordance with the Oregon Department of Environmental Quality *Erosion and Sediment Control Manual* (Oregon Department of Environmental Quality 2005). | BMP |
| | | Drip pads would be placed under equipment when parked to avoid soil contamination from leaking fluids. | BMP |
| | | Under the Navy's RSEPA, Range Condition Assessment 5-year Reviews would continue to be conducted and appropriate steps would be taken to analyze environmental conditions on the range | BMP |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | and to prevent or respond to a release or substantial threat of a release of munitions constituents of potential concern to off-range areas that could pose risks to human health or the environment. RSEPA focus would be expanded to incorporate new range activities and new training areas under periodic assessments. | |
| | | Assessments would be conducted for the MPMGR and both CLFRs in accordance with the Army's Operational Range Assessment Program. These assessments would first determine qualitatively if munitions constituents were leaving the operational range footprint and whether pathways exist for human or ecological receptors. A quantitative assessment would be conducted if the qualitative assessment were inconclusive. The assessments would be conducted on a 5-year review cycle, even if the initial qualitative assessment identified no issues. ORNG would proactively manage the new ranges using applicable strategies outlined in the *Army Small Arms Training Range Environmental Best Management Practices Manual*. | BMP |
| | | Surveys would be conducted during the project design phase to identify existing habitat, evaluate habitat quality, and identify wildlife currently using these habitats. This information would be used during project design to support micrositing decisions. Areas of higher quality habitat (e.g., undisturbed areas with a relatively high percentage of native plant cover) or high wildlife use (e.g., existing Washington ground squirrel burrows) would be avoided in favor of areas of lower quality habitat (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable. Micrositing efforts would be limited to buildings and structures, as opposed to targetry or other range components, because even minor changes to the range design could affect the associated surface danger zone or impact range safety in other ways. The survey data would also be used to support post-construction restoration efforts. | Monitoring/BMP |
| | | On NWSTF Boardman, the vehicle speed limit for the range is 25 miles per hour unless otherwise posted; however, emergency | BMP |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | situations, operational necessities, and certain training events may require vehicle speeds to exceed this standard speed limit. At all times on the range, vehicle operators shall use extreme caution and operate at a slow, safe speed consistent with the mission, safety, and current road and environmental conditions. Vehicle operators shall be cognizant and protective of pedestrians and wildlife while conducting all range activities. The only road posted above 25 miles per hour is the Admin Main road from the main gate access to the range from Bombing Range Road to the on-range road known as "The Interstate". Speed limit on the Admin Main Road is 30 miles per hour. It is not expected that training requirements will require speeds in excess of 25 miles per hour on a routine basis; however in some training events, vehicles need to be able to react to changing tactical situations in training as they would in actual combat. Training differently than that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities. During these activities, the 25 mile per hour speed limit may need to be exceeded for brief periods. | |
| **V-6: Native Vegetation Restoration.** Areas previously impacted by Navy mission, land management activities, or wildfire will be treated to re-establish native plant communities. This will not apply to areas encumbered by UXO. | FY 2014, FY 2016 | Habitat restoration activities would occur at selected locations on the southern portion of NWSTF Boardman. This resource management area of the range consists of approximately 11,226 ac. (4,543 ha.). Restoration efforts at NWSTF Boardman would focus on: 1) reducing threats to existing high-quality native grassland and shrub-steppe and 2) increasing the proportion of native-dominated grassland and shrub-steppe by restoring degraded sites to the greatest extent possible. This would be completed by:<br>• Begin implementing habitat restoration/enhancement for permanently lost habitat at 2:1+ ratio (ratio between 2:1 and 3:1 depending on existing ecological condition) within 2 years following construction. Achieve site specific restoration objectives within 3 years of beginning restoration effort.<br>• Implement habitat restoration/enhancement for degraded habitat at 1.25:1+ (ratio between 1:25 and 2:25 depending | Mitigation |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | on existing ecological condition) starting 3 years following construction at a rate of at least 50 ac. (20 ha) per year until requirements are met. Achieve specific restoration objectives for individual restoration sites within 3 years of initial restoration effort.<br>Restoration efforts would be allocated by priority until the agreed-upon mitigation acreage requirements have been met. Priorities would be based on the plant species composition of the restoration site, its proximity to high or medium-high quality native plant communities, and Washington ground squirrel occupancy. Reducing threats to high-quality native habitats by restoring degraded adjacent sites would be a top priority. This habitat restoration would be completed based on ratios of disturbed habitats, habitat quality, and implemented as each proposed action is constructed over time. | |
| **WL-2: Washington ground squirrel surveys.** Washington ground squirrels are a state protected species. Military training can impact the ground squirrel population on the installation. Burrow and population estimate data is available from past surveys, but new data is required to assess changes or stability due to 1) termination of grazing and resulting changes in vegetation, 2) recent fires, and 3) new mission requirements. | FY 2013 – FY 2016 | **Long-term facility-wide monitoring program for Washington ground squirrels.** A long-term, facility-wide monitoring program would be initiated to inform the adaptive management process and assess the effects of the increased training on the Washington ground squirrel. The Navy will develop a site-specific sampling design in cooperation with USFWS and ODFW that will incorporate a random stratified sampling strategy which would be designed to provide an index of population trends over the entire property and support the evaluation of effects of training activities. Given the large size of NWSTF Boardman and the fact that most or all of the property is potentially suitable Washington ground squirrel habitat, methods would be evaluated to identify the most effective and efficient approach to collecting facility-wide squirrel data. Additionally, the sampling design would also consider how to incorporate existing long-term term monitoring plots. Since training is not scheduled to begin immediately, the timeline would allow the Navy to implement a before and after control impacts design to collect baseline data to also support the assessment of impacts due to facilities construction. Information collected would be used to | Monitoring |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | continuously inform the adaptive management process, with appropriate modifications based on findings. | |
| | | **Pre-construction surveys for Washington ground squirrels.** Site specific survey protocols per the Long-term Facility-wide Monitoring, described above, would be used to survey individual construction sites prior to construction. Data from the long-term facility-wide monitoring would be used to meet these data needs to the extent possible. These surveys would cover the "affected area" of a range enhancement where permanent habitat loss or long-term habitat degradation is expected to occur. These areas include the range enhancement footprints for all projects and areas within the single-event 140 dBP contours associated with the MPMGR and CLFRs. This data would provide baseline information and would be used to avoid impacts on Washington ground squirrels during construction. | Monitoring |
| | | **Construction Monitoring and After-Action Inspections.** Construction monitoring and after-action inspections would be conducted to report any Washington ground squirrel mortality to the USFWS. Monitoring would be conducted during construction to avoid strikes by construction equipment. Any incidental mortality during construction would be documented, reported to the NWSTF Boardman Natural Resources Manager, and included in the annual report to USFWS. Standard operating procedures for after-action range inspections would be updated to include identification and reporting of Washington ground squirrel mortality that might be associated with training activities. Range control personnel would inspect target locations and heavily travelled roads at the conclusion of a ground-based training exercise. Location and description of any observed Washington ground squirrel carcasses would be recorded and photographed. Any Washington ground squirrel mortality would be reported to the NWSTF Boardman Natural Resources Manager and included in the annual report to the USFWS. | Monitoring |
| | | **Project-specific Washington ground squirrel surveys.** Site specific survey protocols would be used to measure achievement of | Monitoring |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| | | management objective 1c (interim) (ensure that Washington ground squirrel continue to occupy habitat in areas adjacent to the proposed ranges). These surveys would be conducted in areas adjacent to the identified affected areas for the MPMGR, eastern CLFR, western CLFR, and DTR and in control areas. "Adjacent areas" are defined as a 1,312 ft. (400 m) buffer around the affected areas. These areas are outside the range enhancement footprints, but could be exposed to single-event noise levels less than 140 dBP. Based on the analysis, no habitat loss, long-term habitat degradation, or decline in Washington ground squirrel numbers is expected in these adjacent areas. The proposed surveys are intended to help validate conclusions of the analysis and reduce uncertainty. When possible, data from the long-term facility-wide monitoring surveys would be used to meet these data needs.<br>The project-specific Washington ground squirrel survey areas would encompass the following approximate acreages:<br>• MPMGR: 1,120 acres<br>• Western CLFR: 1,375 acres (exclusive of the area overlapped by MPMGR monitoring)<br>• Eastern CLFR: 1,020 acres<br>• DTR: 300 acres<br>• Control areas: 300 acres each<br>One or more paired controls would be established for each survey location. The controls would be located on NWSTF Boardman (well outside areas affected by the action) or on the adjacent Boardman Conservation Area in areas with similar soils and vegetation. Baseline surveys would be conducted prior to the start of construction for the CLFRs and the DTR, and for two years prior to the MPMGR. After a range is operational, surveys would be conducted once every 2 years for a period of 10 years to evaluate long-term trends. Vegetation surveys would also be conducted within the survey areas to help determine if any observed differences in squirrel abundance or distribution might be attributable to vegetation conditions. | |

| INRMP Measures | FUNDED THROUGH (FY) | Additional Procedure/Mitigation/Monitoring Defined by FEIS | Classification |
|---|---|---|---|
| **FM-2:** Annually, as needed, map all wildfire perimeters and assess natural resource damage from the event to be used for future monitoring needs and restoration prioritization. | FY 2012 – FY 2016 | The causes, size, and location of all wildfires at NWSTF Boardman and associated suppression efforts would continue to be documented. This information would be reviewed after each wildfire to identify lessons learned and opportunities to improve fire prevention and suppression efforts. | Monitoring |

# Military Readiness Activities at

# Naval Weapons Systems Training Facility Boardman

## Washington Ground Squirrel
## Conferencing Package


Commander, U.S. Pacific Fleet
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FINAL
May 2013

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| °C | degrees Celsius |
| °F | degrees Fahrenheit |
| ac. | acre(s) |
| AGL | Above Ground Level |
| B2H | Boardman to Hemingway |
| BCA | Boardman Conservation Area |
| BLM | Bureau of Land Management |
| BMP | Best Management Practice |
| CFR | Code of Federal Regulations |
| CLFR | Convoy Live Fire Range |
| dBA | A-weighted decibels |
| dBP | decibels peak |
| DNL | Day-Night Sound Level |
| DoD | Department of Defense |
| DoN | U.S. Department of the Navy |
| DTR | Demolition Training Range |
| DEIS | Draft Environmental Impact Statement |
| EIS | Environmental Impact Statement |
| ESA | Endangered Species Act |
| EOD | Explosive Ordnance Disposal |
| FAA | Federal Aviation Administration |
| GUNEX | Gunnery Exercise |
| ft. | foot/feet |
| $ft^2$ | square foot/feet |
| ha | hectare(s) |
| INRMP | Integrated Natural Resources Management Plan |
| kg | kilogram(s) |
| km | kilometer(s) |
| $km^2$ | square kilometer(s) |
| LATT | Low Altitude Tactical Training |
| lb. | pound(s) |
| m | meter(s) |
| $m^2$ | square meter(s) |
| mi. | mile(s) |
| MOA | Military Operations Area |
| MPMGR | Multi-Purpose Machine Gun Range |
| MSCCAA | Multi-Species Candidate Conservation Agreement with Assurances |
| MSL | Mean Sea Level |
| NAS | Naval Air Station |
| NEW | Net Explosive Weight |
| $nm^2$ | square nautical mile(s) |
| NWSTF | Naval Weapons Systems Training Facility |
| ODFW | Oregon Department of Fish and Wildlife |
| ORNG | Oregon National Guard |
| PGE | Portland General Electric |
| PK-15 | unweighted peak 15 (in decibels) |
| RNA | Research Natural Area |
| RSEPA | Range Sustainability Environmental Program Assessment |
| SDZ | Surface Danger Zone |
| SEL | Sound Exposure Level |
| SOPs | standard operating procedures |
| SUA | Special Use Airspace |
| TOW | tube-launched, optically-tracked, wire-guided |
| UAS | Unmanned Aerial System |
| UCD | Umatilla Chemical Depot |
| UEC | Umatilla Electric Cooperative |
| U.S. | United States |
| USFWS | United States Fish and Wildlife Service |
| VFR | Visual Flight Rules |
| WDZ | Weapons Danger Zone |

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# 1 INTRODUCTION

## 1.1 BACKGROUND

The United States (U.S.) Department of the Navy (Navy) and Oregon National Guard (ORNG) are proposing to increase use and enhance capabilities of the Naval Weapons Systems Training Facility (NWSTF) Boardman, in Morrow County, Oregon to achieve and maintain military readiness. The Commander, U.S. Pacific Fleet prepared a Draft Environmental Impact Statement (DEIS) for proposed military readiness activities at NWSTF Boardman in August 2012 (U.S. Department of the Navy 2012). The purpose of this conferencing package is to review the proposed activities in sufficient detail to determine if and to what extent the Proposed Action (Alternative 2, the Preferred Alternative in the DEIS) may affect the Washington ground squirrel (*Urocitellus washingtoni*).

Although none of the wildlife or plant species found in the NWSTF Boardman Action Area are currently listed or proposed for listing under the Endangered Species Act (ESA) of 1973, the Washington ground squirrel, a candidate species, occurs on NWSTF Boardman and in other parts of the Action Area. Candidate species are plants and animals for which the U.S. Fish and Wildlife Service (USFWS) has sufficient information to propose them as endangered or threatened under ESA, but for which development of a proposed listing regulation is precluded by other higher priority listing activities. Candidate species receive no statutory protection under ESA, but USFWS encourages cooperative conservation efforts because they may warrant future protection under ESA.

## 1.2 CONFERENCING HISTORY

While conferencing for candidate species is not required under ESA, the Navy and ORNG determined through the Environmental Impact Statement (EIS) scoping process that it would be appropriate and useful to enter early conferencing with USFWS regarding the Proposed Action and Washington ground squirrels. This decision was based on the site-specific management situation for the Washington ground squirrel at NWSTF Boardman. Conferencing activities accomplished to date include the following:

- The Navy submitted a request for early conferencing to USFWS on 12 April 2012
- The Navy submitted a preliminary draft EIS (Draft Version 4) for review by USFWS in June 2012
- Meeting with USFWS on 8/1/2012 in Oregon to discuss USFWS comments on Draft Version 4 of the EIS and to discuss mitigation and Best Management Practices (BMP)
- Meeting with USFWS, Oregon Department of Fish and Wildlife (ODFW), Confederated Tribes of the Umatilla Indian Reservation, Verne Marr, and The Nature Conservancy (who also represented Defenders of Wildlife) on 10/25/2012 to discuss the conferencing process, Washington ground squirrel monitoring and mitigations, and the proposed actions.

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# 2 DESCRIPTION OF THE PROPOSED ACTION

The focus of this conferencing package is the analysis of effects of proposed military readiness activities at NWSTF Boardman. The following sections contain a more detailed description of the action area and a summary of the Proposed Action.

## 2.1 ACTION AREA

NWSTF Boardman is located in north-central Oregon, in Morrow County, approximately 2 miles (mi.) (3.2 kilometers [km]) south of Boardman, Oregon and the Columbia River and 16 mi. (25.7 km) southwest of Hermiston, Oregon. NWSTF Boardman consists of 47,432 acres (ac.) (19,195 hectare [ha]) of land and 358 square nautical miles ($nm^2$) of associated Special Use Airspace (SUA). The SUA includes several different airspace designations that are depicted in Figure 1, and are explained in greater detail in Section 2.1.2.

### 2.1.1 TRAINING LAND

NWSTF Boardman consists of 47,432 ac. (19,195.1 ha) of relatively flat, vegetated landscape. The land area is predominantly rectangular in shape and is approximately 12 mi. by 6 mi. (19.3 km by 9.6 km). Several air-to-ground targets currently exist within the boundaries of NWSTF Boardman and have been in place for many years, although their scoring systems have been removed. There are several structures (administrative building, etc.) that currently exist to support training activities as well as an unimproved Unmanned Aerial System (UAS) airstrip used by the ORNG. The land component of NWSTF Boardman is federally withdrawn land with title held by the United States but with management functions held by U.S. Navy, Commander, Navy Region Northwest. The Commander, Navy Region Northwest has delegated the management functions to Naval Air Station (NAS) Whidbey Island. As such, NAS Whidbey Island is responsible for environmental resource management in those areas (i.e., natural and cultural resources, hazardous waste, air monitoring, etc.).

As part of the natural resource management at NWSTF Boardman and before the designation of the Boardman Conservation Area, three Research Natural Areas (RNAs) were established on NWSTF Boardman in 1978 and are co-managed by The Nature Conservancy under a long-standing Memorandum of Understanding with the Navy. The RNAs are part of a federal government system established for research and educational purposes. Natural features are preserved for scientific purposes and natural processes are allowed to dominate. The RNA program was created to (1) preserve examples of all significant natural ecosystems for comparison with those influenced by man, (2) provide educational and research areas for ecological and environmental studies, and (3) preserve gene pools of threatened and endangered plants and animals. The RNAs on NWSTF Boardman were the first established on Department of Defense (DoD) lands. The Nature Conservancy activities in the RNAs include research and monitoring of the native habitat types and wildlife species, as well as control of noxious weeds.

### 2.1.2 SPECIAL USE AIRSPACE TRAINING AREAS

The airspace over NWSTF Boardman is comprised of two different types of SUA: Restricted Areas (R-5701 [A-E] and R-5706) that overlay portions of the NWSTF Boardman land areas and a Military Operating Area (MOA) (Boardman MOA, OR) that overlies most of the Restricted Areas. Designated by the Federal Aviation Administration (FAA), Restricted Areas are SUA within which the flight of non-participating aircraft, while not wholly prohibited, is subject to restrictions. Activities taking place in the airspace must be confined due to their nature and the need to adhere to limitations imposed on aircraft activities for which the SUA is designated (FAA JO 7400.8U). Non-participating military and civilian aircraft are not allowed into the Restricted Areas without the controlling authority's approval.

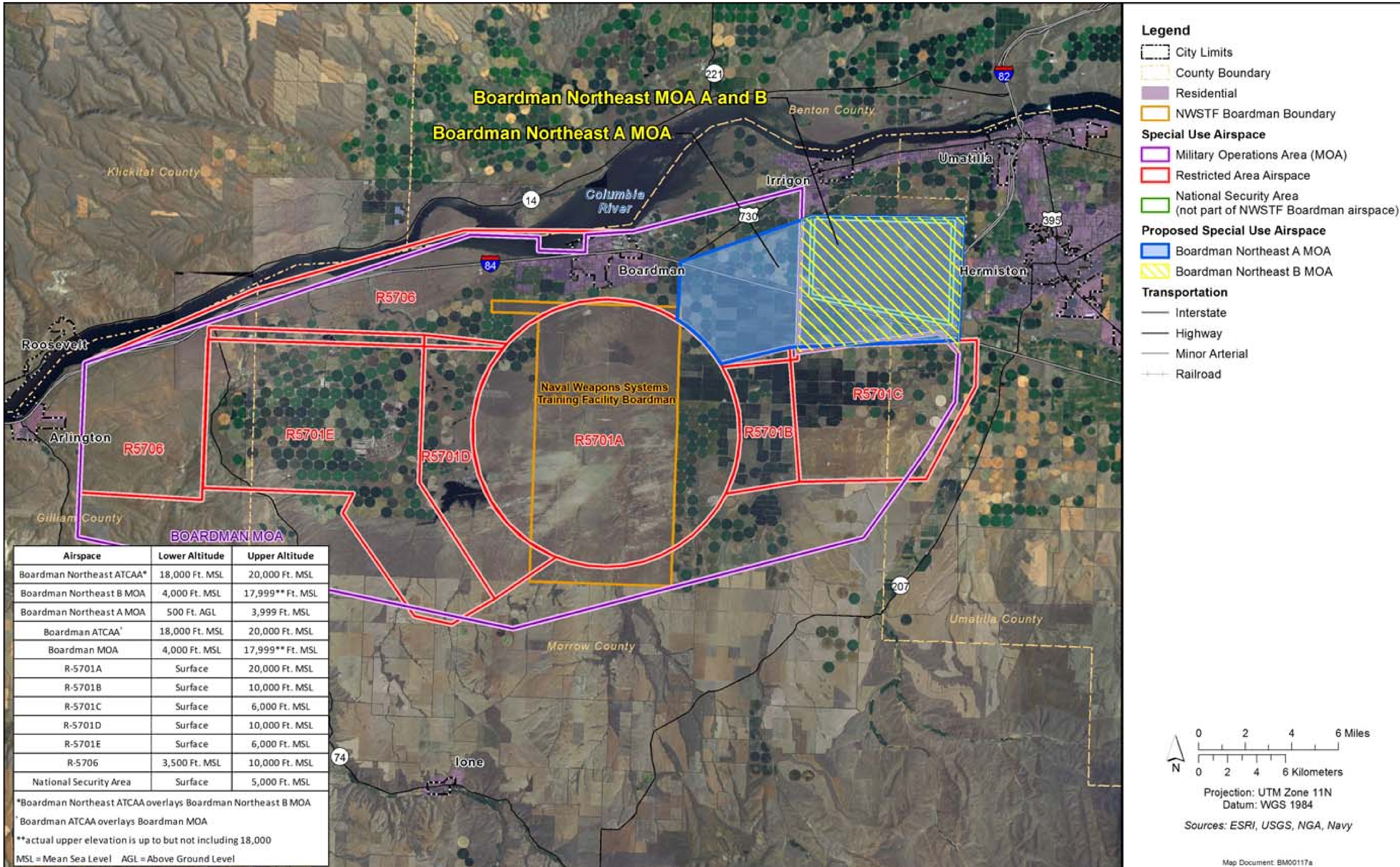
According to 14 Code of Federal Regulations (CFR) §1.1, a MOA is airspace established outside Class A airspace (18,000 to 60,000 feet [ft.] [5,486.4 to 18,288 meters {m}] Mean Sea Level [MSL]) to separate or segregate nonhazardous military activities from Instrument Flight Rules traffic and to identify for Visual Flight Rule (VFR) traffic where these activities are conducted. The designation of a MOA identifies for other users the areas where military activity occurs, provides for segregation of that activity from other fliers, and allows charting to keep airspace users informed. MOAs do not restrict VFR operations; however, pilots operating under VFR should exercise extreme caution while flying within, near, or below an active MOA. The Boardman SUA currently has only one MOA and it provides military aircraft maneuver space for training. Table 1 provides additional information on NWSTF Boardman's Restricted Areas, which make up the only Restricted Areas in the state of Oregon.

**Table 1: Existing NWSTF Boardman Airspace**

| Area Designation | Description |
|---|---|
| Boardman Military Operations Area | Located above north-central Oregon and covers 358 $nm^2$ in area. This Military Operations Area is available from 4,000 ft. (1,292 m) to but not including 18,000 ft. (5,486 m) MSL. The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| Boardman Air Traffic Control Assigned Airspace | Superimposes the Boardman Military Operations Area, covers 358 $nm^2$ and starts at 18,000 ft. (5,486 m) MSL with an upper limit of FL200 (6,096 m [20,000 ft]). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701A | A 78 $nm^2$ circular area over the central portion of Boardman that extends from the surface to 20,000 ft. (6,096 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701B | An 11 $nm^2$ rectangular area immediately east of R-5701A that extends from the surface to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701C | A 31 $nm^2$ rectangular area immediately east of R-5701B that extends to the east slightly outside the Boardman Military Operations Area boundary. R-5701C extends from the surface to 6,000 ft. (1,829 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701D | A 21 $nm^2$ area south and west of R-5701A that extends from the surface to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5701E | A 64 $nm^2$ area immediately west of R-5701D that extends from the surface to 6,000 ft. (1,829 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |
| R-5706 | A 107 $nm^2$ area in the north and western portions of the Boardman Military Operations Area that extends from the 3,500 (1,067 m) to 10,000 ft. (3,048 m). The scheduling authority is NAS Whidbey Island and Seattle Center is the controlling authority. |

Notes: $nm^2$ = square nautical miles, $km^2$ = square kilometers, ft. = feet, m = meters, NAS = Naval Air Station, MSL = mean sea level, FL = Flight Level, R = Restricted Areas, Seattle Center = Air Route Traffic Control located in Auburn, WA, FAA = Federal Aviation Administration

Source: FAA JO7400.T, National Geospatial-Intelligence Agency 2008




| Airspace | Lower Altitude | Upper Altitude |
|---|---|---|
| Boardman Northeast ATCAA* | 18,000 Ft. MSL | 20,000 Ft. MSL |
| Boardman Northeast B MOA | 4,000 Ft. MSL | 17,999** Ft. MSL |
| Boardman Northeast A MOA | 500 Ft. AGL | 3,999 Ft. MSL |
| Boardman ATCAA† | 18,000 Ft. MSL | 20,000 Ft. MSL |
| Boardman MOA | 4,000 Ft. MSL | 17,999** Ft. MSL |
| R-5701A | Surface | 20,000 Ft. MSL |
| R-5701B | Surface | 10,000 Ft. MSL |
| R-5701C | Surface | 6,000 Ft. MSL |
| R-5701D | Surface | 10,000 Ft. MSL |
| R-5701E | Surface | 6,000 Ft. MSL |
| R-5706 | 3,500 Ft. MSL | 10,000 Ft. MSL |
| National Security Area | Surface | 5,000 Ft. MSL |

*Boardman Northeast ATCAA overlays Boardman Northeast B MOA

† Boardman ATCAA overlays Boardman MOA

**actual upper elevation is up to but not including 18,000

MSL = Mean Sea Level AGL = Above Ground Level

**Figure 1: NWSTF Boardman Action Area**

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### 2.1.3 SURROUNDING LAND USE

NWSTF Boardman is located approximately 0.5 mi. (0.8 km) south of the Boardman city limits. Interstate 84 runs east-west through the city of Boardman, dividing it roughly one-third to the north and two-thirds to the south of the highway. Within the city limits, land use zoning is a combination of residential, industrial, commercial, open space, and easements, as designated by the City of Boardman. NWSTF Boardman property is located wholly within Morrow County. The land use zoning established by Morrow County immediately surrounding NWSTF Boardman on all sides is Exclusive Farm Use. Land uses to the east, south, and west of NWSTF Boardman are predominantly agricultural production, but also include a Boeing Company test facility, a commercial solid waste landfill, and a Portland General Electric (PGE) electrical generation plant.

In 2004, Threemile Canyon Farms (the "Farm"), a large, privately-owned farm located immediately west of NWSTF Boardman, and PGE, whose Boardman power plant is located approximately 2.8 mi. (4.5 km) west of the Installation and within the Farm's land, agreed to designate 23,430 ac. (9,502 ha) as conservation areas for management by The Nature Conservancy, to protect habitat for several animal species, including the Washington ground squirrel (*Urocitellus washingtoni*). Collectively, the designated conservation areas are known as the Boardman Conservation Area (BCA). The BCA was established under the terms of a Multi-Species Candidate Conservation Agreement with Assurances between the Farm, PGE, the USFWS, and the ODFW. Other areas of the Farm, including the Boeing test facility and the PGE property, may be used and developed. The ODFW holds a permanent conservation easement on the 22,600 acres of the Farm property included in the BCA (Evans and Associates 2004).

Oregon has vast wind energy resources and ranks in the top ten states with the most wind energy generation capacity installed (U.S. Department of Energy 2011). Several wind energy generation projects have been developed in the vicinity of NWSTF Boardman and others are planned. Section 6.2 Impacts of Other Actions, provides additional information on surrounding land uses and wind energy projects in the area.

### 2.1.4 DESCRIPTION OF HABITATS IN THE ACTION AREA

The vegetation at NWSTF Boardman primarily consists of shrub-steppe and grassland habitats. In contrast to much of the surrounding area, large-scale agriculture has not taken place at NWSTF Boardman. As a result, the installation persists as a large tract of predominately native shrub-steppe and grassland habitats. In fact, the installation and the adjacent Boardman Conservation Area represent one of the largest remaining single blocks of predominantly native shrub-steppe and grassland habitats in Oregon's portion of the Columbia Plateau Ecoregion (approximately 69,000 ac. [27,923 ha]) (National Audubon Society 2011).

The composition of existing vegetation communities at the installation is influenced by numerous factors including climate, soils, military use, wildfire, past grazing, a limited amount of past agricultural use, and introduction of invasive plants (noxious weeds). In particular, two related factors, wildfire and invasive plants, have affected vegetation in recent years. Since 1998, more than 85 percent of NWSTF Boardman has been burned by wildfires, which have caused short- and long-term habitat alterations. Large fires swept portions of the installation in 1998 (17,514 ac. [7,088 ha]), 2007 (11,664 ac. [4,720 ha]), and 2008 (30,612 ac. [12,388 ha]), while smaller areas burned in 2002 (1,639 ac. [663 ha]) and 2009 (618 ac. [250 ha]). With the exception of the 2009 fire, all of these fires were started by lightning strikes. The cause of the 2009 fire is unknown (U.S. Department of the Navy 2012). Training-related wildfires also occur occasionally at NWSTF Boardman. Range safety monitoring by participating military units allows for early detection of training-related fires and rapid response. Therefore, fires that start during training activities are typically contained to relatively small areas compared to lightning-caused fires, which might go undetected for a period of time after ignition.

Historically, the area was comprised of fire-adapted vegetation communities with fire return intervals that likely ranged from about 20 to 70 years based on information for similar habitats (Leenhouts 1998, Paysen et al. 2000). With the widespread introduction of invasive, non-native annual grasses such as cheatgrass, the amount of fuel for wildfires has increased. Wildfires now tend to be more frequent and more severe (burn hotter), and can be long-term or permanent habitat altering events. Frequent and hot burning fires like those that have occurred at NWSTF Boardman favor a shift from shrublands to grasslands. Humple and Holmes (2001) documented decreases in sagebrush cover and increases in cover of grass, primarily cheatgrass, in study plots following the 1998 fire at NWSTF Boardman.

Maintaining an up-to-date vegetation inventory and associated mapping for NWSTF Boardman has been a challenge given the recent wildfire history. Habitat types were mapped and described for the entire installation in 1997 by interpreting aerial photographs and conducting ground-truthing studies (U.S. Department of the Navy 2012). In 2007, the U.S. Navy initiated a survey to update vegetation mapping for the entire installation. However, the large 2007 wildfire (11,664 ac. [4,720 ha]) occurred soon after the aerial imagery data were collected. A decision was made not to finalize the vegetation mapping effort because fire-induced vegetation changes rendered the imagery data obsolete. The *NWSTF Boardman Integrated Natural Resources Management Plan (INRMP)* (U.S. Department of the Navy 2012) includes a project recommendation to collect high-resolution aerial photography to map all vegetation and produce geographic-information-system-based vegetation mapping in the near future.

The remainder of this section provides descriptions of vegetation communities and habitat types based on information taken from the *NWSTF Boardman INRMP*. As discussed above, the best available vegetation/habitat data are from 1997, prior to a series of wildfires that occurred from 1998 through 2009. Vegetation conditions have changed at the installation since 1997 and will continue to change based on future fire regimes and other factors such as invasive species.

A list of plant species known to occur on NWSTF Boardman is provided in Appendix A. The following six major plant associations occur on NWSTF Boardman (U.S. Department of the Navy 2012).

- Big sagebrush/bluebunch wheatgrass
- Bluebunch wheatgrass/Sandberg’s bluegrass
- Big sagebrush/western needle-and-thread grass
- Antelope bitterbrush/needle-and-thread grass
- Needle-and-thread grass/Sandberg’s bluegrass
- Snowy buckwheat/Sandberg’s bluegrass

Lesser represented communities include the matchweed (an introduced species) variant of the big sagebrush/bluebunch wheatgrass association, and relict stands of western juniper/big sagebrush/bluebunch wheatgrass association. It should also be noted that large portions of nearly all of these associations are currently invaded by cheatgrass. Finally, there are some largely unvegetated sand dune and “alkali” areas.

Sagebrush/wheatgrass and wheatgrass/bluegrass plant associations dominate the southern half of NWSTF Boardman where soils are deeper and loamier. The presence of sagebrush differentiates these communities. Sagebrush is more prevalent in the draws and lowlands where deep, subsurface water resources are easier obtained. Both of these communities have been severely impacted by grazing (circa 1870s to 1950s) and now are largely dominated by cheatgrass. Healthy stands of wheatgrass are mostly limited to small patches on north-facing slopes, while sagebrush/wheatgrass association stands have been often heavily invaded with cheatgrass.

Moving south to north on the facility, the soils become sandier, resulting in a replacement of the sagebrush/wheatgrass and wheatgrass/bluegrass plant associations with the sagebrush/ needle-and-thread grass and needle-and-thread grass/bluegrass associations. Prior to the invasion of alien weedy annuals around the early 1900s, much of the land now supporting these associations was characterized as isolated patches of western needle-and-thread surrounded by blowing sand. Outlines of the extensive dune systems that dominated this portion of the range are still evident in aerial photographs. While much of the original needle-and-thread stands have been replaced by dense stands of cheatgrass, needle-and-thread appears to also be establishing in areas of former dunes now stabilized by weedy annuals, including cheatgrass. Quality stands of needle-and-thread can still be found on the center portion of the range, especially where historically protected from grazing in the RNAs. The resilience of needle-and-thread, compared to bluebunch wheatgrass, to withstand grazing probably resides in its lesser palatability to livestock. However, gray and green rabbitbrush now dominate large portions of these communities because of disturbance from fire and historic grazing.

On the farthest northern edge of NWSTF Boardman is found the sandiest soils supporting the bitterbrush/needle-and-thread association and, where parent soils are slightly rocky, small patches of buckwheat/bluegrass plant associations. Very little needle-and-thread is found in these communities because it has either been replaced by cheatgrass, Russian thistle, and other alien weedy annuals, or has not yet colonized these areas since dune stabilization. Finally, due east of RNA-C is a small community of matchweed, a small, non-native shrub that apparently established in the John Day River drainage in the late 1940s and has been moving eastward since. This plant is an indicator of previous severe grazing.

In their pristine state, apparently none of these plant associations supported a diverse floristic composition, largely because of harsh climatic conditions and the deep soil lichen layers that developed between the grasses. Usually no more than 1 shrub and 1 or 2 species of grass, along with soil lichens and bare ground, accounted for greater than 90 percent of the ground cover. Phlox, lomatium, yarrow, and various members of the pea family were the most conspicuous forbs. However, livestock trampling of the lichen layer and intensive grazing of the palatable forage species has encouraged the invasion of alien weedy annuals such as cheatgrass, Russian thistle, tumblemustard, and whitlow-grass. It has dramatically increased the number of unpalatable native species, such as hairy golden-aster in the sagebrush/wheatgrass plant associations, and fiddleneck tarweed, lance-leaf scurf-pea, and hairy plantain in the needle-and-thread grass associations.

Table 2 provides a summary of major habitat types that were identified during the mapping effort completed in 1997 (U.S. Department of the Navy 2012). Habitat types are units that can be mapped with discrete characteristics that separate them from other habitat types, and provide a specific set of components important as life requisites for specific wildlife species. Most habitat types are based loosely on the plant communities described earlier using vegetative structure and floristic composition as classification parameters.

**Table 2: Summary of Habitat Types and Acreage at NWSTF Boardman**

| Habitat Type | Size (Acres)[1] | Description | Wildlife Uses |
|---|---|---|---|
| Sagebrush | 7,415 | Sagebrush stands can be found throughout much of the facility, but are most prevalent in and near Juniper Canyon. Sagebrush can be structurally separated into a lowland type of larger plants with an understory of cheatgrass or sandy bare ground, and a structurally shorter upland type with lichen typically covering the understory. | Birds such as the black-billed magpie, Brewer's blackbird, lark sparrow, and loggerhead shrike appear to prefer the larger lowland sagebrush, while the sage sparrow and Brewer's sparrow may prefer the upland sage. |
| Bitterbrush | 2,555 | Antelope bitterbrush dominates large portions of the sandy-soiled region in the northern edge of the facility. Structurally it can become very tall (greater than six feet) and is sometimes co-dominated with gray rabbitbrush. | Larger bitterbrush plants provide nesting habitat for black-billed magpies, black-throated sparrows, and loggerhead shrikes, and perching habitat for burrowing owls. It also provides important cover for black-tailed jackrabbits and northern sagebrush lizards. |
| Bunchgrass | 12,100 | Bunchgrass habitat types include areas on the central and northern portion of the facility dominated by western needle-and-thread grass, and on the southern end by bluebunch wheatgrass. Portions of these habitats have been purposely historically protected from grazing. | Wildlife species typically found here include the grasshopper sparrow and Washington ground squirrel. |
| Open Low Shrub | 9,150 | The low shrub habitat type includes areas throughout the facility dominated by gray rabbitbrush, although green rabbitbrush and matchweed may comprise a significant portion of the shrub component. The presence of rabbitbrush on the facility, extensive in some areas, is largely a result of past fires as both rabbitbrush species are fire-tolerant, especially compared to other dominant shrubs. | The black-tailed jackrabbit, northern pocket gopher, gray partridge, and western meadowlark are among the dominant wildlife species found here. |
| Annual Grass/Forb | 15,840 | Annual grass/forb habitats are the areas on the facility dominated by cheatgrass, or co-dominated with the perennial Sandberg's bluegrass, usually associated with weedy forbs such as lance-leaf scurf-pea, fiddleneck tarweed, Jim Hill mustard, whitlow-grass, and hairy plantain. These habitats typify areas that were once heavily disturbed by grazing or crop production, or have invaded sandy areas that they have subsequently stabilized. | This habitat type provides nesting habitat for long-billed curlews, burrowing owls, horned larks, and western meadowlarks, and Great Basin pocket mice are very common here. |

**Table 2: Summary of Habitat Types and Acreage at NWSTF Boardman (continued)**

| Habitat Type | Size (Acres)[1] | Description | Wildlife Uses |
|---|---|---|---|
| Juniper | Not applicable[2] | The juniper habitat type includes both the small juniper "forest" found in the Juniper Canyon, and the scattered juniper trees found on the periphery of Juniper Canyon and the western edge of the facility. In 1999 there were 188 mature juniper trees found on the facility. Some of these trees have since died and a number of young junipers have been found. | Junipers provide nesting habitat for Swainson's hawks, ferruginous hawks, ravens, long-eared owls, western kingbirds, and black-billed magpies. They also provide shade for mule deer and cover for porcupines. |
| Human Structures/Disturbed | 145 | This habitat type includes buildings associated with the existing headquarters area, previous locations of buildings that have been demolished, and disturbed areas such as the old moving target indicator track, the main bulls-eye, the old cattle corrals, and used weapons accumulation areas. | Buildings may provide habitat for a variety of non-native pests such as starlings, house sparrows, and house mice. The observation tower in the southeastern corner of the target area has been used for several years by nesting ravens. |
| Dune | 210 | Dune habitats are found mostly on the north central end of the facility and within central Juniper Canyon. | Sagebrush lizards are commonly found along the dune edges. |
| Alkali | 45 | Alkali habitats occur in southern Juniper Canyon and at Well Springs. These habitats are devoid of vegetation. | The short-horned lizard is one of the few wildlife species found here. |

[1] Acreages are based on data collected in 1997, prior to a series of lightning-caused wildfires.
[2] Acreage was not calculated because most junipers are scattered and largely fall within another habitat type.
Source: U.S. Department of the Navy 2012

Surveys were conducted in late February 2013 to assign ecological condition classifications to habitats on selected portions of NWSTF Boardman to support impact assessment and mitigation planning efforts (Figure 2). Ecological condition classes were assigned based on the following classifications, which have also been used at the Boardman Conservation Area by The Nature Conservancy (Elseroad 2002):

- High: Understory plant community dominated by native perennial bunchgrasses. Bunchgrasses abundant and robust, soil crust intact. Very few if any exotic species present.
- Medium-high: Understory plant community dominated by native perennial bunchgrasses. Cheatgrass and other exotic species present but in very low amounts or only in small isolated patches.
- Medium: Native perennial bunchgrasses present, but cheatgrass and other exotic species are widespread throughout the community.
- Medium-low: Community dominated by cheatgrass, other exotic species, and disturbance-adapted native species such as rabbitbrush. *Poa sandbergii* is often the only native perennial bunchgrass present.
- Low: Community dominated by cheatgrass and other exotic species. Few if any native species present (although rabbitbrush may be a dominant species) and no native perennial bunchgrasses present.

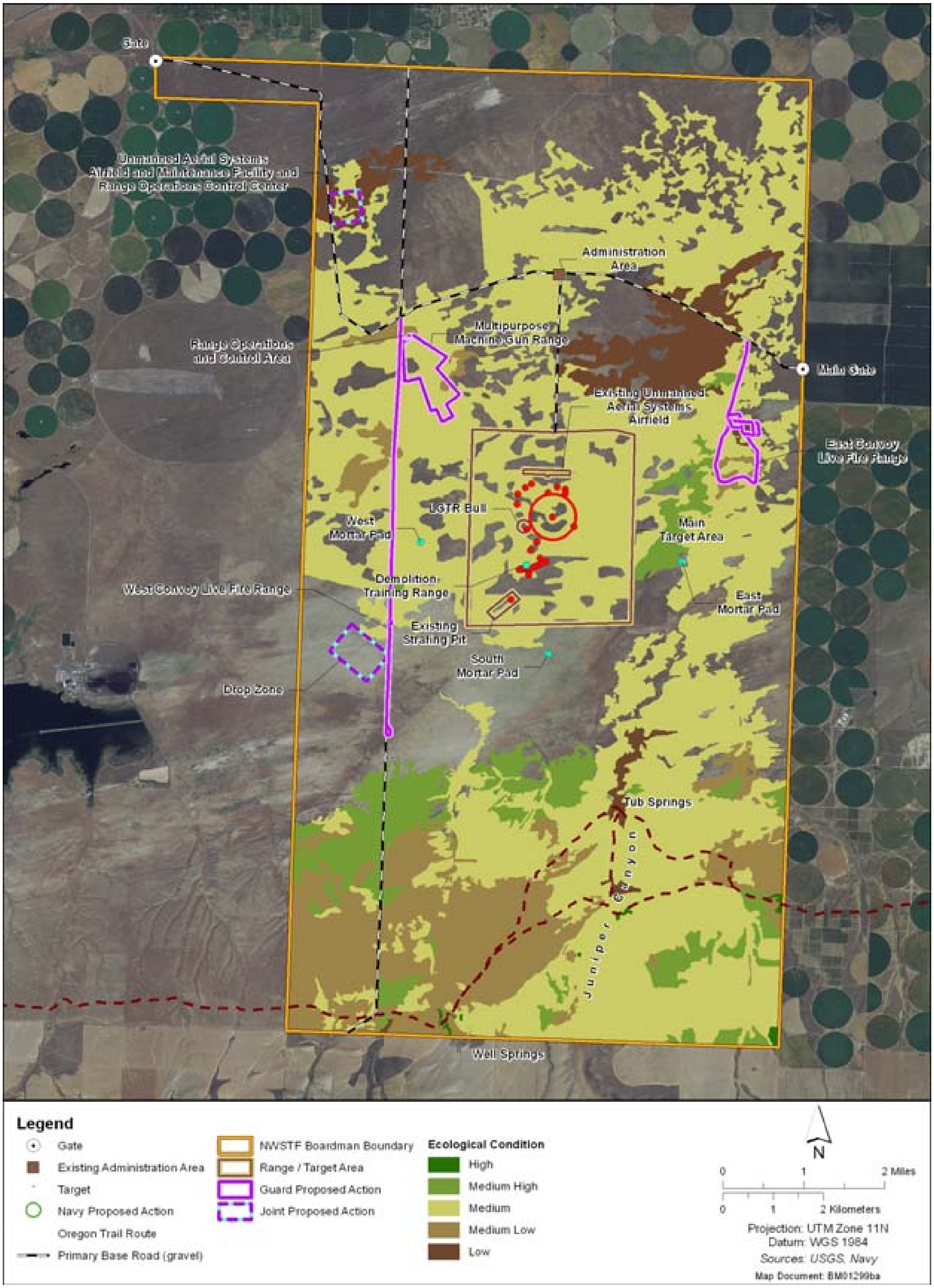


**Figure 2: Ecological Condition Classification for Selected Areas on NWSTF Boardman**

#### 2.1.4.1 Soil Types at NWSTF Boardman

Three major soil associations occur on the facility as shown in Figure 3: Quincy-Koehler, Sagehill-Taunton, and Warden (U.S. Department of Agriculture 1983). These major associations are represented by 34 soil mapping units, some of which are classified as prime farmland or farmland of statewide importance (Table 3). The Quincy-Koehler association consists of soils on alluvial sand over alluvial gravel deposits on gently sloping terraces. On NWSTF Boardman, the association includes about 55 percent Quincy soil, 35 percent Koehler, and a combined 10 percent for Burbank, Hezel, Quinton, and Royal. These deep, loamy fine sand soils dominate the northern half of the facility.

Moving southward on the facility, the Quincy-Koehler association is replaced by the more sandy loam Sagehill-Taunton association. Soils in this association were formed on loess over lacustrine or a hardpan, and dominate the terrace front of the facility south end. Major soils include Sagehill (65 percent), Royal (20 percent), Taunton (10 percent), and Ellum (5 percent). These soils are very deep with a sandy loam or fine sandy loam surface.

The southern one-quarter of the facility is almost entirely Warden soils (90 percent). This is a very deep, well-drained soil with a silty loam surface. Warden soils developed in loess over lacustrine silt and form the terrace tops above Juniper Canyon and other canyons of the south end. Lesser (less than 10 percent) represented soils include Lickskillet and Xeric Torriorthents. Lickskillet soils are shallow stony soils composed of loess and basalt residuals. These soils are found on west and south-facing slopes of Juniper Canyon, and are punctuated with rock outcroppings. Xeric soils are deep wind and water lain accumulates in dry canyon bottoms. Because of high summer temperatures and excessive draining, these soils are unusually dry.

In some locations, wind and water processes have dramatically altered the surface layers of native soils presenting a much different appearance. These include areas where wind-borne sand has accumulated into dunes devoid of vegetation. Dunes are largely found on the north end of NWSTF Boardman and in the middle of Juniper Canyon. “Alkaline” soils, also bare of vegetation, can be found on the south end of NWSTF Boardman. These include areas near Tub Spring where the surface soil has eroded away revealing calcareous lacustrine silt under layers high in sodium and calcium. More classic alkaline soil is found at Well Springs where excessive evaporating of rain and spring water has allowed the accumulation of salts, especially sodium, on the surface horizon.

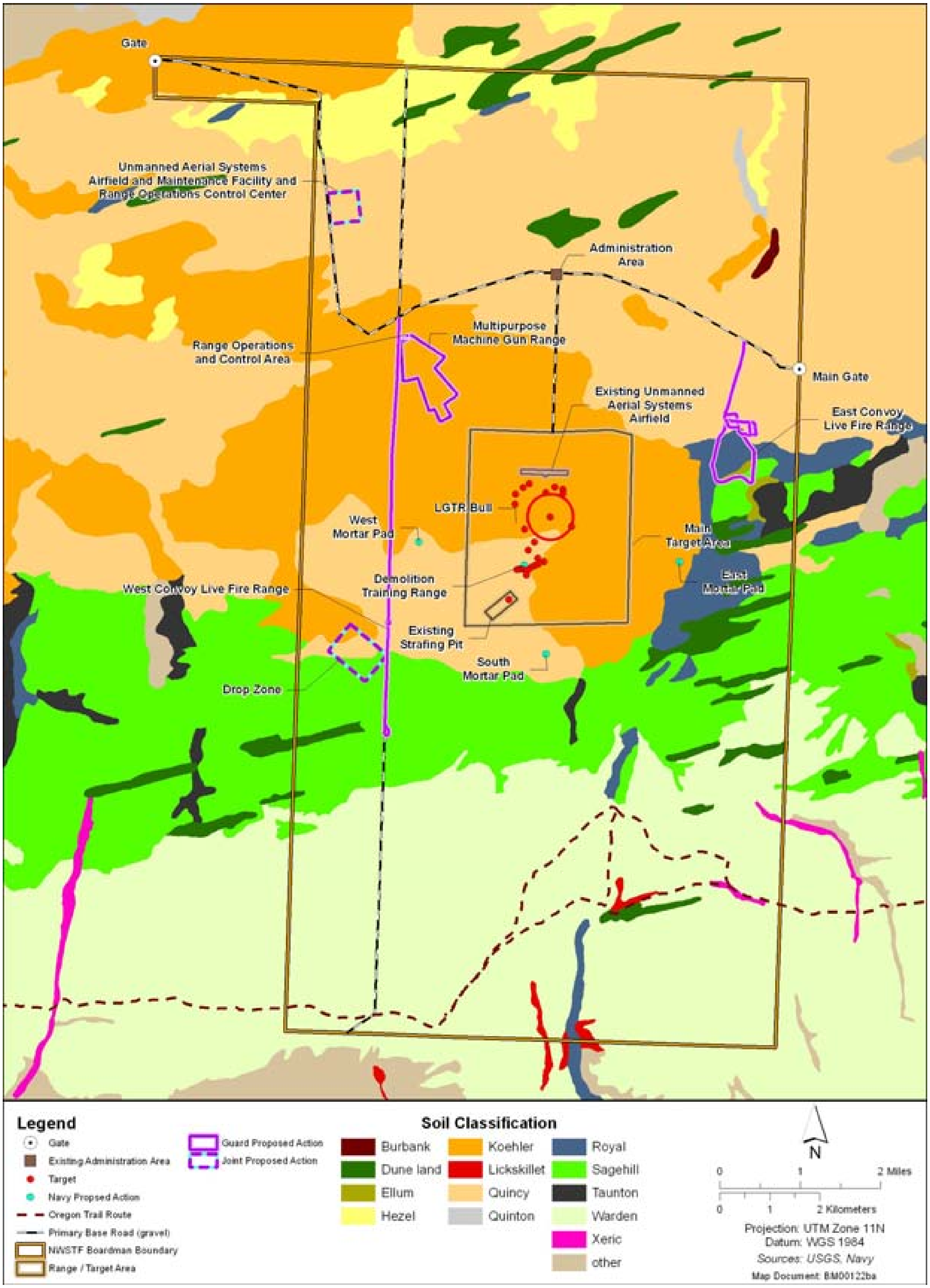


**Figure 3: Soils at NWSTF Boardman**

**Table 3: Soil Map Units, Soil pH, and Farmland Classification of Soils at NWSTF Boardman**

| Soil Mapping Unit | pH | Farmland Classification |
|---|---|---|
| Burbank loamy fine sand, 2 to 5 percent slopes | 7.2 | Not prime farmland |
| Dune land | | Not prime farmland |
| Ellum fine sandy loam, 5 to 12 percent slopes | 7.6 | Farmland of statewide importance |
| Hezel loamy fine sand, 2 to 5 percent slopes | 8.4 | Farmland of statewide importance |
| Hezel loamy fine sand, 5 to 12 percent slopes | 8.4 | Farmland of statewide importance |
| Koehler loamy fine sand, 2 to 5 percent slopes | 7.9 | Not prime farmland |
| Koehler loamy fine sand, 5 to 12 percent slopes | 7.9 | Not prime farmland |
| Lickskillet very stony loam, 7 to 40 percent slopes | 6.7 | Not prime farmland |
| Quincy loamy fine sand, 2 to 12 percent slopes | 7.3 | Not prime farmland |
| Quinton loamy fine sand, 2 to 5 percent slopes | 7.8 | Not prime farmland |
| Royal fine sandy loam, 2 to 5 percent slopes | 7.2 | Prime farmland if irrigated |
| Royal fine sandy loam, 5 to 12 percent slopes | 7.2 | Farmland of statewide importance |
| Royal loamy fine sand, 2 to 5 percent slopes | 7.2 | Not prime farmland |
| Royal silt loam, 0 to 3 percent slopes | 7.2 | Prime farmland if irrigated |
| Sagehill fine sandy loam, 2 to 5 percent slopes | 7.5 | Prime farmland if irrigated |
| Sagehill fine sandy loam, 5 to 12 percent slopes | 7.5 | Farmland of statewide importance |
| Sagehill fine sandy loam, 12 to 20 percent slopes | 7.5 | Farmland of statewide importance |
| Sagehill fine sandy loam, hummocky, 2 to 5 percent slopes | 7.5 | Farmland of statewide importance |
| Sagehill fine sandy loam, hummocky, 5 to 12 percent slopes | 7.5 | Farmland of statewide importance |
| Sagehill fine sandy loam, hummocky, 2 to 5 percent slopes | 7.5 | Farmland of statewide importance |
| Taunton fine sandy loam, 2 to 5 percent slopes | 6.9 | Prime farmland if irrigated |
| Taunton fine sandy loam, 5 to 12 percent slopes | 6.9 | Farmland of statewide importance |
| Warden very fine sandy loam, 2 to 5 percent slopes | 7.2 | Prime farmland if irrigated |
| Warden very fine sandy loam, 5 to 12 percent slopes | 7.2 | Farmland of statewide importance |
| Warden very fine sandy loam, 12 to 20 percent slopes | 7.2 | Farmland of statewide importance |
| Warden silt loam, 0 to 2 percent slopes | 7.2 | Prime farmland if irrigated |
| Warden silt loam, 2 to 5 percent slopes | 7.2 | Prime farmland if irrigated |
| Warden silt loam, 5 to 12 percent slopes | 7.2 | Farmland of statewide importance |
| Warden silt loam, 12 to 20 percent slopes | 7.2 | Farmland of statewide importance |
| Warden silt loam, 20 to 40 percent slopes | 7.2 | Farmland of statewide importance |
| Warden silt loam, 3 to 12 percent slopes, Eroded | 7.2 | Farmland of statewide importance |
| Warden silt loam, 12 to 20 percent slopes, eroded | 7.2 | Farmland of statewide importance |
| Xeric Torriorthents, nearly level | 7.0 | Farmland of statewide importance |

## 2.2 DESCRIPTION OF THE PROPOSED ACTION

### 2.2.1 PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose of the Proposed Action is to achieve and maintain military readiness by using NWSTF Boardman and its associated airspace to support and conduct current, emerging, and future military readiness activities, while enhancing training resources through investments and development of necessary infrastructure on the range.

NWSTF Boardman and its associated airspace are important to military readiness because of the unique training environment it provides. Due to shortfalls in range capabilities at NWSTF Boardman and associated airspace, and within the state of Oregon and in the Pacific Northwest, the Navy and ORNG would take actions for the following purposes:

- Ensuring that NWSTF Boardman and its associated airspace continue to support critical military training activities in a realistic and cost-effective manner;
- Achieving and maintaining military readiness using NWSTF Boardman and its associated airspace to support and conduct current, emerging, and future military readiness activities; and
- Upgrading and modernizing the existing capabilities of NWSTF Boardman and its associated airspace to address training range shortfalls in Oregon and the Pacific Northwest.

The Proposed Action is needed to provide a training environment consisting of ranges, training areas, and range instrumentation with the capacity and capabilities to fully support required training tasks for operational units utilizing NWSTF Boardman. In this regard, NWSTF Boardman and its associated airspace further the military's execution of its roles and responsibilities under United States Code Title 10 (federal military) and Title 32 (State National Guard). To comply with Title 10 and Title 32 mandates, the military needs to maintain current levels of military readiness through improvement of training capabilities at NWSTF Boardman and within its associated airspace, accommodation of possible future increases in training, and maintenance of the long-term viability of NWSTF Boardman and its associated airspace as a military training and testing area.

### 2.2.2 Description of the Proposed Action

The Proposed Action involves construction and operation of new range facilities and changes in existing training activities at NWSTF Boardman. The Proposed Action would result in enhancements and increases in training that are necessary to ensure NWSTF Boardman supports military training and readiness objectives. The components of the Proposed Action stem from U.S. Navy training requirements (Fleet Response Training Plan) and other military training requirements, including Army Regulation 350-1, *Army Training and Leader Development*; Army Regulation 350-2, *Reserve Component Training*; Department of the Army Pamphlet 350-38, *Standards in Training Commission*; and ORNG regulations and policies. In general, the Proposed Action would:

- Increase the types of training activities and the number of training events conducted at NWSTF Boardman
- Accommodate force structure changes
- Provide enhancements to training facilities and operations at NWSTF Boardman and its associated SUA

#### 2.2.2.1 Training and Testing Activities

Descriptions of training and testing activities analyzed in this conferencing package are organized by the Navy's primary mission areas, regardless of the Service that is conducting the activity. This grouping or bundling of similar activities helps to streamline the analysis of potential impacts and ensures that the overall potential effects of a particular activity are considered, irrespective of the Service conducting the activity. For example, the potential effects of an air-to-ground gunnery exercise conducted by the Navy are expected to be the same as one conducted by the Air National Guard. Separate descriptions are presented when a Services' activity does not align with a Navy primary mission area. Training and testing activities conducted under the Proposed Action at NWSTF Boardman include the following:

- Anti-Air Warfare Training – Low-Altitude Tactical Training (LATT), and Surface-to-Air Counter Tactics

- Strike Warfare – Air-to-Ground Bombing Exercises, Air-to-Ground Gunnery Exercises, and Air-to-Ground Missile Exercises (captive-carry only, nothing is dropped/released from the aircraft)
- UAS Operations
- Electronic Warfare Training – Electronic Attack and Electronic Surveillance
- Equipment and Personnel Insertion and Extraction Training
- Helicopter Training Operations (Low-Level Training Flights, Hoisting Operations, Sling-Load Operations, and Austere Landings and Take-Offs)
- Live Fire Range Operations (marksmanship and small arms training) and Dismounted Maneuver Training (Maneuver to Contact Live-fire Training)
- Intelligence, Surveillance, and Reconnaissance Training

Table 4 provides the annual number of testing and training events at NWSTF Boardman under the Proposed Action. Table 5 and Table 6 present the annual ordnance use at NWSTF Boardman. Table 7 presents the annual estimates of aircraft overflights in the NWSTF Boardman Special Use Airspace under the Proposed Action

**Table 4: Training and Testing Activities at NWSTF Boardman under the Proposed Action**

| Range Activity | Representative Platform | Annual Number of Training Events | Location |
|---|---|---|---|
| **Anti-Air Warfare** | | | |
| Surface to Air Counter Tactics and Low-Altitude Tactics Training | EA-6B, EA-18G, F-15, F-16, FA-18, F-35,C-130 | 1,047 | Boardman MOA, Restricted Areas |
| **Strike Warfare** | | | |
| Air-to-Ground Bombing Exercise | FA-18, F-35, AV-8 | 133 | Main Target Area |
| Air-to-Ground Gunnery Exercise | F-15 , F-35, CH-47, H-60 | 70 | Main Target Area, Strafe Pit |
| Air-to-Ground Missile Exercise/High Speed Anti-Radiation Missile Exercise (non-firing) | EA-6B, EA-18G | 180 | Main Target Area, Boardman MOA, Restricted Areas |
| Intelligence, Surveillance, and Reconnaissance | P3-C, EP-3, EA-18G, EA-6B | 9 | Boardman MOA, Restricted Areas |
| **Electronic Warfare** | | | |
| Electronic Attack and Electronic Support | EA-6B, EA-18G, EP-3 | 500 | Boardman MOA, Restricted Areas |
| **Support Activities** | | | |
| Unmanned Aerial System/Tactical Unmanned Aerial Systems Operations | RQ-7, RQ-11 | 1,709 | TUAS Airfield, R-5701 (all), R-5706 |
| Insertion and Extraction | C-130, C-17, C-23 HH-53, CH-46, CH-47 UH-60 | 12 Days | NWSTF Boardman, Drop Zone |
| Small Arms Training | 5.56, 7.62, 20mm, 25mm, 40mm, 50 mm caliber weapons | 18 Days | Main Target Area MPMGR |

**Table 4: Training and Testing Activities at NWSTF Boardman under the Proposed Action (continued)**

| Range Activity | Representative Platform | Annual Number of Training Events | Location |
|---|---|---|---|
| Mortar Firing | M224 60mm, 81mm and 120mm (using sub-caliber training rounds) | 18 | Main Target Area |
| **Conduct Airborne Operations** | | | |
| Night Vision Goggle Low-Level Training | EA-18G, H-60, CH-47 | 21 | Boardman MOA, Restricted Areas |
| **Conduct Fire Support** | | | |
| Convoy Live Fire Training | HMMWV, FMTV M1A2 Abrams, M2□M3 Bradley, M88 Wrecker | 45 days | CLFR |
| Multi-Purpose Machine Gun Range Training | HMMWV (weapons systems would include M249 SAW, M240B, M60, M2, Mk 19, Sniper rifles up to and including 50 cal) | 117 days | MPMGR |
| **Ordnance Disposal and Demolition** | | | |
| Land Demolition Training | EOD personnel, ORNG Engineers | 50 | DTR |

Notes: MOA □ Military Operations Area, TUAS □ Tactical Unmanned Aerial Systems, MPMGR □ Multi-Purpose Machine Gun Range, CLFR □ Convoy Live Fire Range, EOD □ Explosive Ordnance Disposal, ORANG □ Oregon Air National Guard, DTR □ Demolition Training Range, FMTV □Family of Medium Tactical Vehicles--mostly 2.5-ton LMTV □ light medium tactical vehicle, and 5-ton MTV
All items are non-explosive practice munitions except for Demolition Training.
Platforms presented are representative platforms and other similar platforms could be used.

**Table 5: Estimated Total Annual Ordnance Use at NWSTF Boardman under the Proposed Action**

| Training Area and Ordnance Type | Number of Rounds Per Year[1] |
|---|---|
| **Practice□Training Ordnance** | |
| MK-76 | 392 |
| MK-82 | 10 |
| MK-83 | 3 |
| MK-84 | 2 |
| Laser-Guided Training Rounds | 20 |
| **Mortar Rounds** | |
| M224 60mm mortars (non-explosive) | 1,440 |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 269,500 |
| 7.62 mm | 333,000 |
| 20 mm | 88,800 |
| 40 mm grenades (non-explosive) | 10,500 |
| .50 caliber | 102,000 |
| **High Explosive Charges** | |
| 200 pounds net explosive weight or less | 50 |

[1] Actual values will vary based on specific training requirements, which are influenced by factors such as deployments and world events.

Note: All items are non-explosive practice munitions except for Demolition Training.

**Table 6: Summary of Estimated Annual Ordnance Use by Range Area under the Proposed Action**

| Training Area and Ordnance Type | Number of Rounds Per Year[1] |
|---|---|
| **Main Target Area (includes strafing pit)** | |
| **Practice Training Ordnance** | |
| MK-76 | 392 |
| MK-82 | 10 |
| MK-83 | 3 |
| MK-84 | 2 |
| Laser-Guided Training Rounds | 20 |
| **Total** | **427** |
| **Mortar Rounds** | |
| M224 60mm mortars (non-explosive) | 1,440 |
| **Total** | **1,440** |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 19,500 |
| 7.62 mm | 13,000 |
| 20 mm | 88,800 |
| 40 mm grenades (non-explosive) | 500 |
| .50 caliber | 2,000 |
| **Total** | **123,800** |
| **Multi-Purpose Machine Gun Range** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 160,000 |
| 7.62 mm | 220,000 |
| .50 caliber | 75,000 |
| **Total** | **455,000** |
| **Convoy Live Fire Range (Eastern)** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 45,000 |
| 7.62 mm | 50,000 |
| 40 mm | 5,000 |
| .50 caliber | 12,500 |
| **Total** | **112,500** |
| **Convoy Live Fire Range (Western)** | |
| **Small and Medium Caliber Rounds** | |
| 5.56 mm | 45,000 |
| 7.62 mm | 50,000 |
| 40 mm | 5,000 |
| .50 caliber | 12,500 |
| **Total** | **112,500** |
| **Demolition Training Range** | |
| **High Explosive Charges** | |
| 200 pounds net explosive weight or less | 50 |
| **Total** | **50** |

[1] Actual values will vary based on specific training requirements, which are influenced by factors such as deployments and world events.

**Table 7: Annual Estimates of Aircraft Overflights in the NWSTF Boardman Special Use Airspace under the Proposed Action**

| Aircraft | Sorties | Flight Time (Hours) | □ Above 3,000 ft. MSL | □ Nighttime |
|---|---|---|---|---|
| **Fixed-Wing** | | | | |
| EA-6B Prowler | 0 | 0 | 0% | 0% |
| EA-18G Growler | 1,348 | 2,791 | 35% | 0% |
| F-15 | 60 | 120 | 65% | 0% |
| F-16 | 5 | 8 | 35% | 0% |
| F-35 | 64 | 126 | 35% | 0% |
| FA-18 | 129 | 154 | 35% | 0% |
| AV-8 | 0 | 0 | 0 | 0% |
| P-3□EP-3□P8 | 50 | 25 | 100 | 20 |
| Parachute Drops from C-130, C-17, CH-47 or C-23 | 12 | 12 | 50% | 20% |
| **Helicopters** | | | | |
| CH-47 Chinook | 65 | 97 | 0% | 33% |
| UH-60 Blackhawk | 22 | 32 | 0% | 33% |
| UH-72 Lakota | 6 | 8 | 0% | 33% |
| **Unmanned Aerial Systems** | | | | |
| RQ-7 Shadow | 204 | 408 | - | 15% |
| RQ-11 Raven | 30 | 100 | - | 15% |
| SCANEAGLE | 1475 | 5,900 | 85% | 15% |
| **GRAND TOTAL** | **3,470** | **9,781** | | |

Notes: Flight Time (Hours) □ Total flight in NWSTF (Naval Weapons Systems Training Facility) Boardman Military Operating Area; % Above 3,000 ft. (914.4 m) MSL □ estimated percentage of total flight time that occurs at an altitude above 3,000 ft. (914.4 m) above MSL; % nighttime □ percentage of total flight time that occurs between 10 pm and 7 am.
Flight Time in hours is a summation of all operations, which often occur concurrent to each other. The total flight hours are not a representation of sequential flight hours.
The F-35 is not currently planned for basing with Navy units in the northwest; however, as with other military aircraft types, potential infrequent utilization of NWSTF Boardman is possible from transient units.

### 2.2.2.2 Maintenance Activities

In addition to training and testing activities, personnel stationed at the facility are tasked with ongoing activities to maintain the usability and safety of the facility:

- Chief of Naval Operations Instruction 3571.4 *Operational Range Clearance Policy for Navy Ranges* (9 October 2009) establishes the policy and requirements for performing operational range clearance on Navy ranges in accordance with DoD Directive 4715.11.
  - Areas that support various range management activities as well as areas that pose a potential concern to human health or the environment shall undergo clearance activities.
  - To ensure the safety of maintenance personnel, operational range clearance requirements must address ingress/egress routes, run-in lines, maintenance roads, and

sufficient area around each target to afford safe movement and operation of personnel and equipment.
    - To ensure all targets resemble the objective of the mission and are distinguishable from its surroundings, all material potentially presenting an explosive hazard located on the surface and partially buried that are greater than 4 in. (10.2 cm) in any dimension, must be removed to an appropriate distance from the target and at an appropriate frequency.
- Range control procedures at NWSTF Boardman limit unanticipated interactions with the public. NWSTF Boardman is fully fenced; entrance into these areas is controlled by unmanned gates. Signs also are posted and maintained to warn the public of potentially hazardous activities.
- Vegetation is managed under the *NWSTF Boardman INRMP* (U.S. Department of the Navy 2012). Actions focus on minimizing disturbance, controlling invasive plants and weeds, and restoring of native habitats.
- Wildlife species are managed under the *NWSTF Boardman INRMP* (U.S. Department of the Navy 2012). Actions focus on minimizing disturbance and restoring native habitats.
- Commander, Navy Region Northwest implements a regional fire management plan. The Navy is currently revising, updating, and expanding the specific portion of that plan applicable to NWSTF Boardman. The current fire strategy is to use the existing road system as the staging lines at which fires will be fought. The Navy currently maintains a system of 60 ft. (18.3 m)-wide fire breaks throughout NWSTF Boardman. A detachment of six Navy personnel are stationed at NWSTF Boardman. Their responsibilities are to maintain the buildings, roads, wells, fences, and other infrastructure and provide security in accordance with NAS Whidbey Instruction 3120.6 (NWSTF Boardman Standard Operating Procedures). Navy personnel stationed at NWSTF Boardman are required to hold Wildland Firefighting Red Cards. Additionally, the Navy personnel stationed at NWSTF Boardman are equipped with appropriate wildland protective clothing. NWSTF Boardman firefighters have nine vehicles assigned to them; however, only two are used for actual firefighting operations, a dedicated firefighting vehicle (Type VI Brush truck) and a General Services Administration truck that has a 250-gallon firefighting skid unit mounted (a "skid" is a water pump with a large water capacity that sits in the rear of a flatbed truck). In addition, the Navy leases a tractor and disc during the 4-month fire season to maintain fire/fuel breaks. In extreme situations, the tractor could also be used for incipient wildland fire suppression efforts when the application of foam lines are unavailable, exhausted, or ineffective.

#### 2.2.2.3 Range Enhancements

The Proposed Action could include the establishment and use of an additional MOA to the northeast of existing NWSTF Boardman airspace, an increase in existing training activities, new training activities, and range enhancements to meet Navy and ORNG training requirements. Some ongoing training activities could increase as a result of force structure changes associated with the introduction of new aircraft or other equipment. The following proposed range enhancements would support new training activities and some ongoing activities.

- Establishment and use of an additional MOA to the northeast of existing NWSTF Boardman airspace. Low-altitude flight tracks would be oriented along a northeast axis to facilitate the use of this additional MOA (Figure 1), avoiding existing and proposed wind turbines on the far eastern end of R-5701C.

- Construction and operation of a Multi-Purpose Machine Gun Range (MPMGR), with a heavy sniper lane, and associated support facilities (Figure 4). The MPMGR would be used to train and qualify Soldiers in the use of various crew-served weapons.
- Construction and operation of two (eastern and western) Convoy Live Fire Ranges (CLFR). The CLFRs would be used for training Soldiers in planning and conducting vehicle convoy operations, including immediate action response using weapons live fire against threats encountered during convoy operations utilizing wheeled and tracked vehicles.
- Construction and operation of a Demolition Training Range (DTR). The DTR would be used by Explosive Ordnance Disposal (EOD) personnel, Combat Engineers, and others for land demolition training (i.e., safely detonating explosive charges).
- Designation and establishment of a Drop Zone to accommodate parachute operations of personnel and small-medium sized equipment (Containerized Delivery Systems)
- Establishment and use of three mortar firing positions
- Construction and use of a UAS Training and Maintenance Facility with small airstrip
- Construction and use of a Range Operations Control Center (separate from the UAS facility)

Table 8 presents the approximate footprints associated with proposed range enhancements.

**Table 8: Summary of Proposed Range Enhancements**

| Proposed Range Enhancement | Total Area of Construction Disturbance (acres) | | | Total Area of Construction Disturbance (acres) |
|---|---|---|---|---|
| | Undisturbed Area (acres) | Previously Disturbed Area (acres) | Area Temporarily Disturbed and Revegetated (acres) | |
| MPMGR and Range Operations Control Area | 16 | 0 | 14 | 30 |
| CLFR (Eastern) | 0 | 12 | 0 | 12 |
| CLFR (Western) | 0 | 12 | 0 | 12 |
| DTR | 0 | 1 | 0 | 1 |
| TUAS Training and Maintenance Facility | 8 | 0 | 1 | 9 |
| Drop Zone | 0 | 0 | 0 | 0 |
| Three Mortar Firing Points | 0 | 0 | 0 | 0 |
| Joint-Use Range Operations Support Center | 0.5 | 0 | 0 | 0.5 |
| **TOTAL** | **24.5** | **25** | **15** | **64.5** |

Notes: MPMGR □ Multi-Purpose Machine Gun Range, CLFR □ Convoy Live Fire Range, DTR □ Demolition Training Range, TUAS □ Tactical Unmanned Aerial Systems

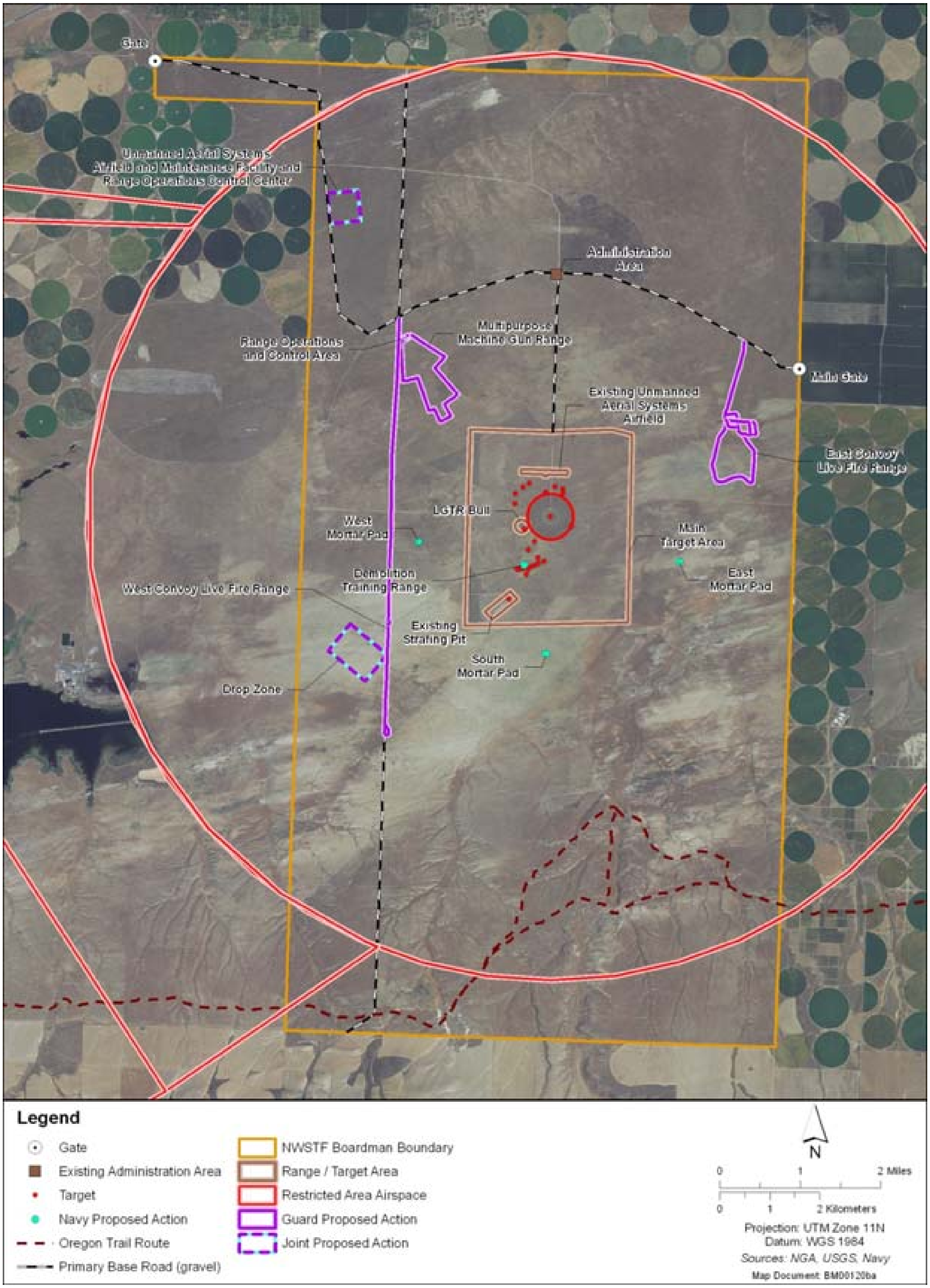


**Figure 4: Navy and ORNG Range Enhancements Under the Proposed Action**

#### 2.2.2.3.1 Establishment and Use of Additional Special Use Airspace

To meet Navy Mission Essential Tasking, the EA-18G and the EA-6B aircraft stationed at NAS Whidbey Island have a training requirement that necessitates low-altitude flying and combat style maneuvering at 350 to 480 knots at 200 ft. (60.9 m) to 500 ft. (152.4 m) AGL. Established wind energy projects have reduced the usable airspace for LATT from 205 $nm^2$ to 201.2 $nm^2$. Due to the anticipated continued development of wind energy projects inside R-5701 airspace, larger portions of R-5701C in the southeast and R-5701-E would no longer be usable for low-altitude flight training. Range capacity at other military installations is very limited and the expectation of range time availability at other ranges is problematic. Flight training capacity at other military installations with low-level restricted-use airspace is very limited, and the airspaces at other Navy or DoD ranges outside of Boardman do not have the capacity to accommodate additional flight training time. All military installations with low-level restricted-use airspace are fully scheduled by locally assigned aircrews currently training in those airspaces. It is not possible to obtain sufficient training time within another installation's airspace for the aircraft crews at NAS Whidbey Island, who require more than 2,000 hours of daytime use. If aircraft crews are unable to accomplish their required training, they would be required to obtain waivers of necessary training qualifications and might even have to deploy without this important training.

A solution to this problem is the creation of the Boardman Northeast MOA as shown in Figure 1. This new training airspace would be 46 $nm^2$ (157.8 $km^2$) and join the current Boardman MOA. The Boardman Northeast MOA would overlie the current national security area that is above the Umatilla Army Depot. The Umatilla Chemical Depot National Security area has a zone of surface to 5,000 ft. MSL. The National Security Area is only "active" during emergencies, all other times it is a recommended no-fly area. Low-altitude flight tracks would be oriented along a northeast axis to facilitate the use of this additional MOA, avoiding existing wind turbines on the far eastern end of R-5701C (Figure 5 and Figure 6).

It is important to note that the proposed airspace would not be designated as a restricted area. The difference between a MOA and a restricted area is that, in a MOA, military aviation units may be using the airspace, but they are not engaged in any firing or bombing activities. Restricted areas denote the existence of unusual, often dangerous, hazards to aircraft such as weapons firing, or aerial gunnery.

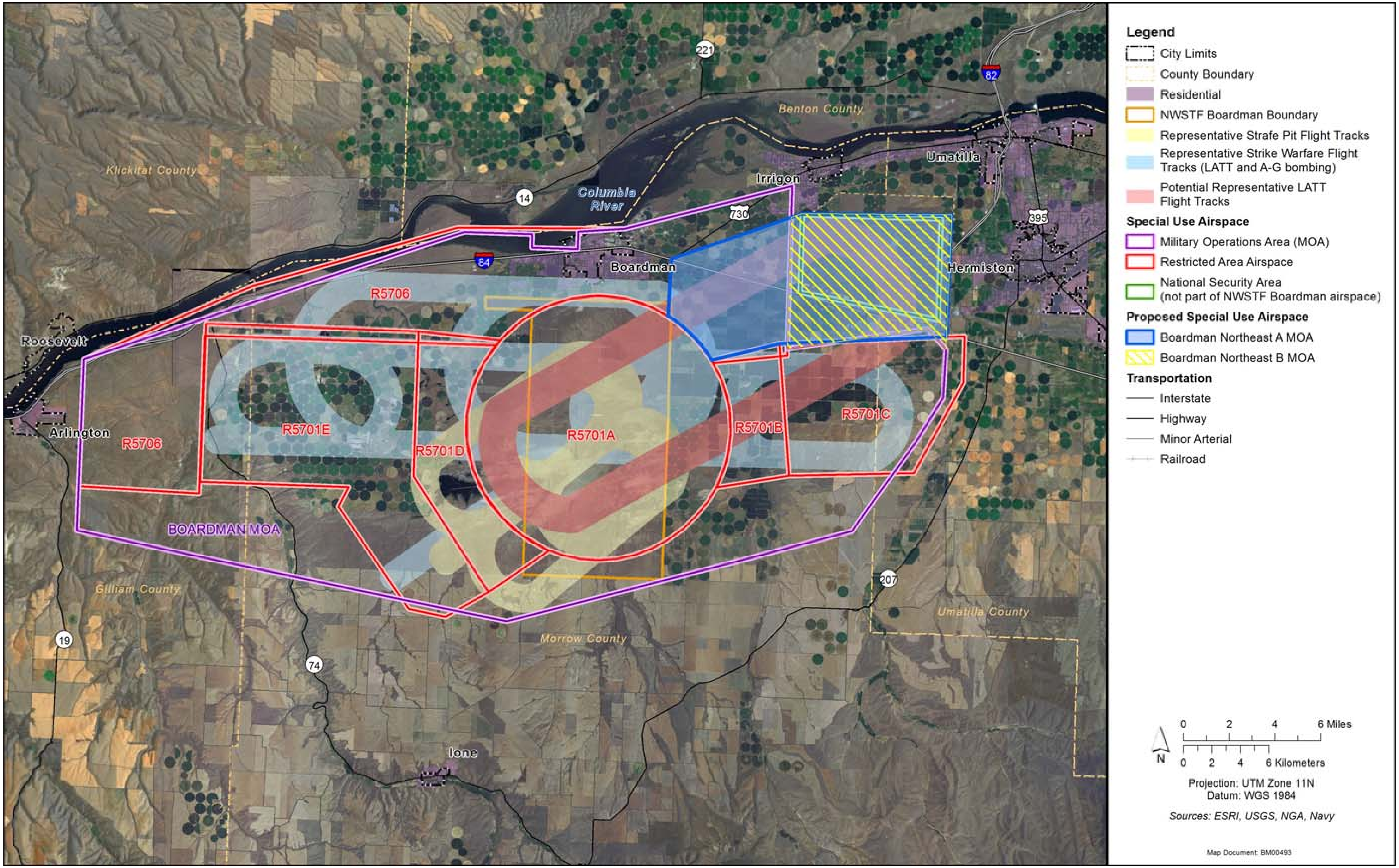


**Figure 5: Proposed Flight Tracks Utilizing Additional Military Operations Area**

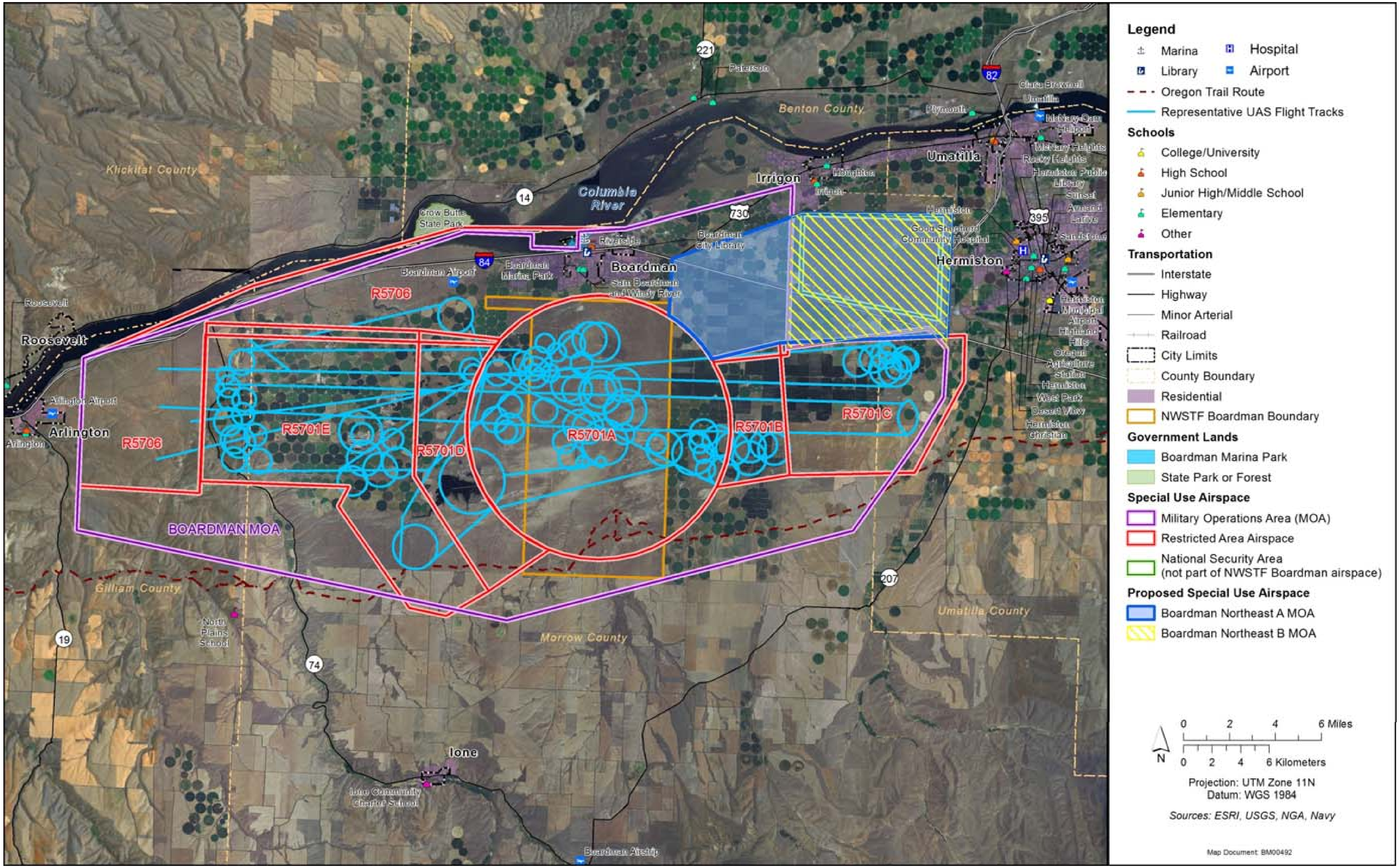


Figure 6: Representative UAS Flight Track

### 2.2.2.3.2 Construction and Operation of MPMGR with Heavy Sniper Overlay

**Construction**

The ORNG would use the MPMGR to train Soldiers in the use of various crew-served small arms such as the M240B 7.62 mm machine gun, the M249 5.56mm machine gun, MK19 40mm Grenade Machine Gun, and the M2 .50 cal machine gun. The proposed design is essentially the same as the Army-Standard MPMGR depicted in Department of the Army Training Circular 25-8, with the addition of one heavy sniper range lane, which includes additional targets and extends from 1,500 m (4,921.3 ft.) to 1,775 m (5,823.5 ft.) (Figure 7). Various sniper rifles, up to and including the .50 cal sniper rifle, would be used on the heavy sniper range lane.

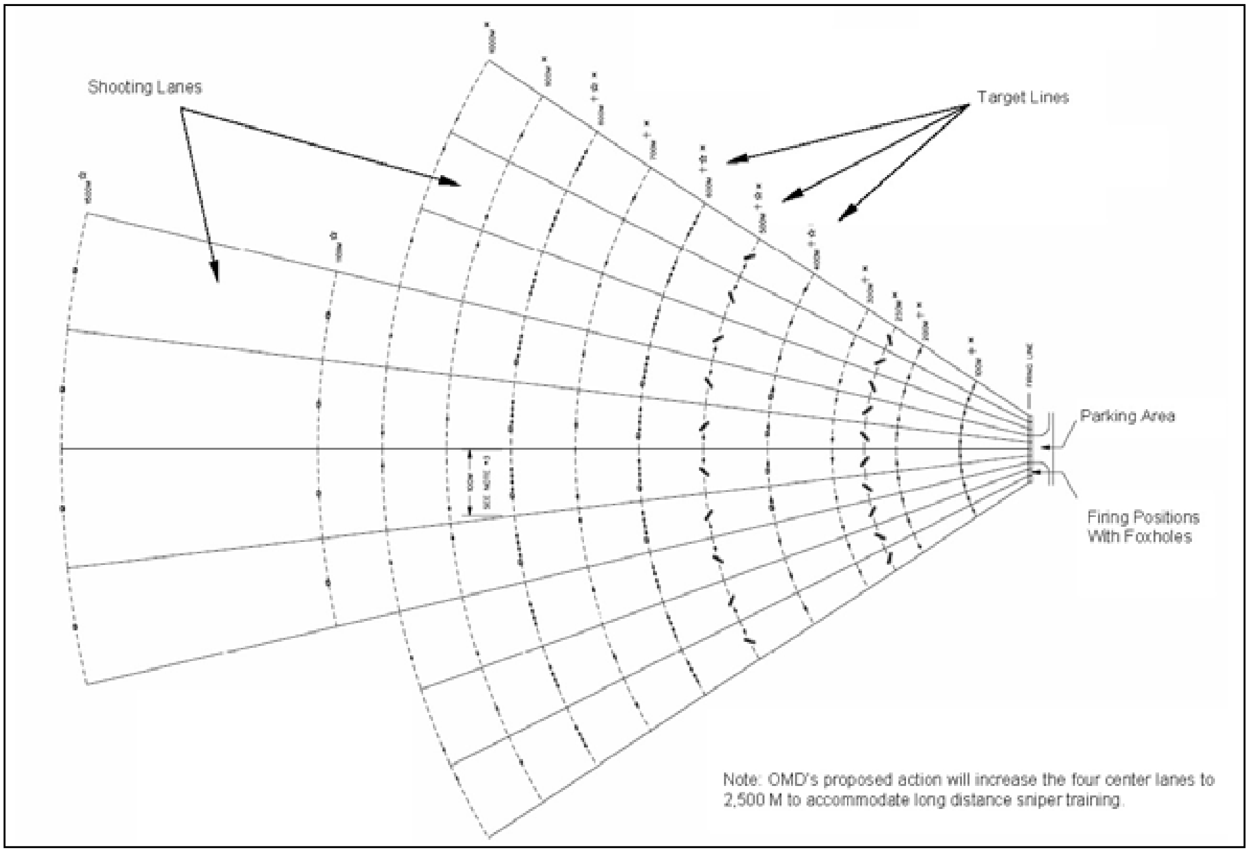


**Figure 7: Army-Standard MPMGR**

The MPMGR would consist of 10 firing lanes with multiple stationary and moving targets in each lane. Six of the firing lanes extend to 1,000 m (3,280.8 ft.). Four lanes extend to 1,500 m (4,921.3 ft.). One 1,500 m (4,921.3 ft.) lane would be lengthened to 1,775 m (5,823.5 ft.) and would contain additional targetry for training and qualification with sniper weapons. The range would be constructed so that the firing points would accommodate a parked vehicle with a mounted machine gun. The range would contain a total of 151 target emplacements. Each target would be mounted on a mechanism to raise the target when it is activated or create a moving target. Each target support structure would be set on a concrete or gravel pad behind an earthen berm to shield the target support equipment from projectile damage. Utility trenching would be required to bring underground power, control, and data cable from the range control tower to each target emplacement within 1,500 m (4,921.3 ft.) of the firing points on the range, targets beyond that would be battery powered and Radio Frequency operated.

Close to the MPMGR, the ORNG also would construct a 10 lane zero range. The zero range would allow Soldiers to adjust (“zero”) the sights of their weapons, each using a single target at a distance of 10 m (32.8 ft.), prior to shooting on the MPMGR. The zero range would be approximately 10 by 40 m (32.8 by 131.2 ft.) in size and would include a range control tower. The Range Operations and Control Area would provide support facilities for the MPMGR. It would occupy approximately 2.2 ac. (0.89 ha) and would consist of about eight small metal-sided buildings, a gravel vehicle parking area, and gravel walking paths. One building would be elevated on legs and used as a control tower. Another would be a ground-level storage building. Other structures include a set of covered bleachers, a general instruction building (classroom), an after-action review building, a covered eating area, an ammunition breakdown building, and concrete slabs for placement of self-contained portable latrines. The layout of the range and Range Operations and Control Area would be sited so as to minimize disturbance and reduce effects to sensitive species where possible.

The MPMGR, along with an associated zero range, Range Operations Control Area, access roads, parking areas, and maintenance trails to access the target emplacements would encompass approximately 260 ac. (105.2 ha). Surface danger zones (SDZ) for the MPMGR and zero range would cover approximately 12,500 ac. (5058.6 ha). The MPMGR and the zero range would be sited so both ranges could operate simultaneously and so that their SDZs would overlap the existing main target area. A SDZ is the mathematically predicted, three-dimensional area that a projectile or fragment could travel through the air and impact the earth, either by direct fire or ricochet. A SDZ is calculated using procedures found in Department of the Army Pamphlet 385-63 - Range Safety. Except for areas on the ranges themselves, none of the areas within SDZs would be disturbed during construction. A SDZ serves only as a human safety buffer downrange from a firing point.

The MPMGR, along with an associated zero range, Range Operations Control Area, access roads, parking areas, and maintenance trails to access the target emplacements would encompass approximately 260 ac. (105.2 ha). Surface danger zones (SDZ) for the MPMGR and zero range would cover approximately 12,500 ac. (5058.6 ha). The MPMGR and the zero range would be sited so both ranges could operate simultaneously and so that their SDZs would overlap the existing main target area. A SDZ is the mathematically predicted, three-dimensional area that a projectile or fragment could travel through the air and impact the earth, either by direct fire or ricochet. A SDZ is calculated using procedures found in Department of the Army Pamphlet 385-63 - Range Safety. Except for areas on the ranges themselves, none of the areas within SDZs would be disturbed during construction. A SDZ serves only as a human safety buffer downrange from a firing point.

Of the 260 ac. (105.2 ha) occupied by the MPMGR and associated development, approximately 27.5 ac. (11.1 ha) would be disturbed during construction. The disturbance would consist of the construction of access roads, parking areas, maintenance trails, the Range Operations and Control Area, weapons firing positions, target emplacements, earthen berms, and associated underground power control and data cables. Of the 27.5 ac. (11.1 ha) of disturbed area, approximately 11.6 ac. (4.7 ha) would be revegetated with native vegetation following construction. The remaining 15.9 ac. (6.4 ha) would contain buildings, concrete structures, or gravel surfaces and would remain permanently altered.

Construction of the MPMGR would be accomplished using typical construction equipment. Building materials, including concrete and gravel and soil for berms, would likely be imported from one or more off-site sources. The Range Operations and Control Area parking area would be constructed first and used for staging construction of the MPMGR and the remainder of the Range Operations and Control

Area. Additional construction staging areas, if needed, would be established within previously disturbed areas at the Navy administrative area.

**Operation and Maintenance**

The ORNG would use the MPMGR and associated zero range year-round, approximately 117 days annually. Typically, use would occur primarily on weekends between approximately 9:00 am and 6:00 pm, although some night time training and qualification also would be conducted. Firing would typically occur in approximately 20 minute blocks while the range is in use. Firing time for a day would usually be around 2 hours, with breaks in shooting to change crews, take meal breaks, repair targets, and for other reasons.

Except for tracer rounds, all ammunition used on the range would be inert/non-explosive. Munitions casings would be collected at the conclusion of training. Tracer rounds would be prohibited during periods of high fire danger. Tracer ammunition (tracer rounds) are bullets that are built with a small pyrotechnic charge in their base. Ignited by the burning powder, the pyrotechnic composition burns very brightly, making the projectile visible to the naked eye. This enables the shooter to follow the bullet trajectory in order to make aiming corrections. If pyrotechnic devices, such as smoke grenades, were used, they would be placed in metal containers to minimize their potential to start a fire.

Maintenance activities on the range would include periodic maintenance, repair, and replacement of targets and target support mechanisms. Periodic vegetation control on the range will be conducted to reduce fire fuel loading or manage exotic vegetation.

Solid wastes would be collected for transportation and disposal at permitted off-site solid waste management facilities. No on-site waste disposal is planned. Waste from the portable latrines would be removed periodically by a local contractor and transported to a local treatment facility by a contractor.

#### 2.2.2.3.3 Construction, Operation, and Maintenance of two (Eastern and Western) CLFRs

**Construction**

The eastern CLFR would be used to train Soldiers in conducting vehicle convoy operations, up to and including immediate action response using weapons live fire against encountered threats. The eastern CLFR would be developed along an approximately 8.0 km (5 mi.) route on the eastern portion of NWSTF Boardman. Portable targets would be sited within approximately 100 m (328.1 ft.) of the road course and used to simulate an ambush. The targets would be periodically relocated to change training scenarios. Temporary structures, such as plywood facades, steel shipping containers (conex boxes), or hay bale walls, may be used to simulate small urban environments and help conceal targets. No permanent construction or alteration of the existing terrain would be anticipated for the eastern CLFR.

The ORNG has sought to develop a proposed CLFR on NWSTF Boardman such that (1) existing roads would be used, (2) the SDZ would be completely contained within the installation boundaries, and (3) the relatively undisturbed wildlife habitat wildlife habitat located on the southern portion of the installation would be avoided. These factors have resulted in the proposal to locate the CLFR along an existing north/south road with potential targets located toward the center of NWSTF Boardman. The SDZs for this range would be mostly within those of the proposed MPMGR and the existing main target area.

Construction of the range would consist of graveling existing two-track roads to support increased vehicle traffic and to reduce fugitive dust emissions during training. Construction also would involve placing portable target-lifters within 100 m of the existing roads and encircling them with sandbags and steel plates to protect the battery power-supply and radio controllers from damage. The target lifters would encompass an area approximately 2 by 3 ft. (0.6 by 1.8 m). Shipping containers, plywood, and hay bales may also be used to create building facades and simulated village walls.

In addition to the eastern CLFR, a second, western CLFR would allow at least one of the CLFRs to be used while the MPMGR is in use. Having two CLFRs also would permit the ORNG to accommodate surges in required training prior to deployments, when many Soldiers need to be trained in a short period of time. The diversity added by these training assets would also increase training realism.

The second (western) CLFR would be established along approximately 4 mi. (6.4 km) of an existing north-south road located west of the proposed MPMGR location and would likely include a simulated traffic round-about near the center of the range and a turn-around area at the southern end (Figure 4). Target emplacements would be located toward the center of NWSTF Boardman to contain the SDZ on NWSTF Boardman. The construction and development of the second, western CLFR would be similar to the eastern CLFR, as described above. The footprint of the western CLFR, not including the SDZ, would cover approximately 68 ac. (27.5 ha). The ORNG has estimated the SDZ for this range would require approximately 15,600 ac. (6,313.1 ha), including the range itself. Most of the SDZs would overlap the SDZs for the MPMGR, eastern CLFR, and the existing main target area.

**Operations and Maintenance**

Up to Platoon-sized (25 to 50 personnel) convoys armed with M249, M240B, M2, and MK 19 machine guns would navigate the installation roads training in Command, Control, and Communications; upon entering the CLFR, the range would become "hot" (firing activities can occur) and units would detect activated targets and engage those simulated hostile targets. Training would occur according to standardized procedures and under the guidance of a Range Safety Officer up to 45 days a year.

Except for tracer rounds, all ammunition used on the CLFRs would be inert/non-explosive. Use of tracer rounds would be prohibited during periods of high fire danger. Any pyrotechnic devices would be placed in metal containers to minimize their potential to start a fire. Training would take place during both day and night hours.

Range maintenance would entail typical gravel road maintenance and periodically servicing the power supply and radio controllers of the target lifters. Targets may be relocated to vary the training scenarios and former target locations would be revegetated with native species. Periodic vegetation control may be required to reduce fire fuel loading or manage exotic vegetation and would be conducted as authorized in approved natural resource and fire management plans.

#### 2.2.2.3.4 Construction and Operation of a DTR

Under the Proposed Action, the Navy proposes to construct a demolition training range (DTR) to accommodate land demolition training (Figure 4). The range would be constructed as a cleared area with approximately 10 ft (3.1 m) berms on each side of the range to reduce detonation fragments outside the immediate range area. Details regarding ordnance that would be used in the DTR and frequency of use are outlined in Table 5 and Table 6. Additionally, Office of the Chief of Naval Operations Instruction 3501.97G requires that explosive ordnance disposal personnel conduct periodic demolition training in order to retain qualifications and the DTR will assist in maintaining those qualifications. The demolition training range would be utilized up to 50 times annually and could support a maximum Net Explosive Weight (NEW) of 200 pounds (lb) (90.7 kilograms [kg]). Training with explosive charges of NEW between 100 lb (45.4 kg) and 200 lb (90.7 kg) would not be a regularly scheduled occurrence, and would only be conducted in special training circumstances. For the analysis of potential impacts, two detonations per year at a NEW of 200 lb (90.7 kg) were included; however, it is anticipated that explosive charges of this size would be a rare occurrence. If requirements to train with charges greater than 100 lb (45.4 kg) are put into place, then special mitigations to help reduce noise levels would be implemented, such as training during times with optimal weather conditions to attenuate noise, burying the explosive charge or bunkering the charge with sand bags. Ordnance used annually at the NWSTF Boardman DTR would consist of explosive charges with a NEW of 200 lb or less, and would include up to two 200 lb charges, five 100 lb charges, ten 50 lb charges, twenty 25 lb charges, and thirteen charges less than 25 lb. Demolition training would normally occur between the hours of 10:00 a.m. and 4:00 p.m. Training is not normally planned to occur in the June to September time frame to help mitigate wildland fire potential, though seasonal conditions and training times may vary.

#### 2.2.2.3.5 Establishment and Use of a Drop Zone

A drop zone would be established at the location shown in Figure 4 under the Proposed Action. The drop zone would be approximately 2,250 ft. (685.5 m) by 3,150 ft. (960.1 m), with an approximate footprint of 167.2 ac. (65.8 ha). No construction or ground disturbance would be required to establish the drop zone. The drop zone would be a designated area, certified to be clear of obstructions (such as fences or telephone poles) for the safety of personnel conducting parachute operations.

Insertion and extraction activities train military forces to deliver and extract equipment and personnel using a variety of techniques. These activities encompass parachute, fastrope, rappel, and troop extractions. The C-130 aircraft, HH-53, CH-46, CH-47 and UH-60 helicopters are typically used for equipment and personnel inserts. Insertion and extraction activities at NWSTF Boardman would be centered on paradropping of military equipment and supplies. This activity typically lasts anywhere from 30 minutes to 1 hour and would occur up to 12 days annually.

#### 2.2.2.3.6 Establishment and Use of Three Mortar Firing Positions

Three mortar firing positions would be established at the locations shown in Figure 4 under the Proposed Action. No construction or ground disturbance would be required to establish the mortar firing points. Weapons Danger Zones (WDZs) for the mortar firing positions would be concentrated on the main target bull and not extend off the NWSTF Boardman boundary. The M224 60 mm lightweight mortar (or a similar system) would be fired for qualification certification or during ground troop support exercises using practice rounds. The M766 60 mm short-range practice cartridge has a flash-bang/smoke fuse. The M224 system is made up of the cannon, bipod, baseplate, and sight unit. The system is very portable and is placed on the ground surface, sighted at a stationary target, and fired. Only non-explosive training rounds would be used and these rounds would be retrieved for reuse or recycling after they are fired. Additionally, 81 mm and 120 mm mortars using sub-caliber training rounds would be used and these spent rounds would be retrieved and scrapped after firing. The mortar firing points would be used for 6 days annually, with up to 1,440 rounds being fired annually.

#### 2.2.2.3.7 Construction, Operation, and Maintenance of an UAS Training and Maintenance Facility

An ORNG platoon is assigned to operate and maintain the RQ-7B (Shadow 200) tactical UAS. The platoon is currently equipped with four Shadow 200 aircraft, ten trucks, and nine trailers. The Shadow 200 is a composite structure aircraft with a 14 ft. (4.3 m) wingspan, powered by a small, gasoline-fueled, rotary engine. The Shadow 200 can carry 15 gallons (56.8 liters) of fuel and 60 lb. (27.2 kg) of sensor and electronic warfare systems equipment and has a maximum flight endurance of 6 to 7 hours. The Shadow is designed for reconnaissance missions and does not currently have a strike capability.

**Construction**

The ORNG would construct a UAS training and maintenance facility that would consist of a single building (approximately 12,200 square feet [ft.$^2$] [1,133.4 square meters {m$^2$}]) for platoon operations, training, maintenance, and storage associated with the Shadow 200 aircraft. The building would be constructed of metal or masonry and would contain space for a UAS maintenance shop, equipment storage, flight simulator, and administrative offices. The facility also would include a building (approximately 4,800 ft.$^2$ [446.03 m$^2$]) for the storage of ground vehicles and a paved UAS runway and an unpaved operations area. The runway would be approximately 50 ft. (15.2 m) wide and 1,000 ft. (304.8 m) long. A gravel operating area used for a UAS launcher, UAS control equipment, and portable generators, would be 164 ft. (50.01 m) wide and 700 ft. (213.4 m) long. The runway would be oriented east to west, the direction of the prevailing winds. A vehicle parking area would be constructed adjacent to the operations and maintenance building. A 500 gallon (1,892.7 liter) aboveground fuel tank in a secondary containment would be located in the vicinity of the building. Additional gravel wildland fire buffers would surround the facility. A well would be drilled in the vicinity of the building to provide non-potable water and a septic system and leach field would be installed for wastewater disposal. In total, the facility is expected to occupy approximately 7 ac. (2.8 ha). The existing road between the northwest gate onto NWSTF Boardman and the UAS training and maintenance facility may be improved to support construction operations access by grading the road and adding rock and gravel.

The UAS facility would be built using typical construction equipment and techniques. Building materials, including concrete and gravel and soil for berms, would likely be imported from one or more off-site sources.

**Operations and Maintenance**

The UAS platoon would have a full-time staff of approximately seven Soldiers working at the facility. During drill weekends and annual training periods, the full platoon of 27 Soldiers would be present at the facility. Training on UAS simulators, maintenance and repair of the UAS aircraft, and UAS aircraft flights would occur at the facility. Maintenance of the truck and trailer rolling stock would likely occur at ORNG facilities located elsewhere in the state.

The Scan Eagle UAS is a relatively small aircraft that is currently operated at NWSTF Boardman. Typically these activities are conducted in NWSTF Boardman airspace, result in 800 to 1,000 sorties a year, and consist of testing and training. The UAS activity lasts approximately 6 hours. UAS activities can only be conducted in Restricted Area 5701 and Restricted Area 5706. Scan Eagle UAS Research, Development, Test, and Evaluation activities in Restricted Area 5701 and Restricted Area 5706 are anticipated to continue. The Broad Area Maritime Surveillance system is a future Navy system that may be used for training within Restricted Area 5701 and Restricted Area 5706. The specific UAS to be used for this system has yet to be determined, but it will likely be a large aircraft such as the Global Hawk, Predator B, or a similar UAS. These aircraft are roughly the size of common military tactical aircraft such as the EA-6B Prowler or FA-18 Hornet. If the Broad Area Maritime Surveillance system is likely to have a strike capability, that training would be covered in a separate NEPA analysis.

#### 2.2.2.3.8 Construction and Use of a Joint Use Range Operations Control Center

The Proposed Action would include the construction of an additional building (approximately 10,000 ft.$^2$ [929 m$^2$]) to house Navy and ORNG range control personnel and equipment. The Range Operations Control Center building would be constructed in proximity to the UAS Training and Maintenance Facility to enable shared use of a water well, septic system, and electrical service.

# 3 SPECIES ACCOUNT AND STATUS OF SPECIES

## 3.1 GENERAL DESCRIPTION

The Washington ground squirrel is diurnal (active during the day) and spends much of the year (approximately July through December) underground in a state of dormancy called estivation (summer) or hibernation (winter). The annual cycle for this species is summarized in Table 9.

Washington ground squirrels are ecologically significant for the following reasons (U.S. Fish and Wildlife Service 2011a):

- They provide an important prey base for predators such as badgers, ferruginous hawks, and golden eagles.
- Burrowing action reduces soil compaction, loosens and aerates soils, and increases the rate of water infiltration into soil.
- Burrowing increases soil fertility, plant diversity and productivity, and microhabitat diversity by bringing nutrients and buried seeds from deep soil layers to the surface.
- Burrows are reused by many species including snakes, lizards, insects, and burrowing owls.

## 3.2 STATUS, POPULATION TRENDS, AND THREATS

The Washington ground squirrel is a candidate for ESA listing. In their 2012 annual status review, the USFWS re-confirmed that listing of the species is warranted. However, to date, publication of a proposed rule to list the Washington ground squirrel has been precluded by other higher priority listing actions (U.S. Fish and Wildlife Service 2012). The species is listed as endangered by the State of Oregon (Oregon Department of Fish and Wildlife 2011).

Although widely abundant historically, its current range has contracted toward the center of its historical range. Approximately two-thirds of the Washington ground squirrel's total historical range has been converted to agricultural and residential uses. NWSTF Boardman and the adjacent privately owned Boardman Conservation Area represent the largest continuous area of occupied habitat in Oregon, and is likely the largest area of contiguous occupied habitat in the entire range of the Washington ground squirrel (U.S. Fish and Wildlife Service 2011a).

As discussed below in Section 3.3, recent surveys have detected Washington ground squirrels in new locations within its current range. However, many site vacancies have occurred range-wide, and habitat conversion continues to reduce the amount of available suitable habitat (U.S. Fish and Wildlife Service 2012). Populations appear to fluctuate widely at a local scale. A good estimate of overall population size and population trends are not available due to an overall poor understanding of the species' population dynamics (U.S. Fish and Wildlife Service 2011a). Historical and current threats to Washington ground squirrels include the following (U.S. Fish and Wildlife Service 2011a):

- Destruction, modification, or curtailment of its habitat or range from agricultural, energy, and other development; non-native plant infestations and associated increases in wildfire frequency; and grazing.
- Historical poisoning and shooting for pest management purposes and recreational shooting.
- Disease, predation, drought, and wildfire.

**Table 9: Washington Ground Squirrel Annual Cycle at NWSTF Boardman**

| Activity / Month | Jan | | | | Feb | | | | Mar | | | | Apr | | | | May | | | | Jun | | | | Jul-Dec | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weeks | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | | | | |
| Emergence of adults | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Breeding | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | | | | | | |
| Emergence of young | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | | | | | |
| Juvenile dispersal | | | | | | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | |
| Most adult males return to burrows | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | | | |
| Most adult females return to burrows | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | | | | | |
| Juveniles return to burrows (through 1st week of July) | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | | | |
| Population in estivation/hibernation | | | | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |

Source: Information summarized in Northwest Wildlife Consultants, Inc. (2007)

## 3.3 DISTRIBUTION

The Washington ground squirrel is endemic to the Columbia Plateau, south and east of the Columbia River and east of the John Day River (Betts 1990). Until recently, the squirrel's range was thought to consist of three clusters of sites, with two in Washington (the Columbia Basin and Badger Mountain) and one in Oregon. The USFWS no longer describes the current range as three clusters of sites based on more recent data. Washington ground squirrel sites have been documented between the Columbia Basin and Badger Mountain clusters, as well as at least two sites near the Oregon and Washington border, well outside the three previously described clusters (U.S. Fish and Wildlife Service 2012).

In Oregon, Washington ground squirrels occur in Gilliam, Morrow, and Umatilla counties, with the population centered primarily on NWSTF Boardman and the adjacent Boardman Conservation Area. Washington ground squirrels are also found on private and Bureau of Land Management (BLM) land west of these properties, on The Nature Conservancy-managed Lindsay Prairie, and on some additional scattered private lands. As of 2012, the ODFW had 705 Washington ground squirrel sites in its database, any one of which could represent an individual, small, or large colony. Fifty-two of these sites were documented between 1938 and 1999, making their current status uncertain. At least 527 of the remaining 653 (80.7 percent) sites occur on the Boardman Conservation Area, NWSTF Boardman, and Lindsay prairie. Eighty sites were discovered during pre-construction and siting surveys for transmission and wind projects, and 39 were located on BLM land. The remaining seven sites are locations where genetic samples were taken for a study, at sites that were previously known (U.S. Fish and Wildlife Service 2012).

In Washington, this species occupies sagebrush-steppe and grassland habitat east of the Columbia River in Adams, Douglas, Franklin, Grant, Lincoln, and Walla Walla counties. Most sites occur in Adams, Grant, and Douglas counties. As of 2012, the Washington Natural Heritage Program contained 567 verified Washington ground squirrel polygons (i.e., mapped estimate of areas containing squirrels) and 65 verified point locations in its database, any one of which could constitute an individual, small, or large colony. This database does not include all the detections that were made during a 2009–2010 survey in the Odessa area. Sites from the Oregon and Washington databases are not directly comparable because a number of factors collectively create a degree of variability and uncertainty in the use of naming conventions to describe areas used by Washington ground squirrels (U.S. Fish and Wildlife Service 2012).

## 3.4 HABITAT

The Washington ground squirrel occurs in shrub-steppe and grassland habitat. It is primarily associated with sagebrush and bluebunch-wheatgrass habitats, although cheatgrass and rabbitbrush have replaced much of the native vegetation within its current range. The Washington ground squirrel occupies sites with sandy or silt-loam texture soils that are deep and supportive enough to accommodate its burrow structures. This species seldom constructs burrows in areas of heavily disturbed soils, such as areas affected by plowing, disking, and crop production (U.S. Fish and Wildlife Service 2011a). Habitats that provide a more stable food source during droughts appear to be important for these squirrels (U.S. Fish and Wildlife Service 2011a).

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# 4 ENVIRONMENTAL BASELINE

The environmental baseline includes pre-existing impacts of activities that occur in the Action Area, including the past, contemporaneous, and future impacts of those activities. The current aggregate impacts of past and present actions are reflected in the environmental baseline and this information is used in Section 5, Effects of the Action, to understand how past and present actions are currently impacting Washington ground squirrels and to provide the context for the effects analysis.

## 4.1 OCCURRENCE IN THE ACTION AREA

Several Washington ground squirrel surveys and research studies have been conducted at NWSTF Boardman. Several characteristics of the squirrel make studying them a challenge, including the short periods when they occur above ground, a tendency for male dispersal, and short-term population fluctuations. These factors and inconsistencies among researchers have led to some uncertainty and variability in the use of terms to describe areas used by Washington ground squirrels. There is not a clear definition of what constitutes a single colony for this species, and terms such as site, patch, detection, and occurrence have been used to describe what might be called a colony (U.S. Fish and Wildlife Service 2011a). The U.S. Fish and Wildlife Service (2011a) hopes to eventually bring a standardized convention to describing squirrel populations.

While various survey methods and terms have been used at NWSTF Boardman, most surveys followed standard protocols (Morgan and Nugent 1999) focused on documenting Washington ground squirrel “active detections.” This approach determines if squirrels are using a specific area based on sighting squirrels, hearing squirrel calls, and finding holes recently used by squirrels as determined by the presence of the current year’s droppings (Northwest Wildlife Consultants 2005, 2006; Marr 2001). These surveys are not designed to estimate population size or density (i.e., number of animals per ac. or ha). Furthermore, this approach does not make a distinction between a colony, an active site, an active hole, or an individual squirrel that is part of a colony or a lone disperser. Large portions of NWSTF Boardman have been surveyed since 1979, but a systematic Washington ground squirrel survey of the entire property has not been conducted.

Figure 8 provides a compilation of known Washington ground squirrel detections at NWSTF Boardman from surveys conducted through 2009. The points shown in Figure 8 indicate locations where squirrels have been present in the past and are part of regular survey efforts. In some cases, the locations represent colonies. In other cases, they represent only an incidental sighting, where there may or may not be a colony (U.S. Department of the Navy 2012). For some of the surveys conducted at NWSTF Boardman, detections were classified as small, medium, or large colonies or sites based on Morgan and Nugent (1999). However, these classifications were not recorded for all detections across all surveys. Consequently, Figure 9 makes no distinction based on colony or site size.

As noted above, a systematic Washington ground squirrel survey of the entire property has not been conducted. Many surveys focused on long-term monitoring points where squirrels had been detected in the past. Therefore, the distribution of squirrel detections shown in Figure 8 is influenced by monitoring effort. While dense clusters of detections indicate areas that have been occupied over time, it is also possible that monitoring effort in these areas was higher. The distribution of squirrel detections would likely be different if equal survey effort had been applied throughout the property on a consistent basis. Therefore, the available data cannot be used to draw definitive conclusions about relative squirrel activity on various parts of the property or to specifically identify Washington ground squirrel “core areas.” A core area is consistently inhabited over many years and has high population densities in most

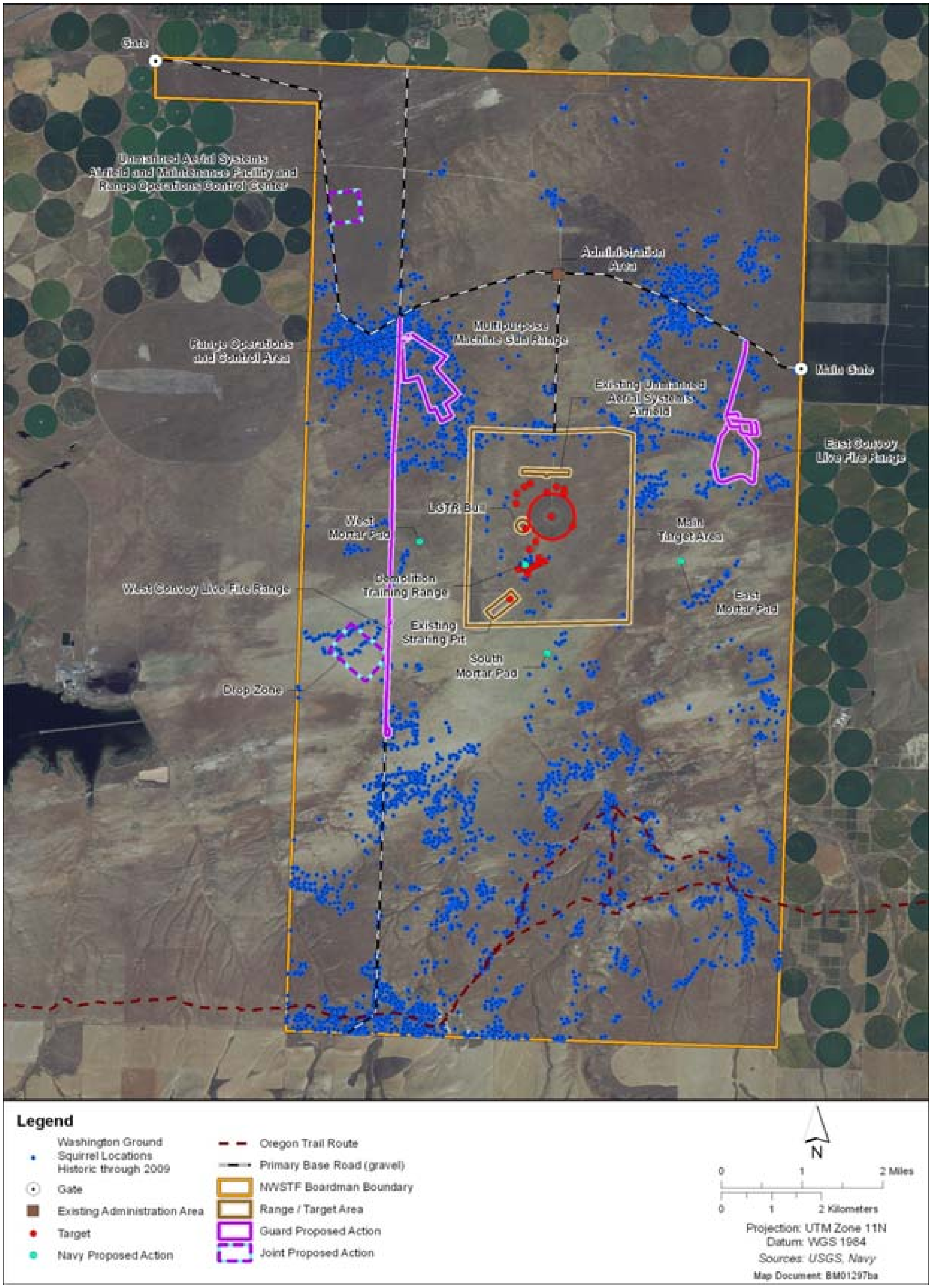


**Figure 8: Known Washington Ground Squirrel Detections at NWSTF Boardman Historic through 2009**

years. At lower ends of a population cycle, which might be related to factors such as precipitation and food availability or quality, squirrels persist in core areas that provide more stable habitat during those less than optimal conditions. Squirrels expand out from core areas when conditions are more optimal.

Although higher concentrations of Washington ground squirrels are said to be associated with Warden Soils (e.g., Greene et al. 2009), definitive studies have been done to identify core areas or variables that are most important to Washington ground squirrels at NWSTF Boardman. Several variables are changing together and moving south on NWSTF Boardman. The precipitation and productivity appear to be increasing with elevation, while soil particle size is generally decreasing. Yensen (2013) suggests that that productivity is as important, or more important, than soil textures on NWSTF Boardman. Although ground squirrels prefer loams, silts, silt loams and sandy loams, most of the soils on NWSTF Boardman, with the exception of the clay pockets, should be suitable for ground squirrels. Higher productivity should translate into denser, more stable ground squirrel populations irrespective of other variables, and productivity generally increases moving south on NWSTF Boardman (Yensen 2013).

Figure 9 shows historically occupied Washington ground squirrel habitat at NWSTF Boardman. This historically occupied habitat was mapped by applying a 785 ft. (239 m) radius buffer to the known squirrel detections shown in Figure 8. The buffer distance is based on that used by Morgan and Nugent (1999) to estimate actual use-areas (i.e., the expected area of squirrel movement around a detection site) and represents a known maximum travel distance described by Carlson et al. (1980). As shown in Figure 9, historically occupied habitat is located on or near the proposed range enhancement sites. Based on the lack of recent, systematic survey data the entire affected area was assumed to be occupied by Washington ground squirrels for impact assessment and mitigation planning purposes. With the exception of highly disturbed areas such as maintained roads, maintained fire breaks, and excavated area, it is reasonable to assume that all of NWSTF Boardman is suitable Washington ground squirrel habitat, especially during high years of a population cycle.

Surveys conducted in 2005, 2006, and 2008 also documented Washington ground squirrels on the proposed MPMGR and DMPTR locations (Table 10) (Northwest Wildlife Consultants, Inc. 2005, 2006, 2008).

**Table 10: Washington Ground Squirrel Surveys Conducted for the Proposed MPMGR and DMPTR at NWSTF Boardman**

| Survey Date | Location | Area Surveyed (acres [hectares]) | Active Detections |
|---|---|---|---|
| June 2005 | Northern portions of Multi-Purpose Machine Gun Range and Digital Multi-Purpose Training Range | 604 (244) | 211 |
| June 2006 | Multi-Purpose Machine Gun Range | 1,700 (688) | 636 |
| March-May 2008 | Digital Multi-Purpose Training Range | 2,996 (1,212) | 76 |

Notes: MPMGR = Multi-Purpose Machine Gun Range, DMPTR = Digital Multi-Purpose Training Range, NWSTF = Naval Weapons Systems Training Facility. The DMPTR is not part of the Proposed Action addressed in this conferencing package, but it is included in one of the alternatives analyzed in the Naval Weapons Systems Training Facility Boardman Environmental Impact Statement.
Source: Northwest Wildlife Consultants, Inc. 2005, 2006, 2008.

The DMPTR is not part of the Proposed Action addressed in this conferencing package, but it is included in one of the alternatives analyzed in the NWSTF Boardman EIS. While numerous detections were recorded in 2005 (211) and 2006 (636), it should be noted that the surveys were conducted in June

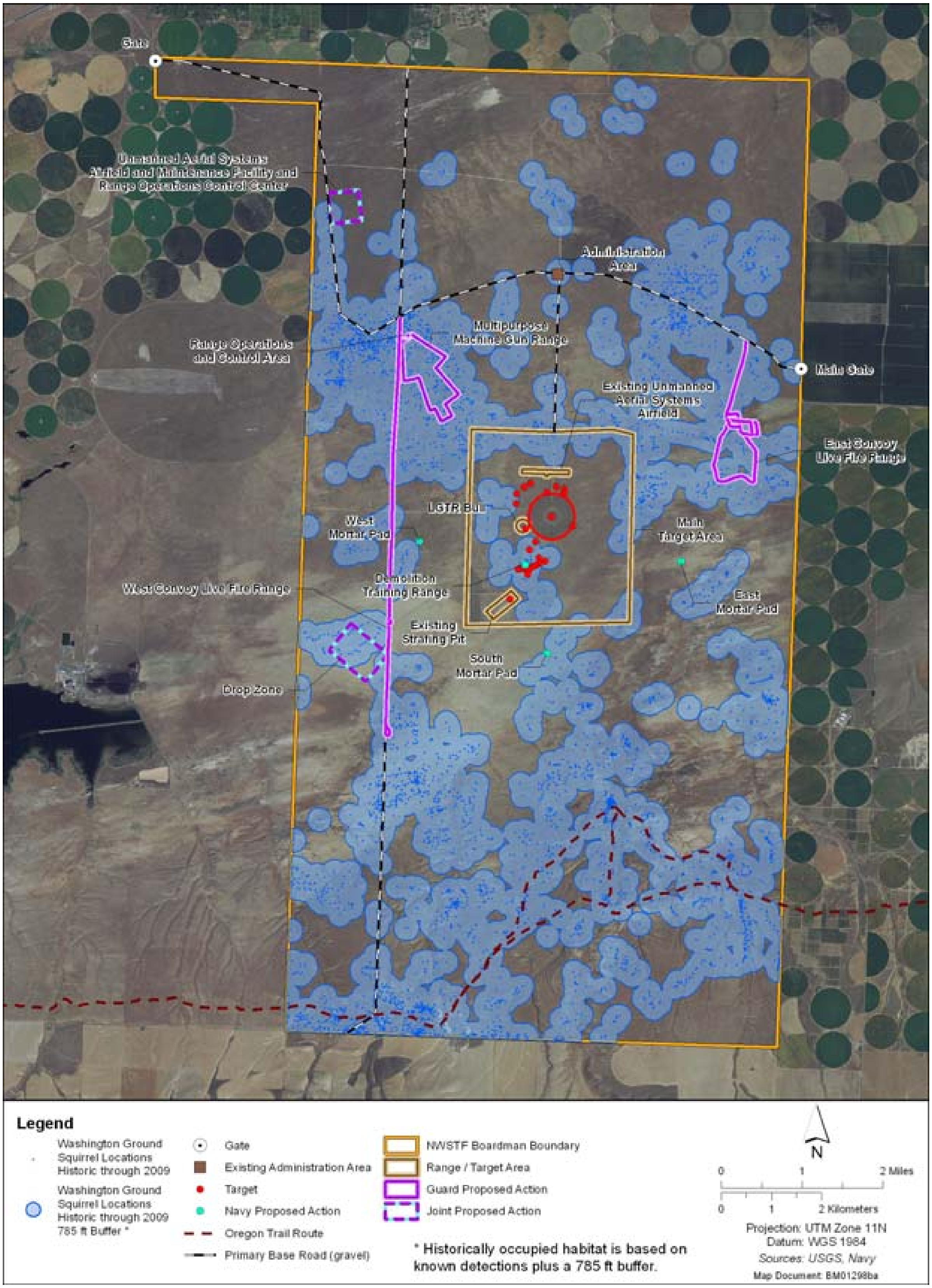


**Figure 9: Historically Occupied Washington Ground Squirrel Habitat at NWSTF Boardman**

when squirrel activity is low. It is possible that additional detections would have been recorded if the surveys were conducted during the peak activity period (late-March through mid-May). Nonetheless, the results provide further confirmation that Washington ground squirrels use habitats at the proposed MPMGR location.

During the 2008 surveys, only 76 active detections were recorded for the DMPTR location, despite being conducted during the peak activity period and covering a larger area than the 2005 and 2006 surveys. Portions of the 2008 survey area were also surveyed in 2005. In the common survey area, there were 211 active detections in 2005 and only 8 active detections in 2008. Anecdotal observations suggest that the late winter and spring of 2008 received below normal precipitation, and the quality of plants that Washington ground squirrels typically forage on were poor when compared to previous years such as 2005 and 2006. Drought or other factors such as disease or squirrel movements to other areas might explain this change in active detections (Northwest Wildlife Consultants, Inc. 2008).

Three research studies conducted at NWSTF Boardman used mark-recapture methods to estimate Washington ground squirrel density. As shown in Table 11, density estimates varied substantially and ranged from 0.2 animal per ac. (0.5 per ha) to 36.5 animals per ac. (82.7 per ha). It should be noted that Delavan (2008) and Klein (2005) sampled relatively small study areas known to be occupied by Washington ground squirrels.

**Table 11: Washington Ground Squirrel Density Estimates from Mark-Recapture Surveys**

| Year | Site Name and Vegetation | Density (animals per acre [hectare]) | Reference |
|---|---|---|---|
| 1997 | Sagebrush 1 | 6.4 (15.7) | Greene et al. 2009 |
| 1997 | Sagebrush 2 | 1.6 (3.9) | Greene et al. 2009 |
| 1997 | Sagebrush 3 | 0.5 (1.1)[2] | Greene et al. 2009 |
| 1997 | Low Shrub 1 | 1.1 (2.6) | Greene et al. 2009 |
| 1997 | Low Shrub 1 | 0.5 (1.2)[2] | Greene et al. 2009 |
| 1997 | Low Shrub 1 | 0.2 (0.4)[2] | Greene et al. 2009 |
| 1997 | Bunchgrass 1 | 0.5 (1.2)[2] | Greene et al. 2009 |
| 1997 | Bunchgrass 2 | 0.2 (0.5)[2] | Greene et al. 2009 |
| 1997 | Bunchgrass 3 | 0.8 (2.0)[2] | Greene et al. 2009 |
| | | | |
| 2004 | Open Low Shrub, open low shrub | 4.3 (10.7) | Delavan 2008 |
| 2004 | Cemetery, annual grass | 18.9 (46.6) | Delavan 2008 |
| 2004 | Large Stipa, bunchgrass[1] | 5.2 (12.9) | Delavan 2008 |
| 2005 | Sage, sagebrush[1] | 11.4 (28.1) | Delavan 2008 |
| | | | |
| 2002 | Tub Springs, annual grass□forbs | 33.4 (82.5) | Klein 2005 |
| 2003 | Tub springs, annual grass□forbs | 35.8 (88.4) | Klein 2005 |
| 2002 | Mystery Road, perennial grass□low shrub | 4.5 (11.1) | Klein 2005 |
| 2003 | Mystery Road, perennial grass□low shrub | 8.2 (20.3) | Klein 2005 |
| 2002 | Cemetery, annual grass, bunchgrass and sagebrush nearby | 16.2 (40.0) | Klein 2005 |
| 2003 | Cemetery, annual grass, bunchgrass and sagebrush nearby | 36.5 (90.3) | Klein 2005 |
| 2003 | Spigot, not described by author | 7.2 (17.7) | Klein 2005 |
| | | | |
| | **Mean □** | 9.7 (23.9) | |

[1] Site is located on Boardman Conservation Area; all other sites are located on NWSTF Boardman.
[2] Estimated values interoperated from graph presented by Greene et al. (2009). The authors did not present numeric values for these sites.

To support the overall research objectives (estimate home range, movement, and dispersal), Klein (2005) sampled areas where squirrels were known to be abundant and Delavan (2008) sampled areas that were expected to support different population sizes (e.g., small, medium, and large). Therefore, density estimates from these studies are not representative of NWSTF Boardman as a whole. Greene et al. (2009) established plots randomly within specific habitat types.

The Washington ground squirrel also occurs at the Boardman Conservation Area and was recently documented along the proposed Carty Lateral Project alignment (Gas Transmission Northwest 2011), portions of which are located beneath the NWSTF Boardman airspace. This species may occur in other areas beneath the airspace where suitable soils exist that have not been converted to agriculture. The Washington ground squirrel has not been documented at Umatilla Chemical Depot (UCD) (U.S. Department of the Army 2007).

## 4.2 Factors Affecting Species Environment Within the Action Area

The U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form, completed in 2012, provides a detailed discussion of threats to the Washington ground squirrel (U.S. Fish and Wildlife Service 2012). This information is incorporated by reference and has been considered in the analysis presented in Section 5. Historical and current threats to Washington ground squirrels include:

- Destruction, modification, or curtailment of its habitat or range from agricultural, energy, and other development; non-native plant infestations and associated increases in wildfire frequency; and grazing.
- Historical poisoning and shooting for pest management purposes and recreational shooting.
- Disease, predation, drought, and wildfire.

# 5 EFFECTS OF THE ACTION

## 5.1 APPROACH TO ANALYSIS

This conferencing package provides the Navy's determinations of effect for the Washington ground squirrel based on guidance contained in the *Endangered Species Consultation Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998). Terms commonly used in making a determination of effect are defined as follows:

- "No effect" is the appropriate conclusion when a species will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species. "No effect" does not include a small effect or an effect that is unlikely to occur.
- "May affect, not likely to adversely affect" means that all effects are beneficial, insignificant, or discountable. Beneficial effects have concurrent positive effects without any adverse effects to the species or habitat (i.e., there cannot be balancing, wherein the benefits of the project would be expected to outweigh the adverse effects). Insignificant effects relate to the magnitude or extent of the impact (i.e., they must be small and would not rise to the level of a take of a species). Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
- "May affect, likely to adversely affect" means that an adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not: discountable, insignificant, or beneficial. In the event the overall effect of the proposed action is beneficial to the listed species, but is also likely to cause some adverse effects, then the proposed action "is likely to adversely affect" the listed species. If incidental take is anticipated to occur as a result of the proposed action, an "is likely to adversely affect" determination should be made.

The impact analysis for the Washington ground squirrel considered effects of the Proposed Action on individual animals and populations. The analysis first looked at how individuals would respond to a stressor or combination of stressors and whether the response would affect the fitness of an individual. Fitness refers to changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. If individual fitness is not affected, then no impacts to populations would be expected. The potential for impacts to occur at the population level depends on several things, including whether individual fitness has been reduced, the number of individuals affected, the size of the affected population, and numerous life history and ecological factors.

The scientific limitations associated with predicting the responses of individuals and populations to stressors create a relatively high degree of uncertainty. Accordingly, a conservative approach was used in making conclusions when the level of uncertainty was considered high.

## 5.2 NOISE

### 5.2.1 OVERVIEW

Under the Proposed Action, Washington ground squirrels in the NWSTF Boardman Action Area would be exposed to noise associated with the following:

- Fixed-wing aircraft overflights

- Helicopter overflights and takeoffs and landings
- UAS overflights and takeoffs and landings
- Weapons firing
- Non-explosive practice munitions striking a target or the ground
- Vehicle and equipment operations
- Explosive detonations

The following section summarizes information about how wildlife, in general, and the Washington ground squirrel may respond to noise. The effects of noise on Washington ground squirrel under the Proposed Action are then analyzed for each noise source.

### 5.2.2 WILDLIFE RESPONSES TO NOISE

Numerous studies have documented that wild animals respond to human-made noise (National Park Service 1994, Bowles 1995, Larkin 1996). The manner in which animals respond to noise depends on several factors including life history characteristics of the species, characteristics of the noise source, loudness, onset rate, distance from the noise source, presence/absence of associated visual stimuli, and previous exposure. Noise may cause physiological or behavioral responses that reduce the animals' fitness or ability to grow, survive, and reproduce successfully. The potential effects of noise on wildlife can take many forms, including changing habitat use and activity patterns, increasing stress response, decreasing immune response, reducing reproductive success, increasing predation risk, degrading communication, and damaging hearing if the sound is sufficiently loud (Larkin 1996).

Behavioral responses are the most commonly used endpoints when studying the effects of noise on wildlife. This is largely based on practical considerations and the difficulty in measuring animal fitness or physiological and ecological endpoints. Researchers have documented a range of behavioral responses to noise, ranging from indifference to extreme panic. Common behavioral responses include alert behavior, startle response, flying or running away, and increased vocalizations (National Park Service 1994, Bowles 1995, Larkin 1996). In some instances, behavioral responses could interfere with breeding, raising young, foraging, habitat use, and physiological energy budgets, particularly when an animal continues to respond to repeated exposures.

While difficult to measure in the field, all behavioral responses are accompanied by some form of physiological response such as increased heart rate or a startle response. A startle is a rapid, primitive reflex that is characterized by rapid increase in heart rate, shutdown of nonessential functions, and mobilization of glucose reserves. Animals can learn to control the behavioral reactions associated with a startle response and often become habituated to noise (National Park Service 1994, Bowles 1995, Larkin 1996). Habituation keeps animals from expending energy and attention on harmless stimuli, but the physiological component might not habituate completely (Bowles 1995). Therefore, animal fitness could still be affected when an animal has habituated to noise (Barber et al. 2009). Gill et al. (2001) described theoretical circumstances when habituation to or tolerance of a stressor could be more detrimental to a population than a strong avoidance reaction. Nonetheless, what appears to be habituation has been observed in many studies and is well-demonstrated in studies evaluating bird control devices (e.g., noise cannons, pyrotechnics, and recorded sounds), which are used to scare birds away from airfields and agricultural areas (Larkin 1996). Larkin (1996) describes one example where red-winged blackbirds began resting on the noise cannon that was intended to scare them away. The birds learned to fly a short distance away when they heard the click of the mechanism that released the gas and signaled an impending explosion.

Likewise, a strong and consistent behavioral or physiological response is not necessarily indicative of negative consequences to individuals or to populations (National Park Service 1994, Bowles 1995, Larkin 1996). For example, many of the reported behavioral and physiological responses to noise are within the range of normal adaptive responses to external stimuli, such as predation, that wild animals face on a regular basis. In many cases, individuals would return to homeostasis or a stable equilibrium almost immediately after exposure. The individual's overall metabolism and energy budgets would not be affected assuming it had time to recover before being exposed again. If the individual does not recover before being exposed again, physiological responses could be cumulative and lead to reduced fitness. However, it is also possible that an individual would have an avoidance reaction (i.e., move away from the noise source) to repeated exposure or habituate to the noise when repeatedly exposed.

Washington ground squirrel responses to noise have not been studied and no anecdotal accounts of responses to noise have been found in the literature. Washington ground squirrel predator alarm calls have been noted in response to moving vehicles, but it is not known if they were responding to vehicle noise or movement (Northwest Wildlife Consultant 2008). Increased calling by individuals can make them more susceptible to predation (Sherman 1977).

Although Washington ground squirrel responses to noise have not been studied, some information exists for other ground squirrels. California ground squirrels (*Otospermophilus beecheyi*), which are in the same family (Sciuridae) as Washington ground squirrels, show higher levels of alertness in the presence of continuous windmill noise (Rabin 2005). Reliance on alert behavior, as opposed to anti-predator calls, is incompatible with other behaviors (e.g., foraging and social behavior) essential in ground squirrel daily activity (Rabin 2005). However, it is unlikely that a pronounced shift from anti-predator call to alert behavior would be observed in an environment where noise was intermittent and infrequent.

Hooper (2011) demonstrated that road noise has the potential to mask the alarm calls of Belding's ground squirrels (*Urocitellus beldingi*), but mainly at peak amplitude levels and only for roadside locations. The effective range of alarm calls produced alongside the road was reduced significantly for all traffic levels. While Hooper (2011) points out that such signal range reductions can have fitness repercussions in the form of increased predation risk, the study did not specifically evaluate predation risk for these apparently stable roadside colonies.

A few studies have evaluated the effects of aircraft overflights on rodent populations in the wild. A three-year study at a U.S. Air Force range evaluated three species of hibernating desert rodents exposed to frequent low-altitude aircraft overflights (Bowles et al. 1995). The mean number of overflights greater than 80 dBA (reported as maximum, fast, A-weighted sound pressure level) recorded on the exposed site was 33.22 flights per day. The highest sound exposure level (SEL) recorded for this area was 115.5 dBA and the mean SEL for the loudest 30 events was 103.4 dBA. Treatment areas did not differ significantly in abundance or population density relative to control populations (Bowles et al. 1995). Mouse densities in a field near Memphis International Airport (80 to 120 dB) were not significantly different than densities in a nearby rural field (80 to 85 dB) (Chesser et al. 1975). These studies suggest that absolute density of rodent populations does not appear to be affected by aircraft noise at these locations (Bowles et al. 1995). However, Chesser et al. (1975) found that mice collected from the airport field had significantly larger adrenal glands than those collected from the rural field. To determine if noise was the causative factor, mice collected from the rural field were exposed to recorded jet noises at 105 dB for two weeks. The experimental group had significantly larger adrenal glands than a control group (Chesser et al. 1975). This appears to be a case where aircraft noise caused a measurable physiological response with no apparent effects to the population. The frequency of overflights in the studies discussed above was substantially higher than those that would occur at NWSTF Boardman.

Long-term monitoring data indicate that military training at Orchard Training Area in southwestern Idaho does not affect population dynamics of the Piute ground squirrel (*Urocitellus mollis*, formerly known as the Townsend's ground squirrel [*Spermophilus townsendii mollis*]). Washington ground squirrels and Piute ground squirrels are members of the same genus (*Urocitellus*). The 138,936-ac. (56,227-ha) training area has been used for military training by the Idaho Army National Guard since 1953. Military training activities conducted at Orchard Training Area include small arms, tank gunnery (firing 120 mm gun), artillery training (firing 155 mm howitzer), armored vehicle maneuver training, helicopter training, troop transport, and bivouac. Active Piute ground squirrel burrows have been counted at 79 monitoring plots on Orchard Training Area. Data collected from 1989 through 2001 indicated a significant increasing trend in burrow abundance at approximately 40 percent (32) of the 79 plots (Hlohowskyj et al. 2004). An increasing trend in active burrow abundance was also indicated for 36 (46 percent) other plots, but the trend for these plots was not significant. A negative trend in active burrow abundance was observed at nine (11 percent) monitoring plots, but the trend for these plots was not significant. While no obvious spatial pattern is evident among the plots exhibiting an increasing trend in burrow abundance, 10 of the 32 plots exhibiting a significant increasing trend in the number of active burrow counts were located within the impact area (Hlohowskyj et al. 2004). Both high explosive ordnance and non-explosive practice ordnance is fired at targets located within the Orchard Training Area impact area. Van Horne and Sharpe (1998) investigated the effects of armored vehicles on Piute ground squirrel on Orchard Training Area. Sagebrush areas and areas dominated by bluegrass have been subjected to low-intensity tracked vehicle operations for 50 years and were compared against similar areas that had no tracked vehicle operations. The study did not detect any effects on ground squirrel population dynamics associated with long-term tracked vehicle operations. While the studies conducted at Orchard Training Area did not specifically evaluate Piute ground squirrel responses to noise, the long-term monitoring data suggest that noise and other potential stressors associated with military training do not appear to be impacting Piute ground squirrel populations at the training area.

While the effects of noise on wildlife have been addressed in numerous studies, research is hampered by a preponderance of small, disconnected, anecdotal, or correlational studies as opposed to coherent programs of controlled experiments (Larkin 1996). These factors, coupled with differences between species, individuals of the same species, and other factors such as habitat, make it difficult to definitively predict how wildlife populations will respond to noise under a specific exposure scenario. As a result, there are no well-established thresholds or criteria for predicting impacts of noise on terrestrial wildlife.

### 5.2.3 Conceptual Framework for Assessing Effects from Noise-Producing Activities

#### 5.2.3.1 Introduction

This conceptual framework describes the different types of effects that are possible and the potential relationships between sound stimuli and long-term consequences for the individual and population. The conceptual framework is central to the assessment of acoustic-related effects and is consulted multiple times throughout the process. It describes potential effects and the pathways by which an acoustic stimulus or sound-producing activity can potentially affect animals. The conceptual framework qualitatively describes costs to the animal (e.g., expended energy or missed feeding opportunity) that may be associated with specific reactions. Finally, the conceptual framework outlines the conditions that may lead to long-term consequences for the individual and population if the animal cannot fully recover from the short-term effects.

An animal is considered “exposed” to noise if the received sound level at the animal’s location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to noise-producing activities. The severity of these effects can vary greatly between minor effects that have no real cost to the animal, to more severe effects that may have lasting consequences. Whether an animal is significantly affected must be determined from the best available scientific data regarding the potential physiological and behavioral responses to sound-producing activities and the possible costs and long-term consequences of those responses.

The major categories of potential effects of noise addressed in this analysis are:

- Hearing loss
- Behavioral responses
- Physiological stress
- Disruption of estivation/hibernation

Masking of biologically meaningful sounds is not expected to be an issue because noise associated with the Proposed Action would be intermittent and the loudest noise events (e.g., ground-based weapons firing) would typically only occur during 2-day, weekend training events. Auditory masking occurs if the noise from an activity interferes with an animal’s ability to detect, understand, or recognize biologically relevant sounds of interest. Masking is primarily a concern for continuous or near-continuous noises such as traffic noise. Therefore, auditory masking is not addressed in detail in this analysis.

#### 5.2.3.2 Hearing Loss

A familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). The distinction between permanent threshold shift and temporary threshold shift is based on whether there is complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), temporary threshold shift has occurred. The recovery time is related to the exposure duration, SEL, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005; Mooney et al. 2009). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a permanent threshold shift.

The threshold of physiological hearing damage to the human ear is approximately 140 decibels peak (dBP) (Humes et al. 2005, U.S. Army Public Health Command 2010). Much of the data used to predict human hearing loss from exposure to impulsive sounds is from studies conducted on chinchillas, which are burrowing rodents. Therefore, it is reasonable to use chinchilla hearing threshold shift data to predict hearing threshold shift in Washington ground squirrels. Hamemik et al. (1987) observed varying degrees of temporary and permanent threshold shift in chinchillas exposed to 1, 10, or 100 noise impulses (one every three seconds) having peak intensities of 131, 135, 139, or 147 dBP. Damage to the cochlear sensory epithelia was also observed for some exposures. Based on the reported responses of chinchillas, exposure to single event noise levels of 140 dBP or higher is used in this analysis to indicate the potential for hearing threshold shift in Washington ground squirrels. In addition, the number of exposures to a single event noise level above 140 dBP and the time interval between exposures is considered when assessing the potential for threshold shift to occur. In general, a threshold shift is more likely when repeated exposures occur over a short duration.

Long-term effects on a Washington ground squirrel that might experience a threshold shift would depend on whether the shift was temporary or permanent, the severity of the shift, the hearing frequencies affected by the shift, and the time required to recover from a temporary threshold shift. Squirrels with impaired hearing could be more susceptible to predation and would be expected to expend more time and energy trying to detect predators via visual cues, rather than auditory cues (e.g., listening for sounds made by an approaching predator or alarm calls of other squirrels). This could lead to decreased foraging success and decreased fitness. Recovery from a temporary threshold shift can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sound. Consequently, a threshold shift would not necessarily result in long-term effects on the individual.

#### 5.2.3.3 Behavioral Responses, Physiological Stress, and Habituation

Based on information presented above in Section 5.2.2 and literature summarized for the other species (National Park Service 1994, Bowles 1995, Larkin 1996), Washington ground squirrels could exhibit a range of behavioral and physiological responses to noise depending on distance from the noise source. It is also likely that squirrels would habituate to some sound levels. Washington ground squirrels exposed to high sound levels would likely perceive the noise and any associated visual or other cues (e.g., vehicle and equipment movement, other human activity, vibration, or projectile impacting the ground nearby) as a threat and exhibit predator defense behavior including alarm calls and taking cover underground. With repeated exposure over a two-day training event, such responses have the potential to reduce an animal's fitness by limiting foraging time, increasing energy expenditure, inducing a stress response, and interfering with breeding.

Lost foraging time could make it difficult to obtain enough fat and protein to supply their nutritional needs in hibernation (resulting in high overwinter mortality) or support reproduction (Sherman and Sherman 2011). This would be of particular concern where native perennial food plants favored by Washington ground squirrels have been replaced by exotic perennials and annuals that produce less nutritious seeds or bear seeds too late in the summer for consumption (Sherman and Sherman 2011). In addition, some training would likely coincide with the breeding season (Table 9). Washington ground squirrels produce one litter annually. Females are sexually receptive on only one afternoon per season, usually within a few days of emergence from hibernation (U.S. Fish and Wildlife Service 2011a). Reproductive success could be diminished if range use coincides with the breeding season.

Various studies have indicated that some animals respond to repeated loud noises by temporarily or permanently abandoning habitat (National Park Service 1994, Bowles 1995, Larkin 1996). While relatively little is known about Washington ground squirrel behavior, this species has several traits that suggest that habitat abandonment might not be a preferred strategy for coping with elevated noise levels. They rely on burrow systems, which they have expended energy to develop, for shelter, protection from predators, and estivation/hibernation. Therefore, abandoning existing habitat would put them at risk. Females are known to form social groups and defend territories (Sherman and Sherman 2011). In addition, home ranges are relatively small and documented dispersal distances of juvenile and adult males are relatively short. Females are not known to disperse and dispersal of juvenile females has not been studied. These factors suggest that habitat abandonment in response to noise is unlikely. If habitat were abandoned, individuals could suffer other consequences such as increased risk of predation. While habitat abandonment seems unlikely, it is possible that animals dispersing from other areas would be deterred from immigrating into areas with high noise levels.

Assuming habitat abandonment does not occur, individuals, particularly those exposed to the highest noise levels, could experience reduced fitness and cumulative stress from noise exposure. It is also possible that individuals would recover during the relatively quiet days (i.e., weekdays between training events). Habituation to some level of noise is also very likely. For example, individuals occupying areas away from the noise source would be most likely to habituate because noise levels would be lower and visual and other cues would be limited. As discussed above, long-term monitoring data indicate that military training at Orchard Training Area in southwestern Idaho, which is similar to the training proposed at NWSTF Boardman, does not appear to affect population dynamics of the Piute ground squirrel.

#### 5.2.3.4 Disruption of Estivation/Hibernation

A possible concern identified by the USFWS during EIS scoping was that activities could cause Washington ground squirrels to emerge from estivation/hibernation at inappropriate times. If squirrels emerged in response to noise, they would expend energy at a time when they need to minimize energy use. Frequent emergence could result in decreased fat reserves when limited resources are available to replenish those reserves.

Recorded motorcycle noise (95 dBA) caused estivating spadefoot toads to emerge from their burrows in a laboratory experiment (Brattstrom and Bondello 1983). In the wild, auditory cues (e.g., thunder and rain) stimulate spadefoot toads to emerge (Dimmitt and Ruidal 1980). There is no indication that estivating/hibernating Washington ground squirrels or other rodents would be stimulated by auditory cues in the same manner. Bowles (1995) reports that sleeping, estivating, and hibernating mammals are difficult to arouse with noise, particularly meaningless noise (i.e., noise that is not accompanied by an actual threat to the animal). However, Bowles (1995) does not present specific data on noise levels that would or would not arouse sleeping, estivating, and hibernating mammals. Speakman et al. (1991) evaluated energy expenditure in hibernating bats in response to various tactile and non-tactile stimuli, including 5-second bursts of generated sound (greater than 90 dB including background). The susceptibility of bats, as measured by energy expenditure, to all five classes of non-tactile stimulation was low. Only one positive response was measured in 39 applications of sound. The failure of non-tactile stimuli to cause arousals from hibernation may arise because there are selective advantages (i.e., energy conservation) to not arousing to such stimuli in the wild (Speakman et al. 1991). This study suggests that loud impulsive noises (e.g., detonating a large explosive charge), which also produce substantial ground vibration (i.e., tactile stimulation), might be more likely to wake a Washington ground squirrel compared to higher frequency noises that produce less ground vibration (e.g., aircraft overflights).

### 5.2.4 FIXED-WING AIRCRAFT NOISE

Fixed-wing aircraft overflights take place at various altitudes and airspeeds throughout the special use airspace (Figure 1) and most occur during the daytime (Table 7). Fixed-wing aircraft do not takeoff or land at NWSTF Boardman and military aircraft do not fly at supersonic speeds in NWSTF Boardman airspace. Only low-altitude flights are a concern from a wildlife exposure perspective because aircraft flying above 3,000 ft. (914.4 m) above ground level are not expected to produce a meaningful response in most wildlife. For discussion purposes here, low-altitude flights generally occur below 3,000 ft. (914.4 m) above ground level and as low as 200 ft. (30.5 m) above ground level for brief periods. These low-altitude flights take place in Restricted Areas 5701A-E, which consists of 209 $nm^2$ of airspace (Figure 1).

The aircraft noise levels that Washington ground squirrels could be exposed to would vary based on exercise-specific conditions including flight tracks (Figure 5), altitude, air speed, and the type of aircraft.

Table 12 provides representative aircraft noise levels that squirrels could be exposed to in the NWSTF Boardman Action Area. Animals on or near the ground and directly under the flight track centerline could be exposed to the noise levels listed in Table 12.

**Table 12: Estimated Average Sound Exposure Level of Single Aircraft Overflights at Various Distances**

| Representative Aircraft Type | Sound Exposure Levels (dBA) at Distance from Source (feet) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 200 | 400 | 800 | 1,600 | 3,200 | 6,400 |
| **Fixed-Wing** | | | | | | | |
| EA-6B | 130.4 | 125.8 | 120.9 | 115.6 | 109.6 | 102.5 | 93.8 |
| F-15 | 123.6 | 119.0 | 114.1 | 108.8 | 102.8 | 95.8 | 87.2 |
| F-16 | 117.8 | 113.2 | 108.5 | 103.3 | 97.4 | 90.5 | 81.6 |
| FA-18□ | 120.8 | 116.2 | 111.3 | 105.9 | 99.6 | 92.1 | 83.2 |
| AV-8 | 116.2 | 111.5 | 106.2 | 100.2 | 93.3 | 85.6 | 77.2 |
| **Helicopters** | | | | | | | |
| CH-47 | 99 | 94.6 | 90 | 85.1 | 79.6 | 73.4 | 66.1 |
| UH-60 | 99.7 | 95.3 | 90.9 | 86.1 | 80.9 | 75.1 | 68.1 |

Notes: Approximate sound exposure levels calculated using United States Air Force SELCAL model, assuming a direct overflight with a 0-degree slant angle, level flight, and 85 percent power. dBA □ decibels, A-weighted.
□The EA-18G Growler is an electronic combat version of the FA-18 E□F that will replace the EA-6B Prowler. As a replacement for existing aircraft, the introduction of this system would not result in substantially different noise levels from the FA-18.

Exposure to fixed-wing aircraft noise would be intermittent and brief (seconds) as an aircraft quickly passes overhead. The rate of increase in sound level, which is referred to as the onset rate, is sudden for jet aircraft flying at low altitudes and high airspeeds. The number of times an individual animal could be exposed to aircraft noise during a specific time period (day, month, year, etc.) would be highly variable based on factors such as specific training schedules, flight tracks, altitudes, number of participating aircraft, and biological factors such as diurnal and seasonal behavior. Given the number of annual sorties (about 1,668), the total annual flight time below 3,000 ft. (914.4 m) above ground level (about 2,049 hours), and a typical exercise duration of 1.5 hours, some individuals could be exposed to aircraft noise several times per day.

Figure 10 shows average day-night sound level (DNL) noise contours for fixed-wing aircraft under the Proposed Action. While the DNL metric and contours are intended to help describe potential impacts to humans, the 65 and 70 dB contours also indicate where potential exposure of Washington ground squirrels to noise from low-altitude overflights could be most frequent. The DNL contours indicate that Washington ground squirrels could be exposed to aircraft noise most frequently around the strafing pit and within a narrow corridor west of the Main Target Area.

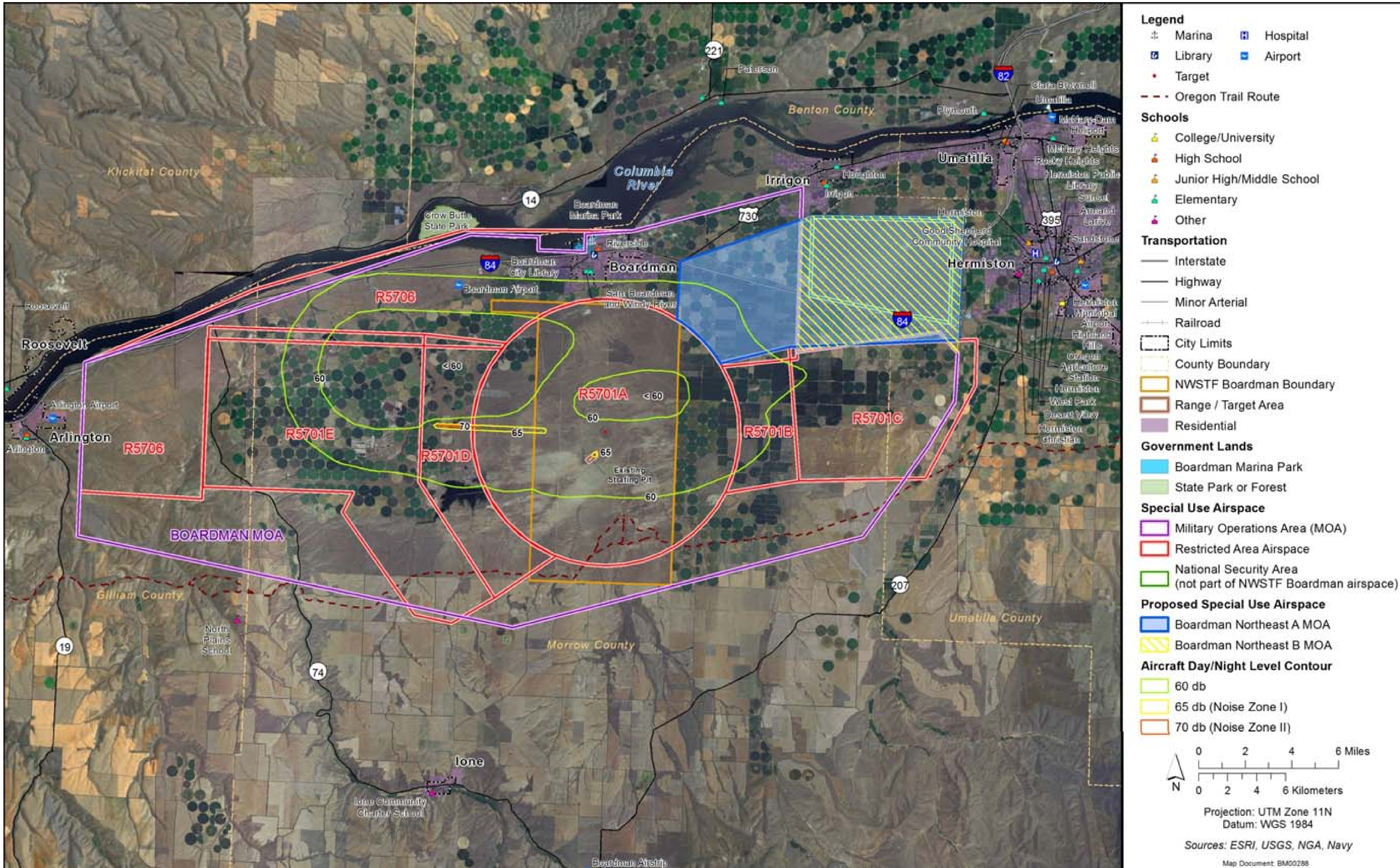


**Figure 10: Projected Aircraft Day-Night-Level Noise Contours for the Proposed Action**

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Aircraft overflights are not expected to result in hearing loss in Washington ground squirrels based on the expected SELs (Table 12) and frequency of exposure. Based on responses of other animals (National Park Service 1994, Bowles 1995, Larkin 1996), it is likely that noise from at least some aircraft overflights would elicit physiological or behavioral responses in Washington ground squirrels. For example, overflights might cause a startle response, which includes a physiological component (e.g., rapid increase in heart rate, shutdown of nonessential functions, and mobilization of glucose reserves) and a behavioral component (Bowles 1995). The behavioral component could be similar to responses to predators or other natural threats, and might include alert behavior, alarm calls, or retreating underground. Squirrels would be expected to quickly recover from these short-term responses, and no long-term effects on the fitness of individuals would be expected.

In addition, it is likely that squirrels have habituated to current levels of aircraft overflight noise at NWSTF Boardman. Washington ground squirrels are known to occur at NWSTF Boardman and on adjacent undeveloped lands to the west. These areas are located under low-altitude flight tracks. Washington ground squirrel populations in these areas have been exposed to noise associated with military aircraft and other military readiness activities for more than 50 years. Washington ground squirrel population dynamics at NWSTF Boardman are not fully understood and the effects of aircraft overflights on squirrel populations have never been studied. Nonetheless, available data indicate that squirrel populations at NWSTF Boardman respond to factors such as precipitation and available forage as would be expected. There is no evidence that suggests current levels of aircraft overflights or other noise influence population dynamics at NWSTF Boardman.

Noise associated with aircraft overflights under the Proposed Action may affect, and is likely to adversely affect the Washington ground squirrel. The effects are expected to be limited to short-term physiological and behavioral responses, and no long-term effects on the fitness of individuals would be expected.

### 5.2.5 HELICOPTER NOISE

Helicopter overflights take place below 3,000 ft. (914.4 m) above ground level throughout the special use airspace (Figure 1), but most helicopter activity occurs directly over the NWSTF Boardman land area. About 93 annual helicopter sorties would take place under the Proposed Action for a total of about 137 flight hours and typical flight durations of 1.5 hours. Approximately 33 percent of the flight hours would occur at night (Table 6). About 72 annual helicopter sorties currently take place at NWSTF Boardman for a total of 108 flight hours per year. Helicopters land and take off at NWSTF Boardman occasionally. Representative helicopter flight altitudes are less than 500 ft. (152 m) above ground level during training exercises. Some exercises might include hovering approximately 20 ft. (6.1 m) off the ground for several minutes.

Washington ground squirrel exposure to helicopter noise would be intermittent and infrequent based on the annual number of sorties (93) that would occur under the Proposed Action. Table 12 provides representative helicopter noise levels that squirrels could be exposed to in the NWSTF Boardman Action Area. The duration of exposure to noise from a helicopter would be longer than a fixed-wing aircraft overflight because helicopters fly at slower airspeeds, and hover, land, and takeoff at NWSTF Boardman. Nonetheless, most exposures would still be brief (seconds to minutes). As noted above, most helicopter activity takes place over the NWSTF Boardman land area and is less dispersed compared to fixed-wing aircraft overflights. Therefore, repeated exposure of an individual animal to helicopter noise during a given exercise is more likely than that of a fixed-wing aircraft overflight. The onset rate for helicopter noise is lower than that of a fixed-wing aircraft.

Similar to fixed-wing aircraft overflights, aircraft overflights are not expected to result in hearing loss in Washington ground squirrels based on the expected SELs (Table 12) and frequency of exposure. Low-altitude helicopter overflights are expected to elicit short-term physiological or behavioral responses in Washington ground squirrels, which may be triggered by noise, visual cues, the downwash from the rotor blade, or a combination of these stimuli. Washington ground squirrels would likely perceive low-flying or hovering helicopters as a threat and could temporarily retreat underground. Given the expected SELs and frequency of exposure, squirrels would be expected to quickly recover from these short-term responses, and no long-term effects on the fitness of individuals would be expected. Helicopter overflights under the Proposed Action may affect, and are likely to adversely affect the Washington ground squirrel.

### 5.2.6 Unmanned Aerial Systems Noise

UAS overflights take place at various altitudes and airspeeds throughout Restricted Areas 5701A-E and 5706 (Figure 6). About 85 percent occur during the daytime (Table 6). The RQ-7 Shadow and RQ-11 Raven take off and land at NWSTF Boardman and typically fly below 3,000 ft. (914.4 m) above ground level. The ScanEagle is launched at facilities located outside of NWSTF Boardman and 85 percent of this platform's flight time is above 3,000 ft. (914.4 m) above ground level. Of the 1,709 annual UAS sorties, 1,475 are ScanEagle sorties. UAS are estimated to be significantly quieter than the manned fighter jets so, even though the UAS account for more than half of the total proposed aircraft sorties, their noise contribution to the overall aircraft noise is negligible. However, noise and visual cues associated with UASs taking off and landing could elicit short-term physiological or behavioral responses in Washington ground squirrels, but no long-term effects on the fitness of individuals would be expected. UAS overflights under the Proposed Action may affect, and are likely to adversely affect the Washington ground squirrel.

### 5.2.7 Noise Associated with Training Activities on the Proposed Ranges

#### 5.2.7.1 Overview

The Proposed Action includes construction and operation of four new training ranges (Figure 4, Table 4):

- The MPMGR would be used for small arms (up to and including .50 caliber weapons) training
- The eastern CLFR would be used for small arms (up to and including .50 caliber weapons) training
- The western CLFR would be used for small arms (up to and including .50 caliber weapons) training
- The DTR would be used for high explosive charge (up to and including 200 lb. [90.7 kg] NEW charge) detonation training

Washington ground squirrel exposure to noise and potential responses to noise exposure depend on loudness of the weapons or munitions used, the number of days the range is used per year, the time interval between noise events (i.e., frequency of weapons firing during the training), seasonal use of the ranges, and the presence or absence of squirrels in the exposed habitats. Figure 11 shows the single-event 130 and 140 dBP noise contours for the MPMGR, eastern CLFR, and western CLFR based on the loudest weapon or munitions (.50 caliber) used on each of these ranges. The noise contours would be smaller when other weapons are fired on these ranges. These single-event noise contours depict the land area that could be exposed to the specified peak sound level and represent a composite of the sound fields surrounding all firing positions on the range. Table 13 provides a summary of range use for the MPMGR and CLFRs, and the land area within the 140 dBP noise contour. Portions of the MPMGR and western CLFR noise contours overlap; however, these contours would not actually overlap in time because the MPMGR and western CLFR would not be used simultaneously.

**Table 13: Summary of Range Use and Land Area within the 140 Decibel Peak Noise Contours for the Multi-Purpose Machine Gun Range and Convoy Live Fire Ranges Under the Proposed Action**

| Range | Days Used Per Year | Seasonal Use | Loudest Weapon | Land Area (acres) within the 140 Decibel Peak Noise Contours for Loudest Weapon |
|---|---|---|---|---|
| Multi-Purpose Machine Gun Range | 117 | Year Round | .50 caliber | 100 |
| Eastern Convoy Live Fire Range | 45 | Year Round | .50 caliber | 340 |
| Western Convoy Live Fire Range | 45 | Year Round | .50 caliber | 199 |

### 5.2.7.2 Multi-Purpose Machine Gun Range

The MPMGR would be used year round, about 117 days per year, and primarily on weekends. The loudest weapon used on this range would be a .50 caliber machine gun or rifle. Training events on the MPMGR would take place in a deliberate progression that involves steps prior to firing weapons. For example, a representative event could include the following:

- Advance crews would arrive to place targets and ensure the range is clear of non-participants.
- Units and equipment would arrive and training plans, safety, and standard operating procedures would be reviewed.
- Weapons would be sighted with a few initial shots, after which feedback is obtained before firing the next series of shots.
- Firing would occur intermittently from about 9:00 a.m. to 6:00 p.m. during 20-minute blocks. Total firing time would be about 2 hours per day. Multiple rounds would be fired from weapons on up to 10 firing lanes during a 20-minute block. Some shots would be fired in rapid succession, but firing would not be continuous during a 20-minute firing block.

The entire MPMGR is historically occupied Washington ground squirrel habitat (Figure 9) based on known squirrel detections through 2009 (Figure 8). If Washington ground squirrels occupy habitats on or near the MPMGR following construction, individuals would be exposed to weapons firing noise approximately 2 days per week. When the range is active, squirrels would be intermittently exposed to noise about 2 hours per day during six 20-minute blocks of firing time. Based on repeated exposures over a two-day training period and the information discussed above in the conceptual framework (Section 5.2.3), it is possible that squirrels within the 140 dBP noise contour could experience noise-induced threshold shift and associated negative effects on individual fitness. Behavioral and physiological responses of squirrels to noise within the 140 dBP contour could also result in reduced fitness of individuals.

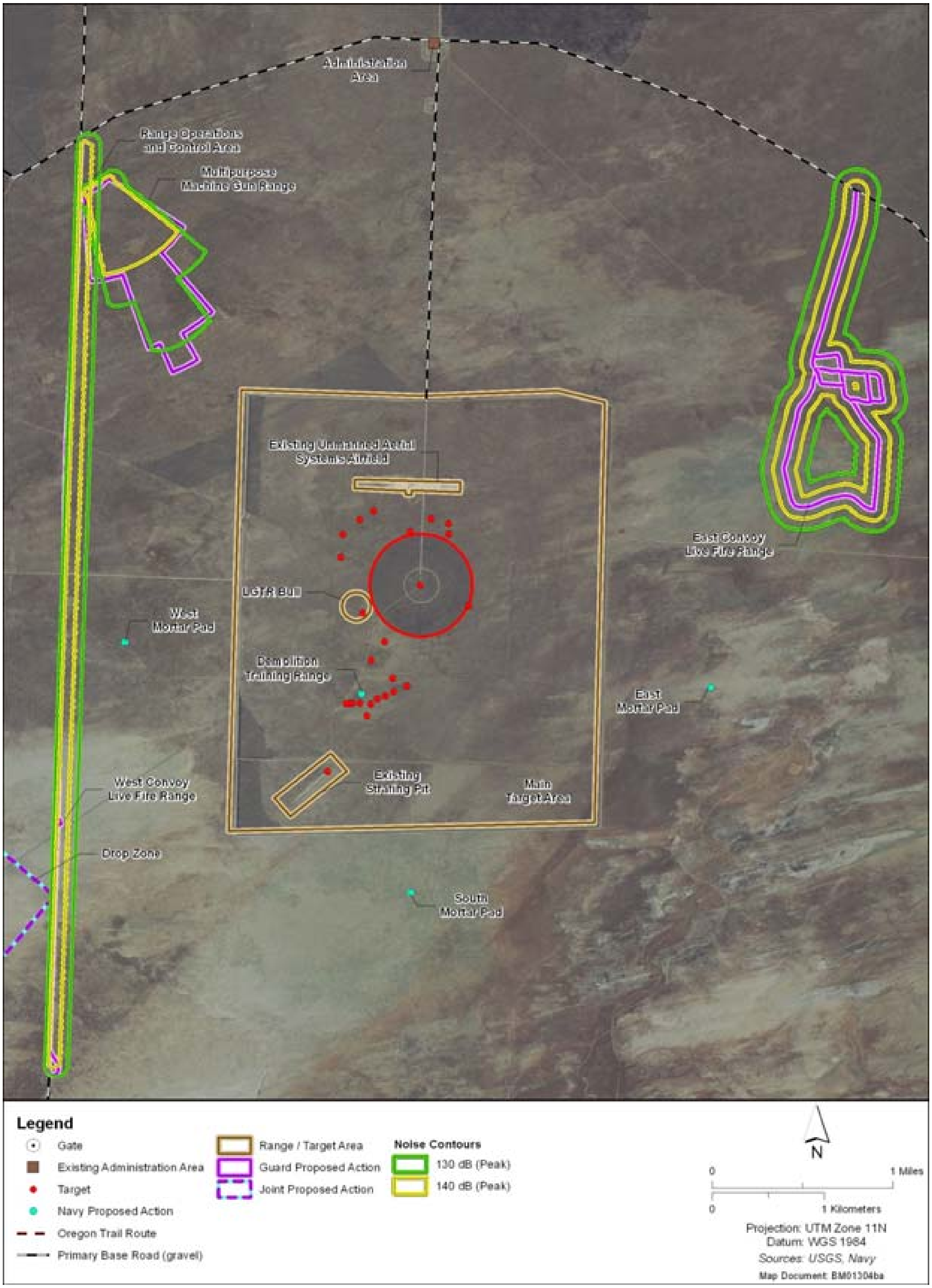


**Figure 11: Single Event 130 and 140 Decibel Peak Noise Contours (approximate) for the MPMGR and CLFRs**

The 140 dBP noise contour for the MPMGR covers about 100 ac. (40.5 ha), 97 ac. (39.3 ha) of which are located within the range footprint (Figure 11 and Table 14). The range footprint and most of the area within the 140 dBP contour would also be subjected to other disturbances during training, including general human activity, vehicle operations, target maintenance, projectiles impacting the ground, and small, training-caused wildfires. Some habitat within the 140 dBP contour would also be permanently lost and temporarily disturbed during construction (see Section 5.3 for detailed analysis of ground disturbing activities and habitat alteration). Although it is difficult to predict exactly how each of these stressors would affect Washington ground squirrels and their habitat, it is likely that the combined effects would result in long-term habitat degradation and a reduction in squirrel abundance in the affected area.

As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise. Although noise thresholds are not available for Washington ground squirrels, long-term effects are most likely to occur in areas within the 140 dBP contour. As discussed in Section 7 below, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the MPMGR range footprint and 140 dBP contour through habitat restoration and enhancement in other areas on NWSTF Boardman. The adaptive management and monitoring process described in Section 7 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contour.

#### 5.2.7.3 Eastern and Western Convoy Live Fire Ranges

Convoy live fire training would be conducted about 45 days per year, primarily on weekends. The loudest weapon used on these ranges would be a .50 caliber machine gun. One or both of the CLFRs could be used during a training event, but firing would not occur simultaneously on both ranges. Approximately 50 percent of the total annual CLFR training time would be spent on each range. Up to platoon-sized (25 to 50 personnel) convoys would navigate the CLFR within vehicles armed with a machine gun. When units within a vehicle detect an activated target, they would engage the target with bursts of fire (typically seven to nine rounds) from one or more machine guns. Firing on an individual target may occur intermittently for a period of less than a minute. Units would then continue to navigate the CLFR, and detect and engage targets until the training event is concluded. Targets would be within about 328 ft. (100 m) of the CLFR roads and oriented so that firing is directed toward the center of NWSTF Boardman. Specific target locations and the number of targets activated and engaged could vary for each training event to increase training realism. A representative CLFR training event would include multiple scenarios, and multiple runs through the course. Approximately 16 training events could occur per representative 24-hour period. Three to six targets could be engaged per day and total firing time would be approximately 30 minutes within a 24-hour period.

Most of the land on and around the CLFRs is historically occupied Washington ground squirrel habitat (Figure 9) based on known squirrel detections through 2009 (Figure 8). If Washington ground squirrels occupy habitats on or near the CLFRs following construction, individuals would be exposed to weapons firing noise approximately 45 days per year, primarily during 2-day training events. When the range is active, squirrels near active targets would be briefly (up to a few minutes) exposed to weapons firing noise while units engage the target. The potential for squirrels to be repeatedly exposed to weapons firing noise during a training event would depend on specific target placements. For example, if two targets were within approximately 200 ft. (61 m) of each other, their associated 140 dBP contours would overlap. In most cases the distance between targets would be more than 200 ft. (61 m), particularly on the western CLFR because of its linear layout. The layout of the eastern CLFR is non-linear; therefore, the potential for the sound fields associated with individual targets is more likely to overlap. As discussed above for the MPMGR, it is possible that squirrels within the 140 dBP noise contours of the CLFRs could experience noise-induced threshold shift and associated negative effects on individual fitness. Behavioral and physiological responses of squirrels to noise within the 140 dBP contour could also result in reduced fitness of individuals. However, the likelihood that these effects would occur on the CLFRs is lower than that of the MPMGR because the CLFRs would be used less frequently and the possibility of repeated exposure is less likely.

The 140 dBP noise contour for the eastern CLFR covers about 340 ac. (138 ha), 333 ac. (135 ha) of which are located within the range footprint (Figure 11 and Table 13). The 140 dBP noise contour for the western CLFR covers about 199 ac. (80.5 ha), 176 ac. (71.2 ha) of which are located within the range footprint (Figure 11 and Table 13). The CLFR noise contours presented in Figure 11 and the area within the 140 dBP contours presented in Table 14 assume that targets could be placed along the entire length of the CLFRs. Therefore, Figure 11 depicts continuous noise footprints along the length of the CLFRs to provide a worst-case, conservative estimate of the area potentially affected by noise. The actual noise footprint during a training event would not be continuous because discrete target locations would be established.

The range footprint and most of the area within the 140 dBP contours would also be subjected to other disturbances during training, including general human activity, vehicle operations, target maintenance, projectiles impacting the ground, and small, training-caused wildfires (see Section 5.3 for detailed analysis of ground disturbing activities and habitat alteration). Although it is difficult to predict exactly how each of these stressors would affect Washington ground squirrels and their habitat, it is likely that the combined effects would result in long-term habitat degradation and a reduction in squirrel abundance in the affected area.

As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise. Although noise thresholds are not available for Washington ground squirrels, long-term effects are most likely to occur in areas within the 140 dBP contour. As discussed in Section 7, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the CLFR range footprints and 140 dBP contours through habitat restoration and enhancement in other areas on NWSTF Boardman. The adaptive management and monitoring process described in Section 7 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contours.

#### 5.2.7.4 Demolition Training Range

Figure 12 shows the single-event 130 and 140 dBP noise contours for the DTR based on a 200 lb. (90.7 kg) NEW charge (conservatively modeled as a 220 lb. [99.8 kg] NEW charge). The sound field for charges less than 200 lb. (90.7 kg) NEW would be smaller than the 200 lb. (90.7 kg) NEW sound field. Detonations on the DTR could be conducted any day of the week between the hours of 10:00 a.m. and 4:00 p.m. Charges of 50 lb. (22.7 kg) NEW or less could be detonated year round, but charges of greater than 50 lb. to 200 lb. (22.7 to 90.7 kg) NEW would not be detonated from January through August to minimize potential impacts to active Washington ground squirrels and nesting birds. A representative annual training scenario for explosive detonation training on the DTR is provided in Table 14.

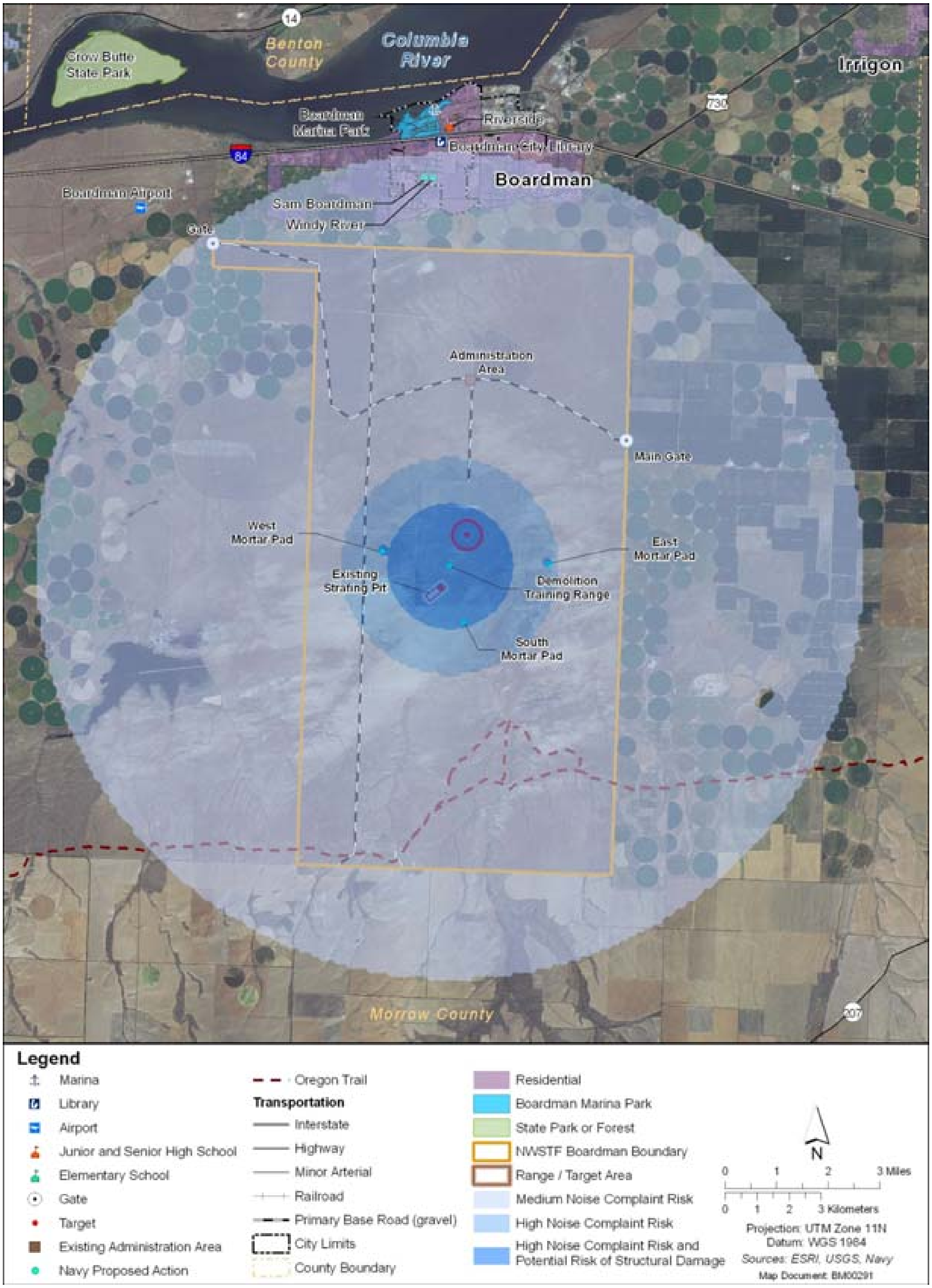


**Figure 12: Projected Single Event Noise Contours for Ordnance Activities Associated with the Main Target Area, Strafe Pit, and Demolition Training Range under the Proposed Action**

**Table 14: Representative Annual Training Scenario for the Proposed Demolition Training Range**

| Net Explosive Weight | Events Per Year (Days) | Detonations Per Event | Total Detonations Per Year |
|---|---|---|---|
| 200 lb. | 2 | 1 | 2 |
| 100 lb. | 3 | 1 or 2 | 5 |
| 50 lb. | 3 | 1 to 6 | 10 |
| 25 lb. | 4 | 1 to 6 | 20 |
| □25 lb. | 3 | 1 to 6 | 13 |
| **Total □** | **15** | | **50** |

Notes: lb. □pounds, □□less than

While the noise footprint associated with the DTR would be large, this range would be used relatively infrequently. Washington ground squirrels within the 140 dBP contours associated with the DTR would be expected to exhibit short-term behavioral and physiological responses to noise, but the time interval between detonations would likely allow for recovery. Seasonal restrictions on the use of charges over 50 lb. NEW would also help to minimize negative effects to active Washington ground squirrels. Based on the relatively infrequent use of the DTR and the limited potential for repeated exposure over short periods of time, noise associated with use of the DTR is not expected to result in long-term habitat degradation or a reduction in squirrel abundance in the affected area. The adaptive management and monitoring process described in Section 7 would be used to reduce uncertainty associated with potential effects of noise associated with the DTR.

Noise associated with weapons firing and detonation of high explosive training activities on the proposed ranges may affect, and is likely to adversely affect the Washington ground squirrel.

### 5.2.8 NON-EXPLOSIVE PRACTICE MUNITIONS NOISE

Air-to-Ground Bombing Exercises at NWSTF Boardman involve dropping various non-explosive practice bombs from fixed-wing aircraft within the Main Target Area (Table 4 and Table 6). A typical exercise might involve dropping two to six non-explosive practice bombs in successive target runs. Though non-explosive practice munitions do not contain a high-explosive charge that detonates on impact, most practice munitions contain a small spotting charge that allows the unit conducting the training to see the impact location through a flash and puff of smoke generated by the spotting change on impact. When a non-explosive practice bomb makes contact with the target, kinetic energy would be transferred and sound would be generated. Sound associated with the impact event is typically of low frequency (less than 250 Hertz) and of a short enough duration (i.e., impulsive sound) that it produces negligible amounts of acoustic energy. This noise would co-occur with aircraft overflight noise. While wildlife near the impact point would likely respond to the overall noise event, it would be difficult to distinguish between responses to the impact noise and the overflight noise, which has a larger footprint. Noise associated with a non-explosive practice bomb impacting the target was not addressed as an independent noise stressor because noise from practice bombs striking the target would co-occur with aircraft noise. Noise associated with non-explosive practice bombs is not addressed in further detail.

### 5.2.9 VEHICLE AND EQUIPMENT NOISE

Vehicles and equipment used during construction and ground-based training activities would produce noise intermittently. Individual pieces of commonly used construction equipment typically generate noise levels of 80 to 88 dBA (U.S. Department of Transportation, Federal Highway Administration 2006). During the peak construction activities multiple pieces of equipment could be operating simultaneously and noise levels could be elevated during daytime periods at locations near the construction site. Washington ground squirrels would likely respond to construction equipment by exhibiting alert behavior, making alarm calls, or retreating underground. These responses may be generated by visual cues, noise, or a combination of visual cues and noise. Washington ground squirrels in the vicinity of persistent equipment operation could be displaced and become susceptible to predation.

Vehicle and equipment use during ground-based training would include transport of Soldiers to and from the range in buses or vans and operation of tactical equipment such as high-mobility multipurpose wheeled vehicles. In addition to traveling to and from the range, tactical equipment would be operated on the eastern and western CLFRs, which would be used about 45 days per year. A high-mobility multipurpose wheeled vehicle generates noise levels of less than 85 dBA at the crew positions when traveling at 30 miles per hour (U.S. Department of the Army 2013). Unlike construction activities where equipment may be operated in one area for several hours, training activities would primarily involve vehicle pass-by events. Washington ground squirrels would likely respond to visual cues and noise from a passing vehicle by exhibiting alert behavior, making alarm calls, or retreating underground. Squirrels would be expected to return to normal behavior soon after a vehicle or series of vehicles pass.

In summary, construction equipment operation has the potential to displace Washington ground squirrels and increase their susceptibility to predation. Vehicle and equipment operation during training activities is expected to result in short-term behavioral responses, but no long-term effects to Washington ground squirrel fitness would be expected. These effects would likely be attributable to both visual cues and noise. Vehicle and equipment operations under the Proposed Action may affect, and are likely to adversely affect the Washington ground squirrel.

### 5.2.10 Summary of Effects from Noise

Portions of NWSTF Boardman would be exposed to noise levels that could cause physiological and behavioral responses in Washington ground squirrels. Individuals within the 140 dBP noise contours for MPMGR would be repeatedly exposed to loud noise on most weekends, and could experience reduce fitness from hearing threshold shift or behavioral and physiological responses. Squirrels could also be repeatedly exposed in the 140 dBP contours for the CLFRs, but the frequency of exposure would be much lower than the MPMGR.

As previously discussed, well-established thresholds or criteria for predicting impacts of noise on terrestrial wildlife do not exist. While a specific noise threshold cannot be defined to predict long-term impacts to Washington ground squirrel fitness based on available data, the Navy and ORNG used 140 dBP to estimate the area where long-term Washington ground squirrel habitat degradation could occur as a result of weapons firing noise on the proposed MPMGR and CLFRs. This value was used because squirrels repeatedly exposed to 140 dBP could experience hearing threshold shifts based on available data for chinchillas and humans (e.g., Hamemik et al. 1987, Humes et al. 2005, U.S. Army Public Health Command 2010). Given the potential for threshold shift, it is also logical to assume that squirrels would exhibit a strong and consistent behavioral and stress response to 140 dBP. It is also likely that squirrels would be exposed to visual and other cues within the 140 dBP contours, making it more likely that squirrels would perceive the loud noise as a threat. When loud noises are perceived as a threat, animals are less likely to habituate to the noise. With repeated exposure to 140 dBP over a two-day training period, which could occur on the MPMGR and CLFRs, it appears likely that squirrels could experience reduced fitness, even if threshold shift did not occur. As discussed in Section 7, the Navy and ORNG are proposing to compensate for unavoidable effects on Washington ground squirrel habitat within the

MPMGR and CLFR range footprints and their associated 140 dBP contours through habitat restoration and enhancement in other areas on NWSTF Boardman.

The Navy and ORNG acknowledge that Washington ground squirrels would respond to some sound levels below 140 dBP. In addition, it is possible that sound levels below 140 dBP could contribute to long-term habitat degradation when accompanied by visual cues, human activity, ground disturbance, wildfire, or other stressors. As discussed in Section 5.3, these other stressors would be expected to occur within the range footprints. Therefore, the area within the range footprints, plus the area of the 140 dBP noise contours for the MPMGR and CLFRs outside the range footprints, was defined as the area of long-term habitat degradation for mitigation planning purposes. As depicted in Figure 11, most of the 140 dBP contours for the MPMGR and CLFRs and a substantial portion of the 130 dBP contour for the MPMGR are within the range footprints. Sound levels below 140 dBP occurring outside the range footprints were not considered as long-term habitat degradation for mitigation planning purposes because:

- As noise levels and associated visual cues decrease with increasing distance from the noise source, the potential for adverse effects on Washington ground squirrels decreases and squirrels would be more likely to habituate to noise.
- The MPMGR and CLFRs would primarily be used on weekends, which provides squirrels opportunity to recover from noise exposures.
- Although studies conducted at Orchard Training Area did not specifically evaluate Piute ground squirrel responses to noise, long-term monitoring data suggest that noise and other potential stressors associated with military training do not appear to be impacting Piute ground squirrel populations at the training area.
- Monitoring and adaptive management measures will be developed and implemented to help reduce uncertainty.

Proposed compensatory mitigation for unavoidable effects on Washington ground squirrel habitat is discussed in detail in Section 7. The adaptive management and monitoring process described in Section 7 would be used to reduce uncertainty associated with potential effects of noise outside the 140 dBP contours. Noise associated with the Proposed Action may affect, and is likely to adversely affect the Washington ground squirrel.

## 5.3 Ground Disturbing Activities and Habitat Alteration

### 5.3.1 Introduction

This section analyzes potential effects of ground disturbing activities on Washington ground squirrel habitat, as well as other stressors that could alter habitat. Proposed activities that would result in ground disturbance include construction, training (non-explosive practice munitions striking the ground and vehicle and equipment operations), and maintenance (fire break and target maintenance). The potential for these activities to directly injure Washington ground squirrels is addressed separately in Section 5.4, Physical Strikes, and effects of noise and general disturbance associated with these activities were addressed in Section 5.2, Noise. Other stressors analyzed in this section that could alter habitat include invasive plants and wildfire.

### 5.3.2 Construction Activities

Site excavation, grading, and equipment operations during construction of the proposed range enhancements would result in temporary disturbances to the ground surface. The area of disturbance for individual construction projects would range from less than 1 to 30 ac. (0.4 to 12 ha). The total area of disturbance would be 65 ac. (26 ha), 25 ac. (10 ha) of which are previously disturbed (mostly consisting of existing gravel or dirt roads). Approximately 40 ac. (16 ha) of previously undisturbed area would be affected, about 25 ac. (10 ha) would be permanently converted to development, and about 15 ac. (6 ha) would be temporarily disturbed and revegetated in accordance with the post-construction revegetation plan (Appendix A). Construction activities for the range enhancements would be spaced over a period of several years as funding becomes available. Therefore, the total area of disturbance at any given time during construction would be much less than 65 ac. (26 ha).

Annual grass/forb, bunchgrass, and open-low shrub communities would be affected by construction based on 1997 vegetation survey data. Ecological condition classifications for the area of disturbance range from medium to low based on data collected in 2013. With the exception of the UAS Airfield and Maintenance Facility and the Range Operations Control Center, the area of disturbance is historically occupied Washington ground squirrel habitat (Figure 9) based on known detections recorded through 2009 (Figure 8). As previously discussed, a systematic Washington ground squirrel survey of the entire NWSTF Boardman property has not been conducted. Therefore, the distributions of squirrel detections and historically occupied habitat presented in Figures 8 and 9 are, in part, a reflection of variable survey effort. As discussed in Section 7.4.4, Monitoring, systematic surveys would be conducted prior to construction to support micrositing decisions. Micrositing would involve looking at proposed construction sites at a “micro” level to identify sensitive features that should be avoided to the extent practicable. Occupied Washington ground squirrel habitat and areas with higher ecological condition classifications (e.g., undisturbed areas with a relatively high percentage of native plant cover) would be avoided in favor of unoccupied habitat with lower ecological condition classifications (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable. Micrositing efforts would primarily be aimed at the UAS Airfield and Maintenance Facility and the Range Operations Control Center. The ability to microsite ranges would be limited based on safety constraints.

As noted above, approximately 25 ac. (10 ha) would be permanently converted to development. Washington ground squirrel habitat in these areas would be permanently lost. The area of permanently lost habitat would be small relative to the total land area at NWSTF Boardman (0.05 percent). Approximately 15 ac. (6 ha) temporarily disturbed during construction would be revegetated and maintained in accordance with the proposed post-construction revegetation plan (Appendix A). After restoration, disturbed areas could provide foraging habitat for Washington ground squirrels. Restoration efforts would include establishment of native plants. Foraging habitat quality could be improved in temporarily disturbed areas that were dominated by invasive plants prior to disturbance, if these areas are not subject to further disturbance during operation of the ranges (see analysis below for training and maintenance activities). The suitability of temporarily disturbed and restored areas for burrowing habitat would depend on the level of disturbance. For example, the natural soil profile would be altered in areas subject to grading or trenching activities. It is unlikely that these areas would be suitable for burrowing for several years following construction. Therefore, a long-term, but not permanent, loss of Washington ground squirrel habitat would occur in temporarily disturbed and restored areas (15 ac.).

### 5.3.3 Training Activities

Training activities on the proposed new ranges would result in increased ground disturbance and habitat alteration. Habitat around targets on the new ranges would be disturbed by non-explosive practice munitions striking the ground and during target maintenance. Some of the areas affected would coincide with areas temporarily disturbed during construction, thus hampering restoration efforts. Areas disturbed by projectile impacts would likely be colonized by invasive plants, which would further reduce habitat quality. Invasive plants are discussed in more detail in Section 5.3.5.

Training activities conducted under the Proposed Action would increase the risk of wildfire at NWSTF Boardman. Effects of training-caused wildfires are analyzed in more detail in Section 5.3.6.

Vehicle and equipment use would increase substantially under the Proposed Action during ground-based training events. However, vehicles, including tracked vehicles, would continue to use existing roads or new gravel roads constructed under the Proposed Action. No off-road maneuver training is proposed. Vehicle and equipment use during training activities would not result in ground disturbance, but would provide pathways for invasive plant seed dispersal. As discussed in other sections, vehicle strikes, noise, and general disturbance associated with vehicles and equipment used during training could affect Washington ground squirrels.

### 5.3.4 Maintenance Activities

Target and fire break maintenance would result in ground disturbance under the Proposed Action. Current target maintenance within the Main Target Area would continue under the Proposed Action. The Main Target Area includes the main bull's eye, the strafing pit, the laser-guided training range bull's eye, and several single targets or grouped target sets (e.g., old vehicles, tanks, etc.). The vegetation in and around each of these targets must be maintained or removed for fire safety and to provide a viable visual cue to pilots. This is accomplished by mechanical disturbance (i.e., plowing or disking) with a tractor one time per year. Approximately 23 ac. (9.3 ha) in the Main Target Area would continue to be subjected to this maintenance under the Proposed Action.

Maintenance activities on the MPMGR and the CLFRs would include periodic maintenance, repair, and replacement of targets and target support mechanisms. Gravel roads associated with the CLFRs would be graded or could include placement of additional gravel. Periodic vegetation control may be required to reduce fire fuel loading or manage exotic vegetation and would be conducted as authorized in approved natural resource and fire management plans. Targets on the CLFRs would be relocated periodically to vary the training, and former target locations would be revegetated with native species.

Currently, approximately 462 ac. (187 ha) of fire breaks throughout NWSTF Boardman are maintained annually by mechanical disturbance (e.g., plowing or disking) with a tractor. The Draft Integrated Wildland Fire Management Plan (Appendix H of the DEIS) includes proposed modifications to the existing system of fire breaks. The width of some fire breaks would be reduced to the width of the adjacent road, some fire breaks that do not follow roads would be eliminated, and two new fire breaks totaling about 19 ac. (7.7 ha) would be created (Figure 13). The total area of fire breaks that would be maintained annually by mechanical disturbance (plowing or disking with a tractor) would decrease from 462 ac. (187 ha) to 243 ac. (98 ha).

Establishment and maintenance of the two new fire breaks would alter 19 ac. (7.7 ha) of potentially suitable Washington ground squirrel habitat. However, long-term revegetation plan (Appendix A) would be implemented to restore the areas removed from mechanical maintenance. These areas would be re-vegetated with native bunchgrasses, primarily Sandberg's bluegrass with some needle and thread or bluebunch wheatgrass, to provide a low-structure and low-fuel load area next to the road/fire break, and also provide some wildlife habitat value. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80 percent density of a representative bunchgrass stand area within two to three years of seeding. Selective herbicide

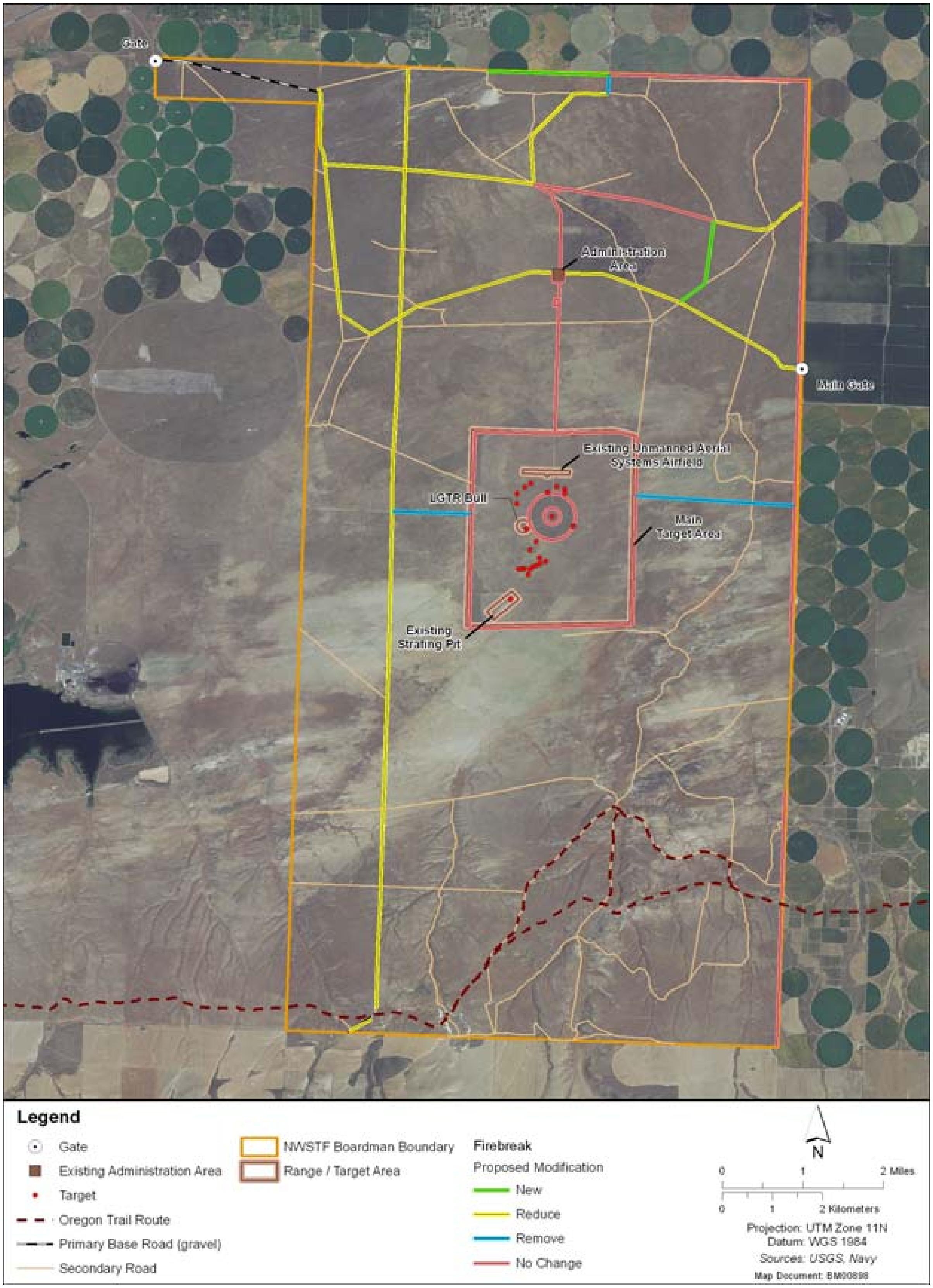


**Figure 13: Proposed Fire Break Modifications at Naval Weapons Systems Training Facility Boardman**

treatments or other appropriate management actions would be used to control invasive plants until these areas are completely restored.

The proposed modifications to the fire break system would result in long-term benefits to vegetation communities at NWSTF Boardman by restoring approximately 219 ac (89 ha) of mechanically disturbed land to native plant communities, which would also reduce the potential for soil erosion, reduce the likelihood of invasive plant infestations, and improve Washington ground squirrel foraging habitat. Native plants appear important to Washington ground squirrels, with Sandberg bluegrass playing a key role in their diets (Tarifa and Yensen 2004a,b). Restoration would also allow natural soil profiles to begin to naturally recover in these areas. While these areas might eventually provide suitable Washington ground squirrel burrowing habitat, the soil recovery process could take several years to decades.

Long-term benefits associated with fire break restoration (219 ac. [89 ha]) would help to offset impacts to Washington ground squirrel habitat from construction activities. Nonetheless, about 25 ac. (10 ha) of potential Washington ground squirrel habitat would be permanently converted to development under the Proposed Action.

### 5.3.5 Invasive Plants

Vegetation communities and Washington ground squirrel habitat at NWSTF Boardman would continue to be affected by invasive plants under the Proposed Action. Non-native invasive plants, including cheatgrass, threaten squirrels by competing with native plants that are important for ground squirrel diets. Exotic annual plant species provide an unstable food resource for ground squirrels because their productivity fluctuates with annual precipitation (Yensen et al. 1992). Washington ground squirrels do eat non-native species, including cheatgrass (Tarifa and Yensen 2004a, Tarifa and Yensen 2004b), but native perennial plant species are more drought-tolerant than annuals. When annual plants dominated the landscape, there is less forage for ground squirrels during drought years and it is available for a shorter period of time (Yensen et al. 1992). Further, plant communities dominated by exotic annuals have lower diversity, reducing dietary choices and probably the ability to avoid toxic secondary compounds (Quade 1994). Exotic-dominated communities are also far more likely to burn than native vegetation (Whisenant 1990).

Ground disturbing activities described above would continue to indirectly affect native plant communities by creating favorable conditions for establishment of invasive plants and providing pathways for seed dispersal. Construction and operation of the proposed new ranges would exacerbate existing invasive plant problems. Construction and military vehicles and equipment coming from offsite would provide a new pathway for introduction of invasive plants and would be a dispersal mechanism for seeds at NWSTF Boardman.

As discussed in Section 7, several BMPs would be implemented to avoid invasive plant infestations, monitor invasive plants, and adaptively manage invasive plants during construction and over the life of the proposed training ranges. In addition to project specific mitigations, NWSTF Boardman-wide invasive plant and noxious weed management actions would be implemented as part of the *NWSTF Boardman INRMP*, with increased efforts to reflect new threats introduced by the Proposed Action. The invasive plant and noxious weed management actions, developed in cooperation with USFWS and ODFW, would be reviewed annually and updated as necessary. Key elements of the plan include the following:

- Standard operating procedures for preventing and minimizing the introduction and spread of invasive plants

- Updates of the invasive plant inventory and mapping prior to implementing the Proposed Action
- Responsibilities and procedures for integrating efforts of the Navy, ORNG, and The Nature Conservancy
- Criteria for prioritizing management actions
- Short- and long-term monitoring programs
- Annual work plans, including funding requirements and funding sources

### 5.3.6 WILDFIRE

Wildfire, in combination with invasive plants, has affected vegetation and Washington ground squirrel habitat at NWSTF Boardman in recent years. Since 1998, wildfires burned more than 85 percent of NWSTF Boardman causing short- and long-term habitat alterations. Large fires swept portions of the installation in 1998 (17,514 ac. [7,088 ha]), 2007 (11,664 ac. [4,720 ha]), and 2008 (30,612 ac. [12,388 ha]), while smaller areas burned in 2002 (1,639 ac. [663 ha]) and 2009 (618 ac. [250 ha]) (Figure 14). With the exception of the 2009 fire, all of these fires were started by lightning strikes. The cause of the 2009 fire is unknown (U.S. Department of the Navy 2012). Training-related wildfires also occur occasionally at NWSTF Boardman. Range safety monitoring by participating military units allows for early detection of training-related fires and rapid response. Therefore, fires that start during training activities are typically contained to relatively small areas compared to lightning-caused fires, which might go undetected for a period of time after ignition.

Historically, the area was comprised of fire-adapted vegetation communities with fire return intervals that likely ranged from about 20 to 70 years based on information for similar habitats (Leenhouts 1998, Paysen et al. 2000). With the widespread introduction of invasive, non-native annual grasses such as cheatgrass, the amount of fuel for wildfires has increased. Wildfires now tend to be more frequent and more severe (burn hotter), and can be long-term or permanent habitat altering events. Frequent and hot burning fires like those that have occurred at NWSTF Boardman favor a shift from shrublands to grasslands. Humple and Holmes (2001) documented decreases in sagebrush cover and increases in cover of grass, primarily cheatgrass, in study plots following the 1998 fire at NWSTF Boardman.

Increases in training under the Proposed Action would increase the risk of wildfire at NWSTF Boardman. Fires resulting from training activities would be expected to occur on the MPMGR and CLFRs, particularly during dry periods. To address these issues the Navy and ORNG prepared a Draft Integrated Wildland Fire Management Plan which contains a Fire Danger Rating and Wildland Fire Risk Management Matrix (Appendix H of the DEIS). The Plan would be finalized prior to implementing the Proposed Action and includes measures to prevent, monitor, and respond to wildfires. The Navy, ORNG, and other range users would implement the Plan.

While preventive measures are expected to reduce the incidence of training-caused fires, it is possible that one or more fires could occur on the ranges each year. Monitoring conducted during training exercises and onsite firefighting assets would ensure rapid response to training-caused fires, and would help to contain the fires to relatively small areas (e.g., less than 100 ac.). While the total area affected by training-caused fires cannot be quantified, long-term adverse effects on vegetation and habitat are likely. A mosaic of recently burned areas, unburned areas, and areas in various stages of recovery would likely develop as the ranges become operational and frequent, small fires occur. Vegetative cover would decrease and bare ground would increase. Conditions would be favorable for establishment and spread of non-native annual grasses such as cheatgrass, although cheatgrass already dominates portions of the

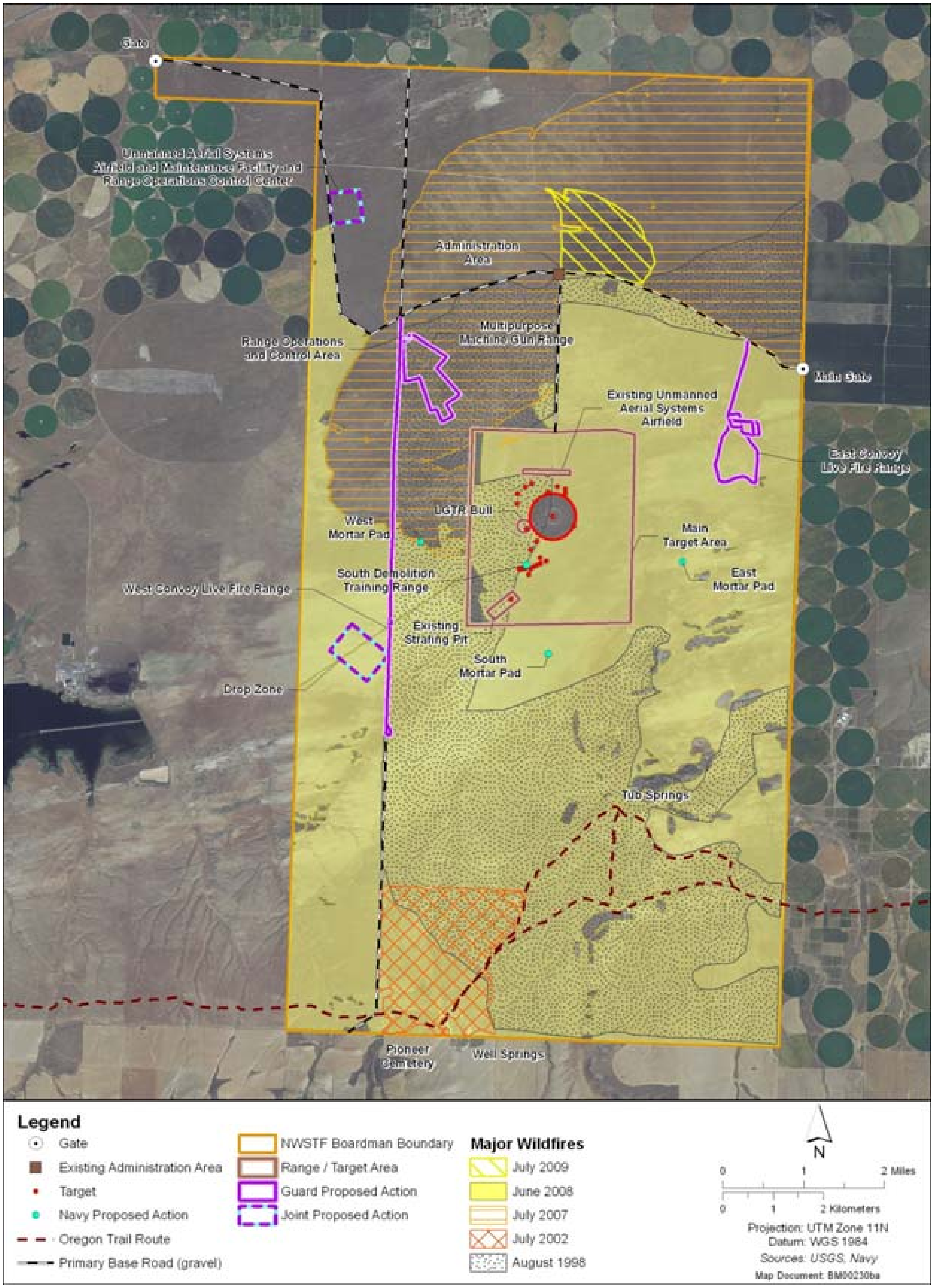


**Figure 14: Extent of Major Wildfires at NWSTF Boardman**

proposed ranges. Washington ground squirrels would be more susceptible to predation in areas of bare ground and their available food supply would decrease. Shifts from native grasses to cheatgrass or other invasive plants could also reduce the quality of available forage. For these reasons, training-caused wildfire is expected to have long-term adverse effects on Washington ground squirrel habitat.

### 5.3.7 Summary and Combined Effects on Washington Ground Squirrel Habitat

This section provides a summary of the analyses presented above and synthesizes this information to consider the overall effects of the Proposed Action on Washington ground squirrel habitat. Consideration of the combined effects on habitat provides a better understanding of potential population-level effects and helps to define the scope of proposed habitat restoration and enhancement efforts to mitigation adverse effects.

As summarized in Table 15, the Proposed Action would result in permanent habitat loss and long-term habitat degradation. Permanently lost habitat includes areas that would be converted to structures or facilities such as the UAS airfield, gravel roads, and targets. Complete loss of habitat functions and values would occur in these areas. Long-term habitat degradation, but not complete loss of habitat functions and values, is expected to occur in areas affected by temporary construction disturbance, projectiles striking the ground, training-caused wildfires, invasive plants, weapons firing noise on the MPMGR and CLFRs, and general disturbance caused by increased human activity. The spatial extent of habitat impacts associated with these stressors cannot be fully quantified. However, based on implementation of BMPs discussed in Section 7, the Navy and ORNG expect that long-term habitat degradation would primarily occur within the range enhancement footprints. One exception would be the 140 dBP contours for the MPMGR and CLFRs, 33 ac. (13.4 ha) of which fall outside the range footprints (Figure 11). Therefore, the area of long-term habitat degradation for the MPMGR and CLFRs was calculated as follows: (total range footprint – permanently lost habitat) + area of 140 dBP contour outside the range footprint. Figure 15 shows the total affected area for the MPMGR and CLFRs. Table 15 provides a summary of permanent habitat loss and long-term habitat degradation for each range enhancement, broken down by ecological condition class.

The area of permanently lost habitat would be 25 ac. (10 ha) and long-term habitat degradation is expected on 788 ac. (319 ha), for a total affected area of 813 ac. (329 ha). Approximately 90 percent of the affected area is known to be historically occupied Washington ground squirrels. However, based on the lack of recent, systematic survey data the entire affected area was assumed to be occupied by Washington ground squirrels for impact assessment and mitigation planning purposes. Assuming that the entire NSWTF Boardman property is suitable Washington ground squirrel habitat, 0.05 percent of the available habitat would be permanently lost and 1.7 percent would be degraded. Quantifying the population-level effects of these habitat impacts is not possible given the current limited knowledge of Washington ground squirrel population dynamics. While squirrel numbers could decline in response to lost and degraded habitat, the area affected would be relatively small compared to the total habitat available at NWSTF Boardman. Therefore, it is unlikely that the viability of the population would be threatened. Large areas of historically occupied habitat would be unaffected by the action. In addition, the proposed habitat mitigation measures discussed in Section 7 would help to ensure no net loss of habitat quantity or quality and a net benefit to Washington ground squirrel habitat. Proposed activities that would result in habitat loss or degradation may affect, and are likely to adversely affect the Washington ground squirrel.

**Table 15: Summary of Habitat Impacts for Proposed Range Enhancements at NWSTF Boardman**

| Range Enhancement and Ecological Condition Classification of Affected Habitat | Permanent Habitat Loss (acres) | Long-term Habitat Degradation (acres) | Total (acres) |
|---|---|---|---|
| **Multi-Purpose Machine Gun Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 8 | 193 | 201 |
| Medium-low | 8 | 6 | 14 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 20 | 20 |
| Subtotal | 16 | 219 | 235 |
| **Eastern Convoy Live Fire Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 12 | 12 |
| Medium | 0 | 272 | 272 |
| Medium-low | 0 | 27 | 27 |
| Low | 0 | 9 | 9 |
| Unclassified | 0 | 20 | 20 |
| Subtotal | 0 | 340 | 340 |
| **Western Convoy Live Fire Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 5 | 5 |
| Medium | 0 | 146 | 146 |
| Medium-low | 0 | 14 | 14 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 63 | 63 |
| Subtotal | 0 | 228 | 228 |
| **Demolition Training Range** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 1 | 0 | 1 |
| Medium-low | 0 | 0 | 0 |
| Low | 0 | 0 | 0 |
| Unclassified | 0 | 0 | 0 |
| Subtotal | 1 | 0 | 1 |
| **Unmanned Aerial Systems Airfield and Maintenance Facility and Range Operations and Control Center** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 0 | 0 |
| Medium | 0 | 0 | 0 |
| Medium-low | 0 | 0 | 0 |
| Low | 8 | 1 | 9 |
| Unclassified | 0 | 0 | 0 |
| Subtotal | 8 | 1 | 9 |
| **Total for All Range Enhancements** | | | |
| High | 0 | 0 | 0 |
| Medium-high | 0 | 17 | 17 |
| Medium | 9 | 611 | 620 |
| Medium-low | 8 | 47 | 55 |
| Low | 8 | 10 | 18 |
| Unclassified | 0 | 103 | 103 |
| Total | 25 | 788 | 813 |

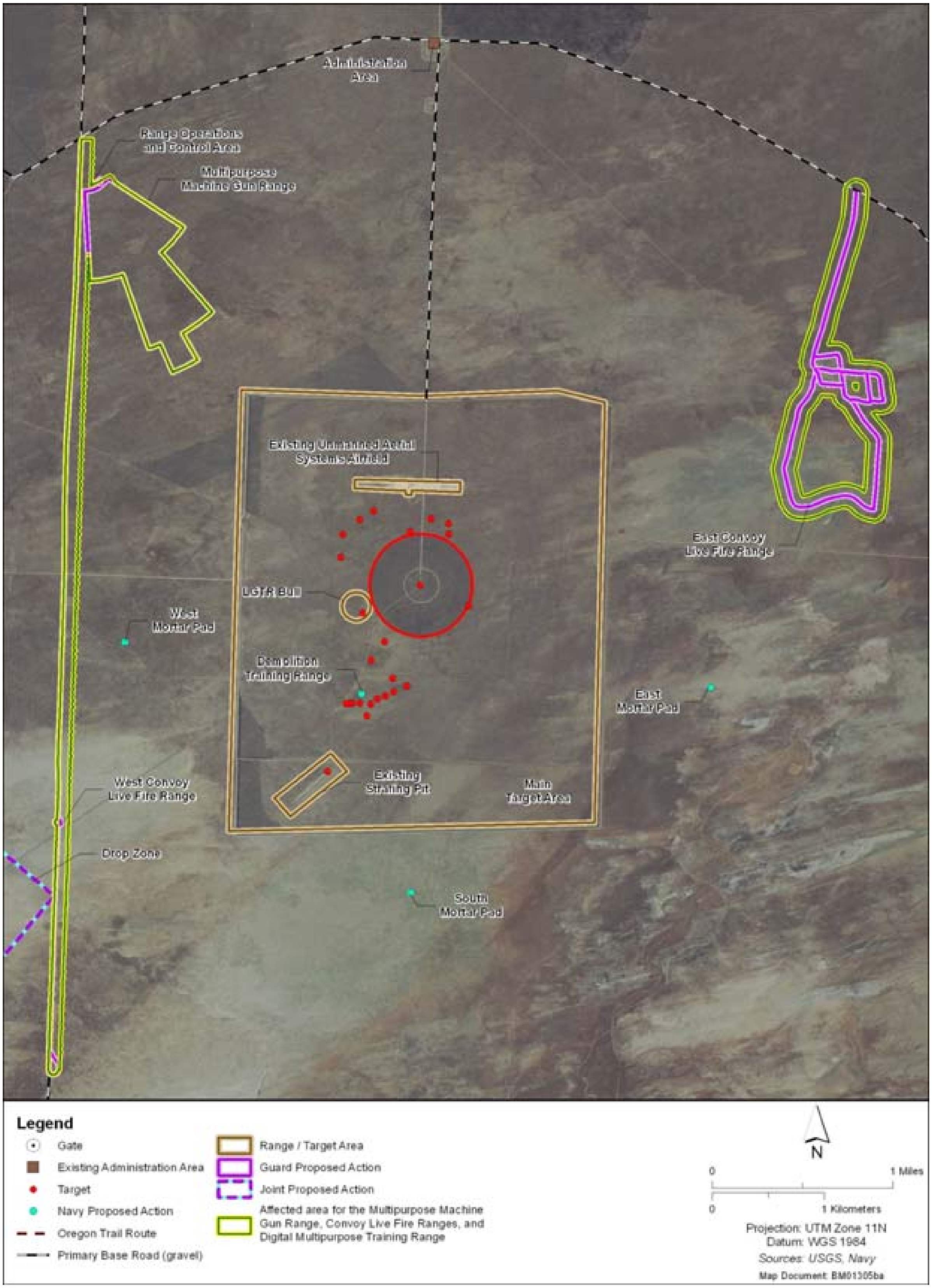


**Figure 15: Area of Habitat Affected by the MPMGR and CLFR**

## 5.4 Physical Strikes

### 5.4.1 Non-explosive Practice Munitions Strikes

Various types of non-explosive practice munitions (e.g., bullets and practice bombs) would be fired at or dropped on targets (Table 4, Table 5, and Table 6) under the Proposed Action. Most projectiles would make contact at or near the designated target, with an occasional round landing within the larger surface or weapons danger zones. A Washington ground squirrel could be struck and killed in the unlikely event that the animal was at the point of physical impact at the time of projectile delivery.

Portions of the Main Target Area are highly disturbed from decades of use. Nonetheless, Washington ground squirrels have been detected in the area. Vegetation around target emplacements in the Main Target Area, where most projectiles would make contact, is periodically maintained by disking or plowing for fire safety and to provide visual cues to pilots. Vegetation around targets on the MPMGR and CLFRs would not be disked, but some level of habitat disturbance would result from projectile impacts. Washington ground squirrels are less likely to use these disturbed areas, reducing the likelihood of a strike. Noise is associated with non-explosive practice munitions use and a noise event often occurs prior to weapons firing. For example, pilots fly over the target area to make safety checks before dropping or firing ordnance during air-to-ground bombing and gunnery exercises. Squirrels might flee the immediate area or take cover underground in response to the fly over, reducing the likelihood of a strike. In addition, other weapons firing exercises take place in a deliberate progression, with target placement being followed by a few initial shots, after which feedback is obtained before firing the next series of shots. Again, the likelihood of a strike might be reduced by squirrels responding to the initial stages of an exercise. Also, the likelihood of a relatively small projectile and an animal co-occurring in time and space within the target area is low. Based on these factors, the risk of non-explosive practice munitions striking a Washington ground squirrel would be low. If strikes did occur, a limited number of individuals would be affected, and no population-level effects would be expected. For compliance purposes, the Navy and ORNG estimate that up to six Washington ground squirrel incidental mortalities could occur per year from a combination of non-explosive practice munitions strikes and vehicle strikes. As discussed in Section 7, range control personnel would inspect the target areas at the conclusion of a firing exercise to record and report any mortality. Non-explosive practice munitions strikes under the Proposed Action may affect, and are likely to adversely affect the Washington ground squirrel.

### 5.4.2 Vehicle and Equipment Strikes

Vehicle and equipment use at NWSTF Boardman would increase substantially under the Proposed Action during ground-based training events and during construction. During training activities, vehicles and military equipment would be driven on existing roads or new gravel roads constructed under the Proposed Action. No off-road maneuver training is proposed. Maximum travel speeds would be limited during training, but the potential exists for Washington ground squirrels to be struck along roads used during training. During construction, vehicle use would be confined to existing roads to the extent possible, but construction equipment would require access to off-road areas to accomplish the work. The potential for squirrel strikes also exists during fire break and target maintenance activities. As discussed in Section 5.3.4, fire break maintenance activities would decrease substantially under the Proposed Action. The following measures would be implemented to avoid and minimize the risk of strikes:

- Washington ground squirrel locations would be identified during pre-construction surveys and monitoring would be conducted during construction to avoid strikes by construction equipment.

- Data from long-term Washington ground squirrel monitoring would be used, in part, to identify areas along heavily traveled roads and maintained fire breaks where squirrel encounters would be most likely. This information would be used to increase awareness and vigilance of range users and equipment operators.
- On NWSTF Boardman, to improve vehicle operation safety, be protective of wildlife, and reduce dust emissions, the vehicle speed limit for the range is 25 mph unless otherwise posted; however, emergency situations, operational necessities and certain training events may require vehicle speeds to exceed this standard speed limit. At all times on the range, vehicle operators shall use extreme caution and operate at a slow, safe speed consistent with the mission, safety, and current road and environmental conditions. Vehicle operators shall be cognizant and protective of pedestrians and wildlife while conducting all range activities.
    - The only road posted above 25 mph is the Admin Main road from the main gate access to the range from Bombing Range Road to the on-range road known as "The Interstate". Speed limit on the Admin Main Road is 30 mph.
    - It is not expected that training requirements will require speeds in excess of 25 mph on a routine basis; however in some training events, vehicles need to be able to react to changing tactical situations in training as they would in actual combat. Training differently than that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities. During these activities, the 25 mph speed limit may need to be exceeded for brief periods.

Although the risk of vehicles or equipment striking a Washington ground squirrel cannot be eliminated, the measures listed above would minimize risk. If strikes did occur, a limited number of individuals would be affected, and no population level effects would be expected. For compliance purposes, the Navy and ORNG estimate that up to six Washington ground squirrel incidental mortalities could occur per year from a combination of non-explosive practice munitions strikes and vehicle strikes. As discussed in Section 7, range control personnel would inspect the training area, including target areas and heavily travelled roads, at the conclusion of a ground-based training exercise to record and report any mortality. Vehicle and equipment strikes may affect, and are likely to adversely affect the Washington ground squirrel under the Proposed Action.

## 5.5 ELECTROMAGNETIC RADIATION

Electromagnetic radiation is a form of environmental pollution that may impact wildlife in various ways depending on type of radiation, duration of exposure, and the species of the receiving animal. Effects on birds may include reduced nesting success (Fernie and Reynolds 2005, Balmori 2009) and various behavioral and physiological responses to electromagnetic fields (Fernie et al. 2000, Fernie and Bird 2001), such as disruption of normal sleep-wake cycles through interference with pineal gland and hormonal imbalance. Salford et al. (2003) and Marks et al. (1995) report various effects on mammals from electromagnetic exposure, including changes in alarm and aversion behavior, deterioration of health, reproductive problems, and changes in normal sleep wake patterns. Nishimura et al. (2010) reported response in lizards to low-frequency electromagnetic fields.

Experiments and field observations in these studies were based on continual and long-duration exposure. For instance, Balmori (2009) reports reduced bird activity (breeding and foraging) followed by extirpation within areas saturated with high microwave radiation (greater than 2 Volts/meter [V/m]). The same study reported anomalies in magpies (*Pica pica*), such as plumage deterioration, limps and deformities in limbs, partial albinism. In another study by Balmori and Halberg (2007), significant declines of house sparrow densities were observed in areas of high electromagnetic field strength. The study predicted that no sparrows would be expected in an electromagnetic field of greater than 4 V/m of long-term constant exposure.

Various forms of electromagnetic sources are used at NWSTF Boardman including radar, threat emitters, communications equipment, and electronic detection equipment, primarily during electronic combat training events. The likelihood of a Washington ground squirrel being exposed to a harmful dose of electromagnetic radiation is extremely low for the following reasons: (1) the sources of electromagnetic radiation are used at high altitudes in the NWSTF Boardman airspace or the source is directed into the airspace and (2) the sources of electromagnetic radiation would not expose squirrels to constant radiation; in other words, no area of NWSTF Boardman would be continuously saturated with electromagnetic fields. Electromagnetic radiation may affect, but is not likely to adversely affect the Washington ground squirrel.

## 5.6 Lasers

Military uses of lasers include applications such as target designation and ranging, defensive countermeasures, communications, and directed energy weapons. Targeting and ranging lasers are the only laser applications used during training and testing on the ground at NWSTF Boardman and within the airspace. These platforms and devices are described in Section 2, Description of Proposed Action. Target designation and ranging laser types are relatively low power lasers (compared to directed energy lasers or lasers used for defensive countermeasures). A targeting laser is a low-power laser pointer used to indicate a target for a precision-guided munition, typically launched from an aircraft. The guided munition adjusts its flight-path to home in to the laser light reflected by the target, enabling a great precision in aiming. The beam of the laser target designator is set to a pulse rate that matches that set on the guided munition to ensure munitions strike their designated targets and do not follow other laser beams which may be in use in the area (Northrop-Grumman 2010). The laser designator can be shone onto the target by an aircraft or ground-based personnel. Lasers used for this purpose are usually infrared lasers, so the enemy cannot easily detect the guiding laser light.

Vision damage is the primary concern for wildlife species for the lasers used at NWSTF Boardman. Most studies of the effects of lasers on terrestrial animals involve birds because of the interest in developing deterrents to minimize bird-aircraft strike hazards at airports and wind developments (Baxter 2007, Burton et al. 2011). Fewer studies are available for other species groups, such as terrestrial mammals and reptiles, but the same range of responses (none to avoidance behavior) are expected.

Lustick (1973) conducted an experiment using pulsing light, which indicated that starlings and gulls were able to look directly into the laser beam and not change their behavior. A later study conducted through the National Wildlife Research Center's Mississippi Field Station demonstrated that there was no eye damage to double-crested cormorants (*Phalacrocorax auritus*) that had been exposed to a moderate-power red laser as close as 3 ft. (0.9 m) (Glahn et al. 2000). Furthermore, the bird eye is protected from thermal damage to retinal tissue associated with concentrated laser radiation (U.S. Department of Agriculture 2003).

For several decades, pulsing light has been used on aircraft, aircraft hangers, and high towers as a means of avian management or bird control. In 2001, the U.S. Department of Agriculture's National Wildlife Research Center conducted research on low- to moderate-power, long-wavelength lasers (630–650 nanometers) as an effective, environmentally safe means of dispersing specific bird species under low-light (sunset to dusk) conditions (Blackwell et al. 2002). Results of the U.S. Department of Agriculture research concluded that waterfowl species, wading birds, gulls, vultures, and American crows (*Corvus brachyrhynchos*) have all exhibited avoidance of laser beams during field trials (Blackwell et al. 2002, U.S. Department of Agriculture 2003). However, avoidance reaction times and duration are dependent upon context and species (Blackwell et al. 2002). In general, diurnal birds (active during the day and resting during the night) are not sensitive to extremely intense laser light and elicit a slow avoidance response to lasers. In contrast, nocturnal birds (active during the night and resting during the day) are more sensitive to light and react more quickly to avoid intense light (Blackwell et al. 2002). Blackwell and Bernhardt (2004) found that the avoidance response to pulsed white and wavelength-specific aircraft-mounted light was inconsistent across experiments with cowbirds (*Molothrus* spp.), and there was little or no avoidance behavior in experiments with other species. Also, some studies on the use of lasers for bird control have shown that birds may become habituated to light quickly, and there is a loss of effect as the distance increases from the bird and the laser (U.S. Department of Agriculture 2003).

Laser guided munitions are used during Air-to-Ground Bombing Exercises within the Main Target Area. There are 133 events of this type per year, but only 20 laser guided bombs are allocated for use (Table 4, Table 5, and Table 6). Lasers used at NWSTF Boardman and in the airspace would be similar to the moderate-powered lasers from the studies cited above, and therefore no damaging effects on vision would be anticipated.

A Washington ground squirrel may experience a detectable response to a laser beam, but would recover after the exposure. The fitness of individual animals would not be affected by this temporary effect (the duration of the laser beam directly sighted on an animal's eyes) from lasers. The use of lasers may affect, but is not likely to adversely affect the Washington ground squirrel under the Proposed Action because any effects would be insignificant.

## 5.7 Soil Contamination

This section analyzes the potential effects of soil lead contamination on Washington ground squirrels. Some ammunition (5.56 mm, 7.63 mm, and .50 caliber tracer rounds) used in the Main Target Area and on the MPMGR and CLFRs contain lead. These projectiles would accumulate in soil over time and lead is constituent of concern because of its toxicity and its ability to persist in the environment (U.S. Army Environmental Center 1998).

Several factors influence the fate and transport of lead on a training range, including soil type, soil pH, annual precipitation rate, and topographic slope (U.S. Environmental Protection Agency 2005). Lead oxidizes when exposed to air and dissolves when exposed to acidic water or soil, but is generally insoluble and immobile under neutral or basic pH conditions (U.S. Environmental Protection Agency 2005). The corrosion products of lead bullets in soil environments consist primarily of hydrocerussite, which is relatively insoluble (Chen and Daroub 2002). However, Dermatas et al. (2004) demonstrated that, in the case of a lead bullet with a copper jacket, the presence of copper increased the solubility of lead significantly, due to a galvanic corrosion reaction. Lead and copper concentrations were highly elevated in surface soils at two small arms ranges on Fort Irwin, California, but quickly decreased as a function of increasing depth from the ground surface. Despite the galvanic corrosion reaction, the mobility of both metals was significantly reduced within the first 10 to 20 in. (25.4 to 50.8 cm) below the surface. The limited mobility was attributed to the alkaline characteristics of the soils (pH 7.48 to 7.65 on one range and 8.03 to 8.30 on the other) and the formation of secondary minerals such as hydrocerussite (Dermatas et al. 2004).

Ideal soil pH for firing ranges is 6.5 to 8.5 because the lead precipitates out of solution and binds to the soil within this pH range (U.S. Environmental Protection Agency 2005). This binding effect prevents the lead from migrating to the subsurface. Koehler and Quincy soils are found within and around the Main Target Area. The proposed MPMGR would be constructed on Koehler and Quincy soils, with pH values in the range of 7.3 to 7.9. The eastern CLFR would be sited on Koehler, Quincy, Royal, Ellum, and Sagehill soils, with pH values in the range of 7.2 to 7.9. Lead precipitates out of solution and binds to the soil within these pH ranges, preventing or limiting migration to the subsurface (Dermatas et al. 2004, U.S. Environmental Protection Agency 2005). Lead mobility would also be limited by the low annual precipitation rate at NWSTF Boardman (9 to 11 in. per year [23 to 28 cm]). Lead would weather slowly under these arid conditions because it would have limited contact with water. Low precipitation coupled with the flat terrain also makes it unlikely that lead would be transported outside the immediate target area by stormwater runoff (U.S. Environmental Protection Agency 2005).

Spent projectiles and projectile fragments would accumulate over time in the vicinity of targets. Lead concentrations in surface soils would be expected to increase as the projectiles slowly corrode. Washington ground squirrels could be exposed to lead via the following pathways:

- Incidental ingestion of lead-contaminated soils while foraging or grooming
- Ingestion of plant materials covered in lead-contaminated soil dust
- Ingestion of plant materials that have accumulated lead from the soil
- Inhalation of lead-contaminated dust
- Incidental ingestion of projectile fragments

# 6 CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 (Interagency Cooperation on the ESA of 1973, as amended): "…those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." Reasonable foreseeable future federal actions and potential future federal actions that are unrelated to the proposed action are not considered in the analysis of cumulative effects because they would require separate consultation pursuant to Section 7 of the ESA. Cumulative effects are usually viewed as those effects that impact the existing environment and remain to become part of the environment. These effects differ from those that may be attributed to past and ongoing actions within the area since they are considered part of the environmental baseline.

The effects analyses of biological opinions considered the "impacts" on listed species and designated critical habitat that result from the incremental impact of an action by identifying natural and anthropogenic stressors that affect endangered and threatened species throughout their range (the Status of the Species) and within an Action Area (the Environmental Baseline, which articulate the pre-existing impacts of activities that occur in an Action Area, including the past, contemporaneous, and future impacts of those activities). We assess the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation by adding their direct and indirect effects to the impacts of the activities we identify in an Environmental Baseline (50 CFR 402.02), in light of the impacts of the status of the listed species and designated critical habitat throughout their range; as a result, the results of our effects analyses are equivalent to or less than those contained in the "cumulative impact" sections of NEPA documents.

The direct and indirect impacts of the Proposed Action were reviewed to identify impacts that are relevant to the cumulative impact analysis. Key factors considered include the current status and sensitivity of the resource and the intensity, duration, and spatial extent of the impacts for each training or testing activity. In general, long-term rather than short-term impacts and widespread rather than localized impacts were considered more likely to contribute to cumulative impacts. For example, for biological resources, population-level impacts were considered more likely to contribute to cumulative impacts than were individual-level impacts. It should be noted that individual-level impacts could also contribute to cumulative impacts, albeit on a much longer time-scale. Negligible impacts were not considered further in the cumulative impacts analysis.

A list of other reasonably foreseeable future actions was compiled for NWSTF Boardman and surrounding areas based on the scoping process, communications with other agencies, state and local officials, a review of other military activities, literature review, and other available information. The combined impacts of all other actions, including the current aggregate impacts of past and present actions, were characterized and summarized. The incremental impacts of the Proposed Action were then "added to" the combined impacts of all other actions to describe the cumulative impacts that would result if the Proposed Action. The cumulative impact analysis considered additive, synergistic, and antagonistic impacts. A qualitative analysis was conducted in most cases based on the available information.

Table 16 lists the other actions and other environmental considerations that were identified for the cumulative impacts analysis and Figure 16 highlights each project's geographic relation to NWSTF Boardman.

**Table 16: Other Actions Identified for the Cumulative Impacts Analysis**

| Name of Action | Lead Agency or Proponent | Location | Timeframe |
|---|---|---|---|
| Leaning Juniper Wind Power Facility | Iberdrola Renewables, Inc. | Gilliam County | Past, Ongoing, Future |
| Montague Wind Power Facility | Iberdrola Renewables, Inc. | Gilliam County | Past, Ongoing, Future |
| Saddle Butte Wind Power Facilities | Saddle Butte Wind LLC | Morrow County and Gilliam County | Ongoing, Future |
| Baseline Wind Energy Facility | First Wind | Gilliam County | Future |
| Rock Creek Wind Power Facility | Rock Creek Wind Power, LLC | Gilliam County | Future |
| Echo Windfarms (eight built inside 5701) | Oregon Wind Farms, LLC | Morrow and Umatilla County | Past |
| Threemile Canyon Wind Farm | John Deere Wind Energy | Morrow County | Past, Ongoing, Future |
| Poplar Wind Farm | First Wind | Morrow County | Ongoing, Future |
| Perennial Wind Chaser Station | Perennial Power Holdings, Inc. | Umatilla | Future |
| Wheatridge Wind Energy Facility | Wheatridge Wind Energy, LLC | Morrow and Umatilla County | Future |
| Ward Butte Wind Farm | American Wind | Umatilla County | Future |
| Sullivan's Wind Farm (Horned Butte) | Invenergy | Gilliam County | Ongoing, Future |
| Butter Creek Projects (1-9) | Intelligent Wind Energy | Morrow and Umatilla County | Past, Ongoing, Future |
| Multi- Species Candidate Conservation Agreement – Habitat Conservation | Threemile Canyon Farms, Portland General Electric, The Nature Conservancy, and the Oregon Department of Fish and Wildlife | Morrow County | Past, Ongoing, Future |
| Implementation of INRMP | U.S. Navy | NWSTF Boardman | Past, Ongoing, Future |

## 6.1 IMPACTS OF THE PROPOSED ACTION THAT MIGHT CONTRIBUTE TO CUMULATIVE IMPACTS

The combined effects of noise, habitat loss and alteration, and general disturbance from human activities under the Proposed Action may have a significant impact on the Washington ground squirrel. Specific impacts include physiological and behavioral responses to noise or human activity, which could lead to reduced fitness of individuals and Washington ground squirrel population declines at NWSTF Boardman. Habitat loss and degradation would result from construction, training, and range maintenance activities. Noise levels that result in temporary or permanent abandonment of an area would also be considered as habitat loss or alteration.

## 6.2 IMPACTS OF OTHER ACTIONS

Other non-federal future actions that could impact wildlife include the various wind energy projects throughout the region, and reuse development at Umatilla Chemical Depot (UCD). The expected impacts may include temporary disturbance, habitat loss and degradation, habitat fragmentation, and incidental mortality.

Future development, consisting of the specific projects listed in Section 4.2, along with regional growth of urban areas and regional increases in wind development, would incrementally increase average sound levels during construction as well as during operation (e.g., wind turbines). Construction related to new development would result in short-term increases in daytime sound levels in the vicinity of those projects. In rural portions of Morrow, Gilliam, and Umatilla Counties, vehicle noise from increased traffic on local roads and regional highways would be the largest sources of increased noise. Daytime sound levels would likely increase more than nighttime sound levels. Substantial increases in sources of intrusive sound are not expected.

Johnson and Erickson (2011) evaluated the cumulative impacts of wind energy development projected to occur within the Columbia Plateau Ecoregion of eastern Washington and Oregon through 2015. Approximately 2,578 ac. (1,043 ha) of non-agricultural vegetation types, primarily grassland and shrub-steppe vegetation, would be lost in the Columbia Plateau Ecoregion to existing and proposed wind energy development through 2015. This loss of vegetation corresponds to a loss of wildlife habitat. Impact estimates for the other projects are not yet available. All of these projects are subject to established environmental planning and review processes. Therefore, it is expected that all of these projects will include measures to avoid and minimize impacts to wildlife, and restore wildlife habitat.

Several ongoing and future actions in the region would provide long-term benefits for shrub-steppe and grassland communities:

- The Multi- Species Candidate Conservation Agreement – Habitat Conservation is protecting and enhancing shrub-steppe and grassland communities at the Boardman Conservation Area adjacent to NWSTF Boardman. The Nature Conservancy is currently implementing a restoration plan for the Boardman Conservation Area, which includes eradicating invasive plants in degraded habitats and revegetating the areas with native plants.
- Implementation of the *NWSTF Boardman Integrated Natural Resources Management Plan* has and would continue to benefit native plant communities by controlling invasive plants, conducting restoration activities, and inventorying and monitoring plant communities on NWSTF Boardman. The Plan includes co-operative management of the Research Natural Areas on NWSTF Boardman by The Nature Conservancy and the Navy, and would be updated if the new ranges were built.
- The possible establishment of a wildlife refuge on the UCD as part of the Redevelopment Plan would protect approximately 5,613 ac. (2,272 ha) of shrub-steppe and grassland communities.
- Continued management of lands at the Lindsay Prairie Preserve by The Nature Conservancy would protect and enhance shrub-steppe and grassland communities.
- Continued management of lands at the Horn Butte Area of Critical Environmental Concern by the Bureau of Land Management would protect and enhance shrub-steppe and grassland communities.

The ongoing and future actions listed above that would provide long-term benefits for shrub-steppe and grassland communities would also benefit wildlife. Additional ongoing and future natural resources management activities on NWSTF Boardman would provide long-term benefits for shrub-steppe and grassland communities through invasive plant control and restoration. Proposed mitigation measures under would include restoring native plant communities in the southern portion of NWSTF Boardman, relocating Research Natural Area A to one or more appropriate locations, and modifying the fire break system.

Future actions outside the boundaries of NWSTF Boardman are expected to impact shrub-steppe and grassland communities in the vicinity of NWSTF Boardman and in the region. Sufficient information is not available to make conclusions regarding the significance of impacts associated with other actions. However, it is expected that other future actions would affect a relatively small percent of shrub-steppe and grassland communities in the Columbia Plateau Ecoregion (approximately 1.5 million ac. [Kagan et al. 2000]). Impacts of the Proposed Action on vegetation would be additive to the impacts of other actions that would adversely affect shrub-steppe and grassland communities in the region; however, the contribution would be small when considered relative to other actions such as wind energy development, electrical transmission lines, and historical habitat conversion to agricultural lands.

## 6.3 Cumulative Impacts on Wildlife

Past actions have resulted in significant impacts on shrub-steppe and grassland communities in the Columbia Plateau Ecoregion. Corresponding significant impacts to wildlife populations occurred as these habitats were converted to agriculture, grazing, and other human uses. Wildfire and noxious weed and invasive plant infestations have also contributed to the impacts on wildlife.

Cumulative impacts of future actions on wildlife were considered in local (e.g., NWSTF Boardman and the contiguous Boardman Conservation Area) and regional (e.g., Columbia Plateau Ecoregion) contexts. Other than the Proposed Action, no actions that would result in adverse effects on wildlife are currently proposed formally on NWSTF Boardman.

Ongoing and future natural resources management activities on NWSTF Boardman, Boardman Conservation Area Lindsay Prairie Preserve, and Horn Butte Area of Critical Environmental Concern would protect and benefit wildlife in the region, including the Washington ground squirrel.

Future actions outside the boundaries of NWSTF Boardman, including wind energy projects and reuse development at UCD are expected to impact wildlife and wildlife habitat in the vicinity of NWSTF Boardman and in the region. Estimating the area of habitat that would be impacted by other actions is not possible based on available information. However, it is expected that wind energy projects would create small patches of permanently lost habitat. Complete loss of habitat functions and values would occur in these areas. Additionally, long-term habitat degradation, but not complete loss of habitat functions and values, is expected to occur in areas affected by temporary construction disturbance and general disturbance caused by increased human activity. The spatial extent of habitat impacts associated with these stressors cannot be fully quantified. Quantifying the population-level effects of these habitat impacts is not possible given the current limited knowledge of Washington ground squirrel population dynamics. While squirrel numbers could decline in response to lost and degraded habitat, the area affected would be relatively small compared to the total habitat available. Proposed activities that would result in habitat loss or degradation may affect the Washington ground squirrel.

Impacts of the Proposed Action on the Washington ground squirrel would be additive to the impacts of other actions that would adversely affect squirrel communities in the region; however, the contribution would be small when considered relative to other actions such as wind energy development, electrical transmission lines, and historical habitat conversion to agricultural lands. Additionally, with the implementation of management practices, monitoring, and mitigation measures, the contribution to overall impacts would be reduced.

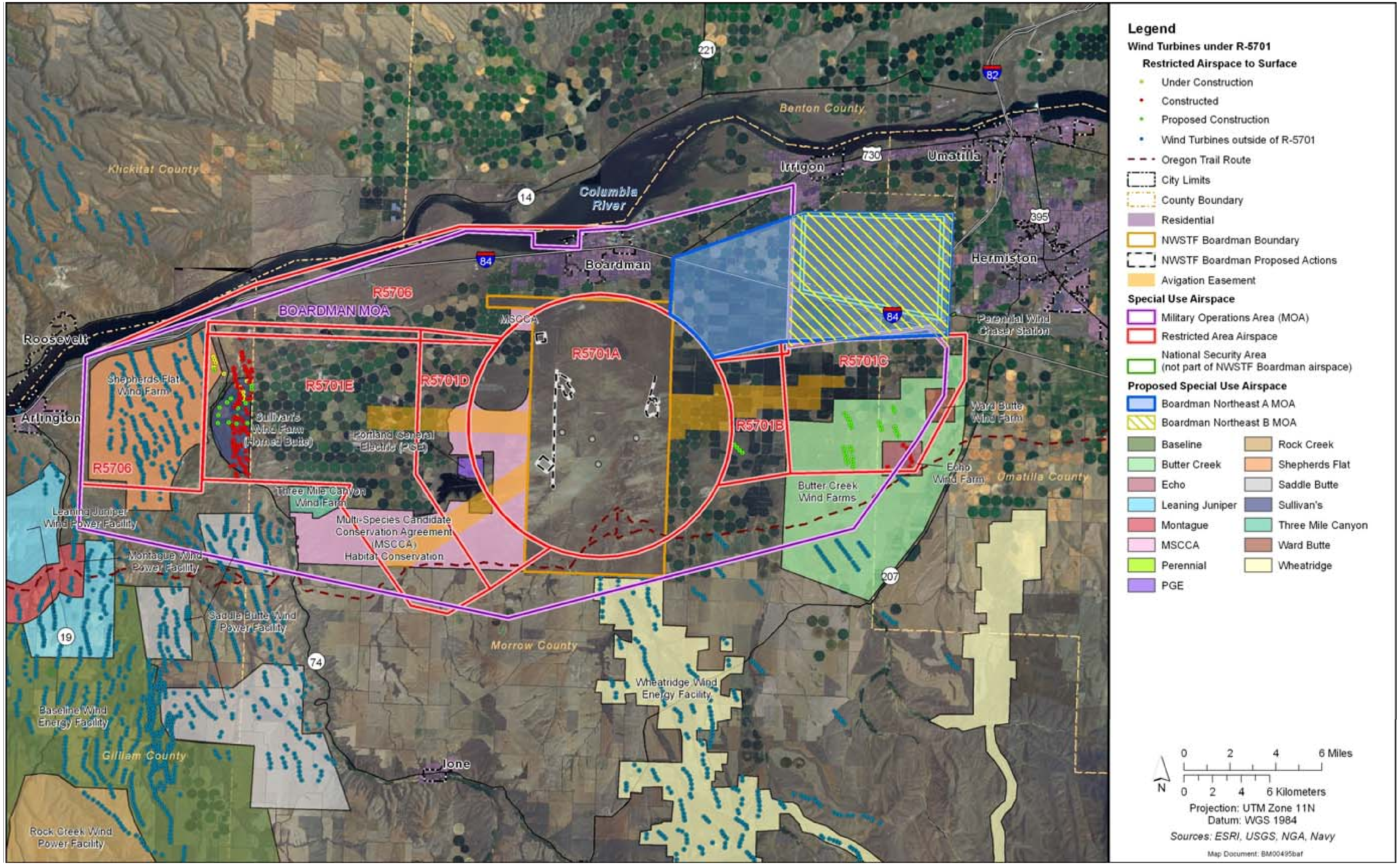


**Figure 16: Locations of Other Actions and Other Environmental Considerations Identified for the Cumulative Impacts Analysis**

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# 7 MANAGEMENT PRACTICES, MONITORING, AND MITIGATION MEASURES

## 7.1 INTRODUCTION

The Navy and ORNG incorporate measures that are protective of the environment into all of their activities. Environmental Management Systems provide a formal management framework to help achieve environmental goals through repeatable and consistent control of operations. Compliance with environmental regulations and associated DoD, Navy, and ORNG policies is accomplished through a variety of well-established programs and related plans, processes, and procedures. The intention of mitigation is to reduce the adverse effects of an action on the environment, utilizing one of the five following methods:

- Avoiding the impact altogether
- Minimizing impacts
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

The process of identifying ways to reduce potential environmental effects of the Proposed Action started early in planning process for the proposed range enhancements and will continue through discussions with the USFWS and ODFW. For example, sensitive resources were identified during development of conceptual plans for the proposed range enhancements, and the proposed ranges were sited to avoid sensitive resources and reduce surface disturbance and site development requirements to the extent possible. In addition, several existing Navy and ORNG environmental programs and plans include established procedures, practices, or management actions that would avoid, minimize, or rectify potential impacts of the Proposed Action. In accordance with DoD, Navy, and ORNG policies, these plans are reviewed and revised on a regular basis and would be updated to reflect changes at NWSTF Boardman if the Proposed Action were implemented.

Accordingly, impact avoidance, minimization, and rectification measures are addressed in this conferencing package within the framework of existing Navy and ORNG environmental programs and plans, where appropriate. For the purposes of this conferencing package, measures that avoid, minimize, or rectify potential impacts are referred to as proposed BMPs. Where appropriate, BMPs would be incorporated into construction contracts to facilitate implementation. The Navy and ORNG also currently employ standard practices or standard operating procedures (SOPs) to provide for the safety of personnel and equipment, as well as the success of the training and testing activities. In many cases SOPs result in incidental environmental, socioeconomic, and cultural benefits, but they serve the primary purpose of providing for safety and mission success, and are implemented regardless of their secondary benefits. Implementation of both BMPs and SOPs has been considered in the analysis presented in Section 5, Effects of the Action.

If the analyses in Section 5 indicated that potential impacts could not be avoided, minimized, or rectified to an acceptable level by implementing BMPs, additional measures were developed to reduce or eliminate the impact over time or compensate for the impact by replacing or providing substitute resources or environments. These additional measures are referred to as proposed mitigation measures in this conferencing package.

The Navy and ORNG also propose an adaptive management and monitoring process to help reduce uncertainty associated with the anticipated effects of the action and the anticipated effectiveness of the proposed BMPs and mitigation measures. Adaptive management is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process (Williams et al. 2009). The *NWSTF Boardman INRMP* currently provides a mechanism to adaptively manage natural resources cooperatively with USFWS and ODFW. If a decision is made to implement the Proposed Action, commitments to fund and implement specific BMPs, mitigation measures, and an adaptive management process would be made in the Record of Decision. As each individual proposed action is funded and constructed, mitigation measures and adaptive management of the area involved with the proposed action would be implemented. The INRMP would continue to provide the overall management structure for implementing adaptive management. After the Record of Decision is signed, the INRMP would be updated to include applicable commitments made in the Record of Decision, including monitoring and mitigation. The INRMP would continue to be reviewed and updated annually through natural resources metrics meetings with USFWS, ODFW, and other stakeholders. This process will help to ensure that a comprehensive and consistent approach to adaptive management and monitoring is accomplished for the entire NWSTF Boardman property.

## 7.2 Proposed Best Management Practices

The current management practices contained in the *NWSTF Boardman INRMP* and other applicable plans would continue to be implemented, and existing programs and plans would be updated to reflect new conditions. The following additional BMPs would be implemented to avoid and minimize potential impacts under the Proposed Action:

- Applicable erosion control measures would be implemented during construction to avoid and minimize the potential for wind and water erosion in accordance with the Oregon Department of Environmental Quality *Erosion and Sediment Control Manual* (Oregon Department of Environmental Quality 2005).
- Drip pads would be placed under equipment when parked to avoid soil contamination from leaking fluids.
- Under the Navy's Range Sustainability Environmental Program Assessment (RSEPA), Range Condition Assessment 5-year Reviews would continue to be conducted and appropriate steps would be taken to analyze environmental conditions on the range and to prevent or respond to a release or substantial threat of a release of munitions constituents of potential concern to off-range areas that could pose risks to human health or the environment. RSEPA focus would be expanded to incorporate new range activities and new training areas under periodic assessments.
- Assessments would be conducted for the MPMGR and both CLFRs in accordance with the Army's Operational Range Assessment Program. These assessments would first determine qualitatively if munitions constituents were leaving the operational range footprint and whether pathways exist for human or ecological receptors. A quantitative assessment would be conducted if the qualitative assessment were inconclusive. The assessments would be conducted on a 5-year review cycle, even if the initial qualitative assessment identified no issues. In addition, ORNG would proactively manage the new ranges using applicable strategies outlined in the *Army Small Arms Training Range Environmental Best Management Practices Manual*.

- Surveys would be conducted during the project design phase to identify existing habitat, evaluate habitat quality, and identify wildlife currently using these habitats. This information would be used during project design to support micrositing decisions. Areas of higher quality habitat (e.g., undisturbed areas with a relatively high percentage of native plant cover) or high wildlife use (e.g., existing Washington ground squirrel burrows) would be avoided in favor of areas of lower quality habitat (e.g., disturbed areas with a relatively high percentage of non-native plant cover), to the extent practicable. Micrositing efforts would be limited to buildings and structures, as opposed to targetry or other range components, because even minor changes to the range design could affect the associated surface danger zone or impact range safety in other ways. The survey data would also be used to support post-construction restoration efforts.
- Habitat temporarily disturbed during construction would be restored in accordance with the proposed post-construction restoration plan (Appendix A). The restoration plan would be implemented by the ORNG in accordance with the Host-Tenant Agreement and Inter-Service Agreement that would be updated prior to implementing the proposed action.
- The management practices contained in the NWSTF Boardman INRMP and other applicable plans that are relevant to WGS conservation would continue to be implemented. Invasive plants would continue to be managed and controlled under the *NWSTF Boardman INRMP*, with an increase in control effort to reflect new threats introduced by the Proposed Action. The Plan would be updated in cooperation with ORNG, USFWS, ODFW, and The Nature Conservancy during routine annual reviews to reflect the evolving invasive plant management situation associated with construction and operation of the new ranges. Updates to the Plan would include provisions for short- and long-term monitoring of invasive plants; responsibilities and procedures for integrating efforts of the Navy, ORNG, and The Nature Conservancy; criteria for prioritizing management actions and adaptive management strategies to control invasive plants; and annual work plans, including funding requirements and funding sources. After range becomes operational, qualitative surveys would be conducted annually within the range footprint to detect noxious weeds (Morrow County list of noxious weeds) within the identified affected areas. The purpose of these surveys is to detect noxious weeds so that they can be controlled immediately, most likely through targeted application of a glyphosate herbicide. Surveys would continue indefinitely, and controls would be implemented as necessary.
- The NWSTF Boardman Draft Integrated Wildland Fire Management Plan (Appendix H of the DEIS) would be finalized and implemented. In addition to other fire protection measures, the Plan includes proposed modifications to the existing system of fire breaks. The width of some fire breaks would be reduced to the width of the adjacent road, some fire breaks that do not follow roads would be eliminated, and some new fire breaks would be created. The total area of fire breaks that would be maintained annually by mechanical disturbance (plowing or disking with a tractor) would decrease from 462 ac. (187 ha) to 243 ac. (98 ha). A long-term re-vegetation plan (Appendix A) would be implemented to restore the areas removed from mechanical maintenance. These areas would be re-vegetated with native bunchgrasses, primarily Sandberg's bluegrass with some needle and thread or bluebunch wheatgrass, to provide a low-structure and low-fuel load area next to the road/fire break, and also to provide wildlife habitat value. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80 percent density of a representative bunchgrass stand area within 2 to 3 years of seeding. Selective herbicide treatments or other appropriate management actions would be used to control invasive plants until these areas are completely restored.

- As part of the *NWSTF Boardman INRMP*, the Navy, in cooperation with The Nature Conservancy, is proposing to relocate RNA-A to a more suitable location. Three RNAs were established on NWSTF Boardman in 1978 and are co-managed by The Nature Conservancy under a Memorandum of Understanding with the Navy. The RNA program was created to (1) preserve examples of all significant natural ecosystems for comparison with those influenced by man, (2) provide educational and research areas for ecological and environmental studies, and (3) preserve gene pools of threatened and endangered plants and animals. RNA-A encompasses the Main Target Area at NWSTF Boardman, which must be used and maintained to meet mission requirements. Portions of the Main Target Area are highly disturbed by military use. While the rationale for originally establishing RNA-A within the Main Target Area appears to have been in part based on its isolation from cattle grazing, it has become clear that this area is not functioning as an RNA and is not providing the intended scientific and educational benefits of an RNA. Therefore, the Navy, in coordination with The Nature Conservancy, is proposing to relocate RNA-A to one or more suitable locations on NWSTF Boardman. The new RNA would be sited to avoid possible conflicts with military activities, and the new location would be more representative of the unique habitat types RNAs are designed to protect. Similar to existing RNA-B and RNA-C, access to the relocated RNA would normally be limited to research activities, invasive plant control, and emergency response. The Washington ground squirrel, as well as other wildlife species and wildlife habitat, would benefit from the increased protection and management provided by relocating RNA-A to a more suitable location.
- Explosive demolition training is not normally planned to occur in the June to September time frame to help mitigate wildland fire potential, though seasonal conditions and training times may vary.
- DTR training includes additional BMPs to help reduce noise levels for training with charges greater than 100 lbs (45.4 kg) NEW. These could include: training during times with optimal weather conditions to attenuate noise, burying the explosive charge, or bunkering the charge with sand bags.
- On NWSTF Boardman, to improve vehicle operation safety, be protective of wildlife, and reduce dust emissions, the vehicle speed limit for the range is 25 mph unless otherwise posted; however, emergency situations, operational necessities and certain training events may require vehicle speeds to exceed this standard speed limit. At all times on the range, vehicle operators shall use extreme caution and operate at a slow, safe speed consistent with the mission, safety, and current road and environmental conditions. Vehicle operators shall be cognizant and protective of pedestrians and wildlife while conducting all range activities.
    - The only road posted above 25 mph is the Admin Main road from the main gate access to the range from Bombing Range Road to the on-range road known as "The Interstate". Speed limit on the Admin Main Road is 30 mph.
    - It is not expected that training requirements will require speeds in excess of 25 mph on a routine basis; however in some training events, vehicles need to be able to react to changing tactical situations in training as they would in actual combat. Training differently than that which would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities. During these activities, the 25 mph speed limit may need to be exceeded for brief periods.

## 7.3 PROPOSED MITIGATION MEASURES

### 7.3.1 INTRODUCTION

The proposed BMPs described above would be implemented to avoid, minimize, and rectify impacts on natural resources. Nonetheless, the analysis presented in Section 5, Effects of the Action, indicates that the Proposed Action would result in unavoidable impacts on historically occupied Washington ground squirrel habitat. This section provides the mitigation framework to compensate for these unavoidable impacts. The mitigation goal is no net loss of habitat quantity or quality, and to provide a net benefit of habitat quantity or quality, which would be achieved through in-kind and in-proximity habitat restoration and enhancement.

Despite being one of the largest remaining blocks of predominantly native shrub-steppe and grassland habitats in Oregon's portion of the Columbia Plateau Ecoregion, non-native plant species invasions have degraded plant communities and wildlife habitat at NWSTF Boardman. Lightning-caused wildfire, historic livestock grazing, plowing, and other land uses have contributed to the spread of non-native plant species on NWSTF Boardman. Non-native plant species were identified as one of the greatest threats to the Boardman Grasslands (Kagan et al. 2000), because they replace native vegetation and degrade wildlife habitat.

In particular, cheatgrass (*Bromus tectorum*) is a serious threat because it alters natural fire regimes by creating more abundant and continuous fine fuels that can result in more intense, larger, and frequent fires. Intense fires that burn through high-quality native habitats can convert a diverse multi-story habitat of cryptogams, perennial grasses and forbs, and shrubs to a monoculture of cheatgrass and other invasive species that is difficult to reverse without active restoration (Elseroad 2007). Since 1998, more than 85 percent of NWSTF Boardman has been burned by wildfires, which have caused short- and long-term habitat alterations. Cheatgrass is a factor that has contributed to the intensity, size, and frequency of wildfire at NWSTF Boardman.

Restoring habitats on NWSTF Boardman that have been degraded by wildfire, non-native invasive plants, plowing, and other causes offers opportunities for in-kind and in-proximity habitat mitigation. Successful restoration or enhancement efforts on ample acreage at NWSTF Boardman could increase available native habitat for the Washington ground squirrel and other wildlife, decrease the frequency and intensity of wildfire, and improve long-term stability of the ecosystem, thus ensuring no net loss and a net benefit of habitat quantity and quality at NWSTF Boardman.

### 7.3.2 LOCATION OF MITIGATION SITES

Proposed habitat restoration activities would occur at selected locations on the southern portion of NWSTF Boardman, as well as other areas throughout the property that are currently maintained as fire breaks (see discussion of fire breaks above in Section 7.2, Proposed Best Management Practices). The NWSTF Boardman resource management area is identified in Figure 17. This area of the range consists of approximately 11,226 ac. (4,543 ha) and was selected for habitat restoration activities for the following reasons:

- This portion of NWSTF Boardman has not been used for ground-based military training activities since Navy ownership of the property in about 1960.
- None of the proposed range enhancements are sited in this area.
- Current and proposed military readiness activities are not expected to have significant impacts on natural resources in the area.

- Proposed habitat restoration activities in this area would be compatible with current and proposed military readiness activities. Long-term habitat mitigation goals could be pursued with no loss to military training or testing capabilities and capacity.
- The area offers opportunities for in-proximity mitigation because it is within the boundaries of NWSTF Boardman and has connectivity to habitats that would be affected by the Proposed Action.
- This southern portion of the range includes a mosaic of shrub-steppe and grassland habitats representing a range of ecological condition classes (e.g., low to high), offering opportunities to achieve ecological uplift through habitat restoration.
- Washington ground squirrels occur in the area and the Warden and Sagehill soils found in this area are thought to provide the most suitable burrowing habitat located on the range property. Therefore, ecological uplift achieved through native plant community restoration would benefit this species by improving forage quality, cover, and ecological stability (e.g., decrease in wildfire frequency and intensity).
- This t portion of NWSTF Boardman receives higher annual precipitation than the northern portions of NWSTF Boardman, which would facilitate native vegetation restoration activities.
- This area of the range is directly adjacent to the Boardman Conservation Area and to RNA-C (Figure 18). Proposed management activities would complement similar ongoing efforts on the Boardman Conservation Area and in RNA-C. The fact that these habitats are connected maximizes the cumulative benefits of management activities in these different areas.
- Habitat restoration activities in the resources management area would be consistent and compatible with the protection of historic sites and cultural resources in this part of the property.

In addition to the NWSTF Boardman resource management area, habitat restoration would occur in areas throughout the property that are currently maintained as fire breaks (Figure 13, also see discussion of fire breaks above in Section 7.2, Proposed Best Management Practices). The fire break areas available for restoration consist of 219 ac. (89 ha), which includes about 198 ac that would be outside areas affected by the Proposed Action. Restoration of the fire breaks is proposed to compensate for permanently lost habitat for the following reasons:

- The fire breaks have been maintained annually through mechanical disturbance and currently provide little value as Washington ground squirrel habitat. Therefore, the fire breaks provide a unique opportunity to “create” Washington ground squirrel habitat to compensate for permanently lost habitat. In addition, restoration of fire breaks would provide ecological uplift through reduced habitat fragmentation and reduced risk of invasive plant and noxious weed dispersal.
- The fire breaks would be amenable to aggressive restoration techniques because they are devoid of native vegetation and are easily accessible to restoration equipment. For example, pre-planting herbicide treatments could be applied to aggressively control invasive plants and restoration equipment could be used without unintended consequences to native plants.
- In addition to creating new foraging habitat by establishing native plants, a roller soil compactor would be used prior to planting to stabilize soil structure and speed recovery of burrowing habitat.

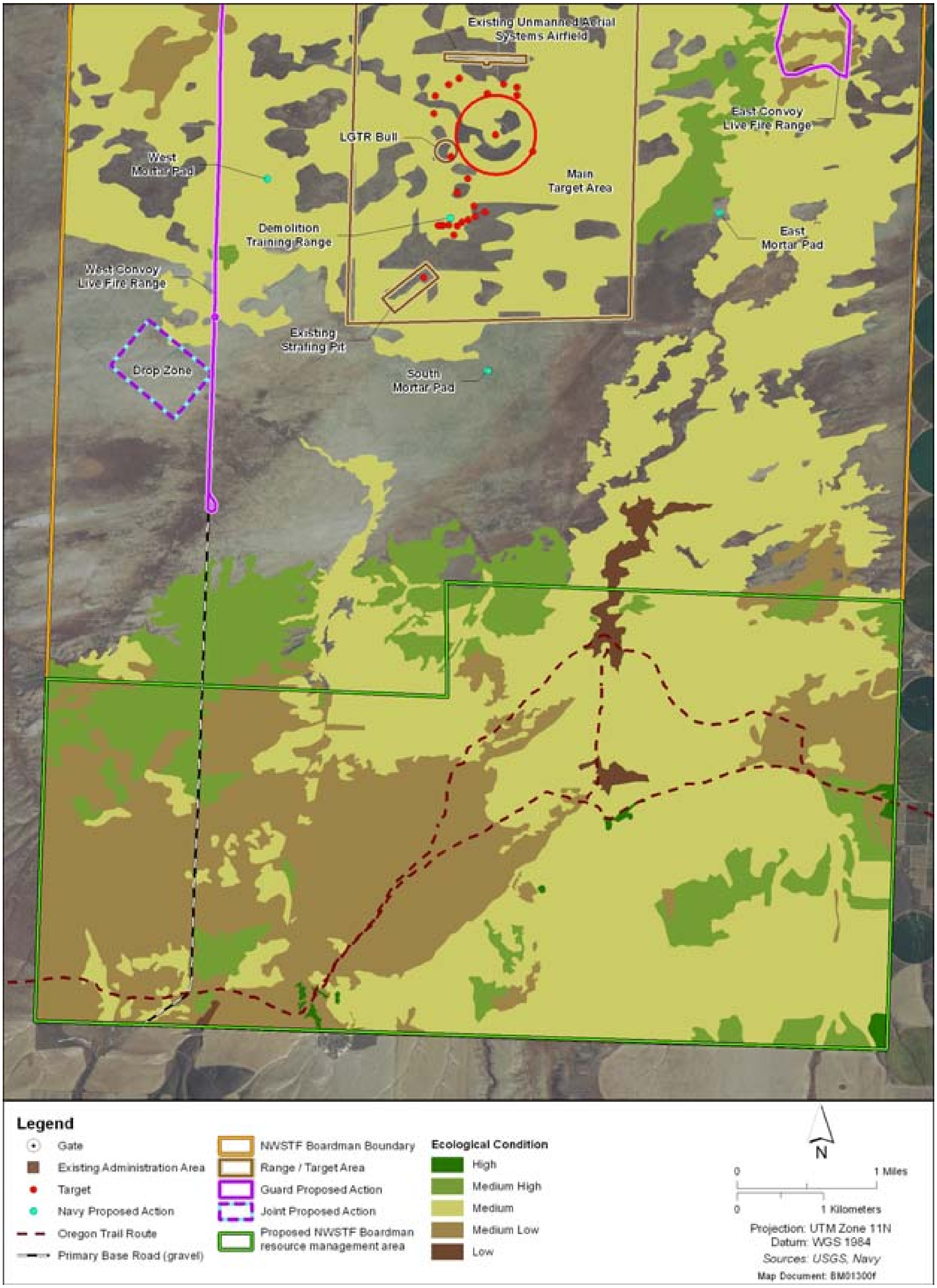


**Figure 17: Ecological Conditions in NWSTF Boardman Resource Management Area**

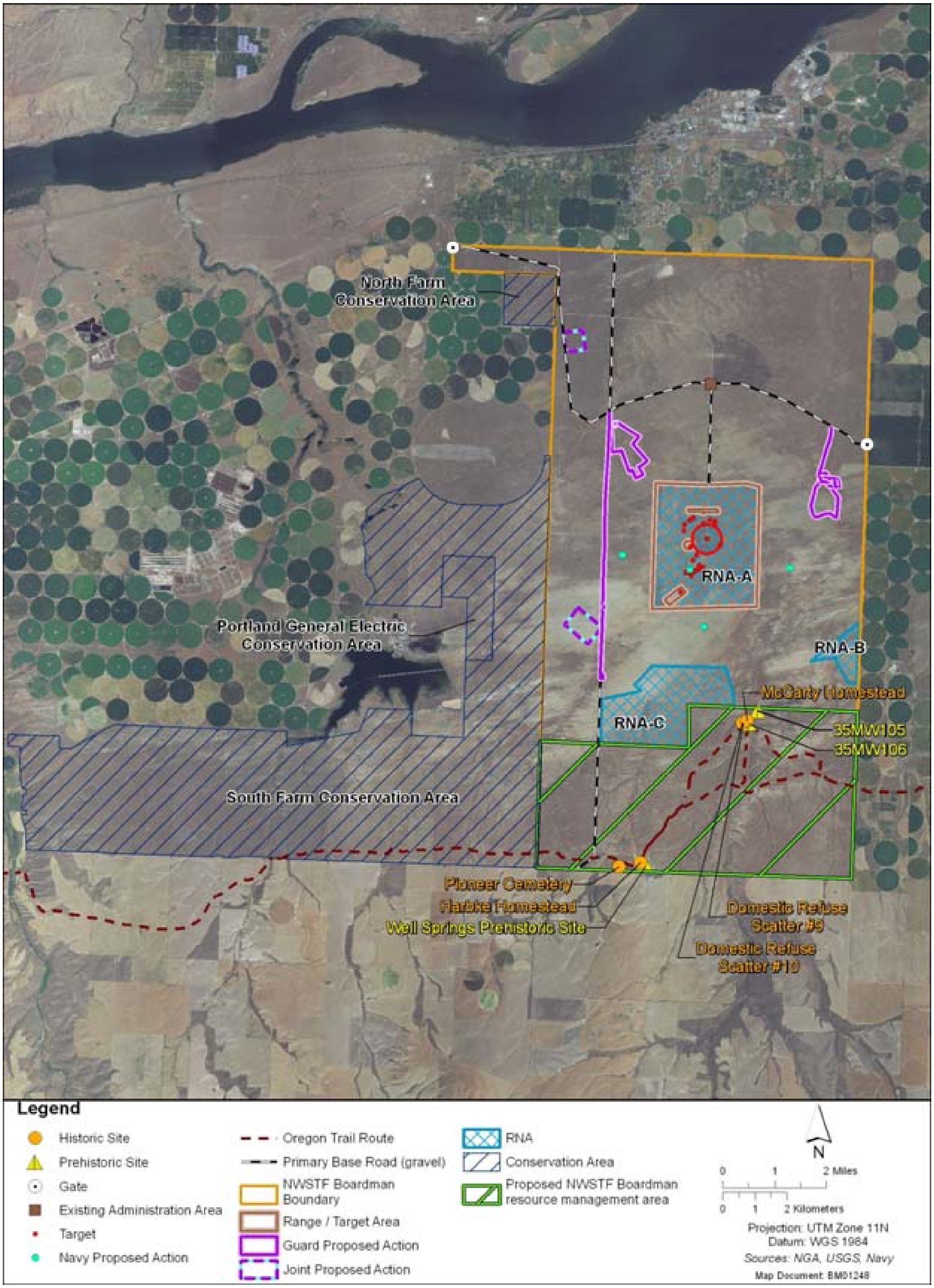


**Figure 18: Boardman Conservation Area, Research Natural Areas, and the Resource Management Area**

### 7.3.3 MITIGATION SITE TYPES

Mitigation sites within the NWSTF Boardman resource management area would be classified into the five categories listed in Table 2. These site categories have been adapted from those used at the Boardman Conservation Area (Elseroad 2007).

### 7.3.4 DESIRED FUTURE CONDITIONS

As discussed above, the mitigation goal is no net loss of habitat quantity or quality, and to provide a net benefit of habitat quantity or quality. Defining specific objectives for desired future habitat conditions provides a means for measuring success in achieving these goals. The resource management area includes a mosaic of shrub-steppe and grassland habitats representing a range of ecological condition classes (e.g., low to high) based on past disturbance. As noted by Elseroad (2007) for the Boardman Conservation, re-creating pre-disturbance conditions is unlikely given that large areas are degraded to some degree and because restoring these semi-arid systems in the presence of highly competitive non-native species will be difficult.

Restoration efforts at NWSTF Boardman would focus on: 1) reducing threats to existing high-quality native grassland and shrub-steppe and 2) increasing the proportion of native-dominated grassland and shrub-steppe by restoring degraded sites to the greatest extent possible (Elseroad 2007). Restoring the dominant grasses, forbs, and shrubs at degraded sites will provide the structure of the pre-disturbance plant communities, increase resistance to further weed invasion, and reduce the risk of high-intensity, frequent fires. Over time, if soil disturbance is minimized, cryptogamic soil crusts may slowly recover. Ideally, existing conditions can be improved such that the grassland and shrub-steppe systems can be self-sustaining with minimal management inputs and their ecosystem functions can be maintained within their historic range of variability (Elseroad 2007).

### 7.3.5 RESTORATION OBJECTIVES AND STRATEGIES BY SITE TYPE

As summarized in Table 17, proposed restoration objectives and strategies would vary based on the current conditions and likelihood of improving current conditions at a given site. Objectives for high-quality habitats will focus on maintaining current conditions by reducing threats from nearby degraded areas, while objectives in lower-quality habitats would focus on increasing the proportion of native species and controlling noxious weeds (Morrow County list of noxious weeds).

**Table 17: Restoration Site Types, Objectives, and Strategies for NWSTF Boardman**

| Site Type | Restoration Objectives | Restoration Strategy |
|---|---|---|
| High quality native grassland and shrub-steppe with low non-native species cover (high and medium-high ecological condition) | 1. Maintain current native plant and soil crust conditions<br>2. Maintain non-native species cover at or below baseline levels | 1. Within sites, control outbreaks of noxious weed as needed<br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire<br>3. Plant sage in burned areas previously dominated by sage. |
| Type 5 □Dominated by a diverse array of native plant species with high cheatgrass densities (medium ecological condition) | 1. Maintain or increase current native plant and soil crust conditions<br>2. Detect and control noxious weeds as necessary to maintain conditions | 1. Within sites, control noxious weeds by using herbicides<br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire |

**Table 17: Restoration Site Types, Objectivies, and Strategies for NWSTF Boardman (continued)**

| Site Type | Restoration Objectives | Restoration Strategy |
| --- | --- | --- |
| Type 4 Dominated by native shrubs with a low diversity of native herbaceous species (medium ecological condition) | 1. Maintain current native shrub conditions<br>2. Increase native perennial herbaceous plant density to provide uniform coverage of at least 80% of a representative bunchgrass stand within 3 years of initial restoration effort<br>3. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds<br>2. In adjacent degraded sites, plant native species and control noxious weeds to reduce spread and risk of high-intensity fire |
| Type 3 Burned area previously dominated by native shrubs and currently dominated by non-native annual plant species (medium-low ecological condition) | 1. Increase native shrub density to one seedling per square meter over a 10 square meter area in each seedling focus area with five focus areas per acre<br>2. Increase native perennial herbaceous plant density to provide uniform coverage of at least 80% of a representative bunchgrass stand within 3 years of initial restoration effort<br>3. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds |
| Type 2 Dominated by non-native annual plant species with a low diversity of native perennial species (medium-low ecological condition) | 1. Increase native perennial herbaceous plant density to provide uniform coverage of at least 60% of a representative bunchgrass stand within 3 years of initial restoration effort<br>2. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control noxious weeds |
| Type 1 Dominated by non-native annual plant species (low ecological condition) | 1. Increase native perennial herbaceous plant density to provide uniform coverage of at least 50% of a representative bunchgrass stand within 3 years of initial restoration effort<br>2. Detect and control noxious weeds annually for a minimum of 3 years following initial restoration efforts, continue as necessary to maintain conditions | 1. Within sites, plant native species and control weeds |

Source: Adapted from Elseroad (2007)

### 7.3.6 PRIORITIZATION OF RESTORATION SITES

Restoration efforts would first be allocated to priority 1 restoration sites, followed by priorities 2 through 8, as necessary, until the agreed-upon mitigation acreage requirements have been met. Priorities would be based on the plant species composition of the restoration site, its proximity to high or medium-high quality native plant communities, and Washington ground squirrel occupancy. Reducing threats to high-quality native habitats by restoring degraded adjacent sites would be a top priority. Moody and Mack (1988) modeled the non-native species invasion process and clearly showed the importance of eradicating non-native species in founding populations ("nascent foci").

Site constraints, technical feasibility, and the likelihood of achieving the restoration objectives would also be considered when prioritizing sites for restoration. Factors considered include the following:

- The terrain in some areas of the resource management area would preclude the safe and efficient use of restoration equipment such as a tractor and seed drill. These areas would be considered a lower priority.
- Cultural resources sites, unexploded ordnance areas, and appropriate buffers would be off limits to any ground-disturbing activity.
- Restoration feasibility and the likelihood of success would be carefully considered for sites in low ecological condition. For example, it might be futile to attempt to increase native bunchgrass densities in valley bottoms that currently support a monoculture of cheatgrass because the additional moisture in these areas provides cheatgrass a competitive advantage.
- Availability of desired plant materials.

The following priorities would be used to guide the habitat mitigation efforts at NWSTF Boardman:

- Priority 1 – Type 2 and 3 restoration sites adjacent to existing native grassland and shrub-steppe habitats rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 2 – Type 4 and 5 restoration sites adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 3 – Burned sites in medium-high ecological condition previously dominated by sagebrush.
- Priority 4 – Remaining Type 2, 3, 4, and 5 restoration sites that include historically occupied Washington ground squirrel habitat, but are not adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition.
- Priority 5 – Remaining Type 2, 3, 4, and 5 restoration sites.
- Priority 6 – Type 1 restoration sites adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition. Historically occupied Washington ground squirrel habitat would occur within the restoration site, the adjacent habitat, or both.
- Priority 7 – Remaining Type 1 restoration sites that include historically occupied Washington ground squirrel habitat, but are not adjacent to existing native grassland and shrub-steppe rated as being in high or medium-high condition.
- Priority 8 – Remaining Type 1 restoration sites.

### 7.3.7 MITIGATION RATIOS

Mitigation ratios often vary depending on the acreage, functions, and values of the habitat lost, the type of mitigation proposed, and other factors. Resource and regulatory agencies have usually required additional acreage beyond that lost through development, because of interim losses in habitat acreage and functional capacity, and because the success and resulting value of compensatory mitigation projects are uncertain.

The proposed mitigation ratios for NWSTF Boardman were developed to help ensure that there is no net loss of habitat quality and a net benefit of habitat quantity or quality. Factors considered in development of the mitigation ratios include the following:

- **Location of the mitigation sites –** The resource management area offers opportunities for in-proximity mitigation because it is within the boundaries of NWSTF Boardman and has connectivity to habitats that would be affected by the Proposed Action. In addition, the resource management area is adjacent to the Boardman Conservation Area and RNA-C, which maximizes the cumulative benefits of management activities in these different areas. Based on these factors, the proposed location of the mitigation sites offers benefits that could not be achieved if mitigation were accomplished in off-site locations. As such, mitigation ratios can be lower than those typically used for off-site mitigation.
- **Quality of the habitat affected by the Proposed Action –** High-value habitat would be affected by the Proposed Action because much of the affected habitat is considered occupied or historically occupied by Washington ground squirrels. Nonetheless, the affected area includes a mosaic of habitats representing a range of ecological condition classes (e.g., low to high). Higher mitigation ratios are proposed for areas assigned higher ecological condition classes.
- **Nature of the habitat impacts –** Habitat impacts have been grouped into two categories for mitigation planning purposes:
    - **Permanent habitat loss –** Includes areas that would be converted to structures or facilities such as gravel roads and targets. Complete loss of habitat functions and values are expected in these areas. Higher mitigation ratios are proposed for these areas.
    - **Long-term habitat degradation –** Includes areas temporarily disturbed by construction and areas that would likely be affected by projectiles striking the ground, training-caused wildfires, invasive plants, training-related noise, and disturbance caused by increased human activity. Long-term habitat degradation is expected in these areas, but complete loss of habitat functions and values are not expected. The mitigation ratios proposed for these areas are lower than those proposed for permanent habitat loss.
- **Condition of the habitat on the proposed mitigation sites –** Similar to the affected area, the resource management area includes a mosaic of habitats representing a range of ecological condition classes (e.g., low to high). The potential to achieve ecological uplift through restoration or enhancement depends, in part, on the existing conditions within the resource management area. In general, restoration or enhancement of sites in low ecological condition would seem to provide the greatest potential to achieve ecological uplift. To be successful, however, the overall mitigation strategy must focus on ecological uplift at a landscape-scale, rather than simply focusing on restoring or enhancing the sites in the lowest ecological condition. This is especially true given the landscape-scale of the historic impacts and future threats to the resource management area (e.g., invasive plants and lightning-caused wildfire). The overall mitigation strategy must also consider the technical feasibility and likelihood of successfully restoring specific mitigation sites. Accordingly, the restoration strategies, objectives, and priorities outlined above reflect the importance of protecting and managing habitats in relatively high ecological condition, as well as restoring or enhancing habitats in lower ecological condition. Implementing mitigation activities in accordance with the established priorities is expected to maximize ecological uplift at the landscape-scale; therefore, the Navy is not proposing a system of variable mitigation credits based on the ecological condition class of specific mitigation sites.

Proposed habitat mitigation ratios for NWSTF Boardman are provided in Table 18. Mitigation ratios assume that all affected habitat is occupied by Washington ground squirrels. The ratios increase with increasing ecological condition of the affected habitat to ensure no net loss of habitat quality and a benefit of habitat quantity. In addition, higher mitigation ratios are proposed for permanent habitat loss, compared to long-term habitat degradation. A minimum ratio of 2:1 is proposed for permanently lost habitat to ensure no net loss of habitat quantity. A minimum ratio of 1.25:1 is proposed for long-term habitat degradation. Setting this ratio above 1:1 acknowledges and compensates for the possibility that even habitats with a low ecological condition class could be occupied by Washington ground squirrels. Proposed habitat mitigation acreage for each range enhancement is provided in Table 19 based on the ratios presented in Table 18 and the habitat impacts summarized in Table 15.

**Table 18: Proposed Wildlife Habitat Mitigation Ratios for NWSTF Boardman**

| Ecological Condition Classification of Affected Habitat | Mitigation Ratio for Type of Impact | |
|---|---|---|
| | Permanent Habitat Loss | Long-term Habitat Degradation |
| High | 3:1 | 2.25:1 |
| Medium-high | 2.75:1 | 2:1 |
| Medium | 2.5:1 | 1.75:1 |
| Medium-low | 2.25:1 | 1.5:1 |
| Low | 2:1 | 1.25:1 |
| Unclassified | 2.5:1 | 1.75:1 |

**Table 19: Proposed Wildlife Habitat Mitigation Acreage for NWSTF Boardman**

| Range Enhancement | Permanent Habitat Loss | | Long-term Habitat Degradation | | Total Mitigation (acres) |
|---|---|---|---|---|---|
| | Affected (Acres) | Mitigation (acres) | Affected (Acres) | Mitigation (acres) | |
| Multi-Purpose Machine Gun Range | 16 | 38 | 218 | 380 | 418 |
| Eastern Convoy Live Fire Range | 0 | 0 | 340 | 587 | 587 |
| Western Convoy Live Fire Range | 0 | 0 | 229 | 398 | 398 |
| Demolition Training Range | 1 | 2.5 | 0 | 0 | 2.5 |
| Unmanned Aerial Systems Airfield and Maintenance Facility and Range Operations and Control Center | 8 | 16 | 1 | 1.25 | 17.25 |
| **Total** | **25** | **56.5** | **788** | **1,366.5** | **1,422.75** |

### 7.3.8 RESTORATION METHODS

The Nature Conservancy initiated a shrub-steppe and grassland habitat restoration program at the Boardman Conservation Area in 2006 and has implemented restoration efforts on approximately 500 ac. as of 2012. These efforts achieved varying degrees of success and provide valuable information and lessons learned for future restoration efforts in the area. The Navy and ORNG propose to accomplish habitat restoration at NWSTF Boardman in coordination with The Nature Conservancy, using methods or refinements of methods successfully used at the Boardman Conservation Area, if the decision is made to implement the Proposed Action. In general, the proposed restoration methods for NWSTF Boardman would follow those outlined in the *Boardman Conservation Area Restoration Plan* (Elseroad 2007) and the *Boardman Conservation Area Five-Year Restoration Implementation Plan* (Elseroad 2008). Specific restoration methods would be finalized as part of the ongoing conferencing process with USFWS. Methods would continue to be refined throughout the restoration process and documented in annual restoration work plan updates (see Section 7.4, Adaptive Management and Monitoring).

Most restoration efforts at NWSTF Boardman would include the following components: obtaining plant materials, site preparation, planting, and post-planting weed control. Options and guidelines for each of these components are described by Elseroad (2007).

## 7.4 ADAPTIVE MANAGEMENT AND MONITORING

### 7.4.1 INTRODUCTION

Adaptive management is a decision process (Figure 19) that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. Adaptive management requires stated management objectives to guide decisions about what to try, and explicit assumptions about expected outcomes to compare against actual outcomes. It is important to know what the available management options and alternative assumptions are, in case the action that is tried does not work as expected (Williams et al. 2009).

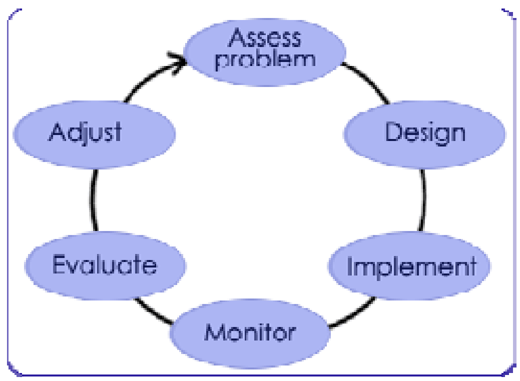


**Figure 19: Adaptive Management Process**

This section outlines the Navy and ORNG's proposed adaptive management process that would be used to help reduce uncertainty associated with the anticipated effects of the action and the anticipated effectiveness of the proposed BMPs and mitigation measures. As discussed above, the *NWSTF Boardman INRMP* currently provides a mechanism to adaptively manage natural resources cooperatively with USFWS and ODFW. If a decision is made to implement the Proposed Action, specific commitments to an adaptive management process would be made in the Record of Decision. These commitments would be incorporated into the INRMP, and the INRMP would continue to provide the overall management structure for implementing adaptive management. This management structure includes a requirement to review and update the INRMP annually through natural resources metrics meetings that include the USFWS and ODFW. The remainder of this section outlines the proposed adaptive management process, including expected outcomes and uncertainties, management objectives and decision points, monitoring, and alternative management actions.

### 7.4.2 EXPECTED OUTCOMES AND UNCERTAINTIES

Adaptive management requires explicit assumptions about expected outcomes to compare against actual outcomes (Williams et al. 2009). The anticipated effects of the action and associated uncertainties are analyzed in detail in Section 5, Effects of the Action. Following is a very brief summary of the expected outcomes of implementing the Proposed Action, including the proposed BMPs and mitigation measures:

- Proposed range construction and military readiness activities would result in permanent habitat loss (25 ac. [10 ha]) and long-term habitat degradation (788 ac. [319 ha]). Washington ground squirrel use of the affected area would decline, foraging and breeding would be adversely affected, and the Washington ground squirrel population on NWSTF Boardman could decline. Uncertainties that can be addressed through adaptive management include the possibility that impacts could be overestimated or underestimated.
- BMPs would avoid and minimize impacts. Mitigation measures (habitat restoration and enhancement) would compensate for lost habitat functions and values and provide a net benefit. Ecosystem stability would improve in restored/enhanced areas, and Washington ground squirrels would persist and possibly increase in numbers in these areas. Uncertainties that can be addressed through adaptive management include the effectiveness and benefits gained from the proposed restoration.

### 7.4.3 Management Objectives and Decision Points

An adaptive approach requires explicit and measurable objectives. Uncertainty about how to achieve objectives is what motivates adaptive management and drives the design of the monitoring system. To address this uncertainty, stakeholders must agree on the objectives (Williams et al. 2009). The management objectives for the Proposed Action are grouped under two broad management goals that are focused on: 1) reducing uncertainties associated potential impacts of the Proposed Action, and 2) reducing uncertainties associated with the effectiveness and benefits gained by the proposed restoration. Specific management objectives under these broad goals would serve as decision points that could trigger evaluation and adjustment phases of the adaptive management process, based on monitoring. Management objectives should be specific, measurable, achievable, results-oriented, and time-fixed. Therefore, an important consideration in establishing management objectives is the availability of reliable and practical monitoring methods that can be used to accurately measured achievement. Specific objectives under the two broad management goals are defined below and associated monitoring is described in Section 7.4.4, Monitoring.

**Management Goal 1 –** Limit impacts on the Washington ground squirrel to the affected areas identified in the impact analysis. This broad goal addresses the need to reduce uncertainty and validate findings of the impact analysis through monitoring and includes the following specific management objectives:

- Management Objective 1a – Maintain Washington ground squirrel densities in areas adjacent to the proposed ranges at or above 50 percent of baseline when compared to a paired control.
- Management Objective 1b – Minimize Washington ground squirrel mortality during construction and military readiness activities.
- Management Objective 1c – Detect and control noxious weeds annually within the identified affected areas.
- Management Objective 1d – Limit training-caused wildfires to the range footprint.

**Management Goal 2 –** Achieve no net loss of habitat quantity or quality and a net benefit of habitat quantity and quality through habitat restoration and enhancement. This broad goal addresses the need to confirm the effectiveness and benefits compensatory mitigation and includes the following specific management objectives:

- Management Objective 2a – Implement habitat restoration/enhancement for permanently lost habitat at 2:1+ ratio within 2 years following construction. Achieve site specific restoration objectives (see Table 17) within 3 years of restoration effort.
- Management Objective 2b – Implement habitat restoration/enhancement for degraded habitat at 1.25:1+ starting within 2 years following construction at a rate of up to 200 ac. (81 ha) per year until requirements are met. Achieve specific restoration objectives (see Table 17) for individual restoration sites within 3 years of initial restoration effort.

### 7.4.4 MONITORING

#### 7.4.4.1 Washington Ground Squirrel Monitoring

##### 7.4.4.1.1 Overview

Various monitoring efforts would be implemented to determine if and how the Proposed Action affects Washington ground squirrels at NWSTF Boardman and to determine if management objectives 1a and 1b are achieved. In addition, long-term monitoring would be conducted to obtain data on Washington ground squirrel distribution, status, and tends throughout NWSTF Boardman. The monitoring program would consist of the following components, which are described in more detail below:

- Long-term facility-wide monitoring
- Pre-construction surveys
- Construction monitoring and after-action inspections
- Washington ground squirrel density surveys

Construction activities for the range enhancements would be spaced over a period of several years as funding becomes available. Therefore, components of the monitoring program would be implemented on an as-needed basis, starting prior to construction of the first range enhancements.

##### 7.4.4.1.2 Long-term Facility-wide Monitoring

Washington ground squirrel surveys have been conducted on large portions of NWSTF Boardman since 1979, but a systematic survey of the entire property has not been conducted. A long-term, facility-wide monitoring program would be initiated a minimum of 2 years prior to construction of the first range enhancement. Approximately 20 percent of NWSTF Boardman would be surveyed annually using standard transect protocols to record active Washington ground squirrel detections (Morgan and Nugent 1999), so that the entire property is surveyed over a period of 5 years. These surveys would continue indefinitely.

##### 7.4.4.1.3 Pre-Construction Surveys

Standard protocols (Morgan and Nugent 1999) would be used to survey individual construction sites annually for two years prior to construction. Data from the long-term facility-wide monitoring would be used to meet these data needs to the extent possible. These surveys would cover the “affected area” of a given range enhancement where permanent habitat loss or long-term degradation of habitat is expected to occur. These affected areas include the range enhancement footprints for all projects and areas within the single-event 140 dBP contours associated with the MPMGR and CLFRs. Data from these surveys would provide baseline information and would be used to avoid impacts on Washington ground squirrels during construction, to the extent possible.

#### 7.4.4.1.4 Construction Monitoring and After-Action Inspections

Construction monitoring and after-action inspections would be conducted to determine if objective 1b is achieved and report any Washington ground squirrel mortality to the USFWS. Monitoring would be conducted during construction to avoid strikes by construction equipment. Any incidental mortality during construction would be documented and reported to the NWSTF Boardman Natural Resources Manager and USFWS.

Standard operating procedures for after-action range inspections would be updated to include identification and reporting of any wildlife mortality that might be associated with training activities. Range control personnel would inspect the training area, including target areas and heavily travelled roads, at the conclusion of a ground-based training exercise. Location and description of any observed wildlife carcasses would be recorded. Small carcasses, including any Washington ground squirrels, would be recovered, tagged, bagged, and delivered to the range administration building for storage (freezing). Any Washington ground squirrel mortality would be reported to the NWSTF Boardman Natural Resources Manager and USFWS.

#### 7.4.4.1.5 Washington Ground Squirrel Density Surveys

Achievement of management objective 1a (maintain Washington ground squirrel densities in areas adjacent to the proposed ranges at or above 50 percent of baseline when compared to a paired control) would be monitored by conducting live trapping, mark and recapture surveys using methods similar to those described by Klein (2005), Delavan (2008), and Greene et al. (2009). These surveys would be conducted in areas adjacent to the identified affected areas for the MPMGR, eastern CLFR, western CLFR, and DTR and in control areas. “Adjacent areas” are defined as a 3,281 ft. (1,000 m) buffer around the affected areas. These areas are outside the range enhancement footprints, but could be exposed to single-event noise levels less than 140 dBP. Based on the analysis presented in Section 5, no habitat loss, long-term habitat degradation, or decline in Washington ground squirrel numbers is expected in these adjacent areas. The proposed density surveys are intended to help validate conclusions of the analysis and reduce uncertainty.

To provide robust data, these density surveys would be conducted in locations that support large, persistent Washington ground squirrel colonies to the extent possible. Sampling would be conducted at three locations for each of the ranges identified. A paired control would be established for each sampling location. The controls would be located on NWSTF Boardman (well outside areas affected by the action or subject to restoration) or on the Boardman Conservation Area in areas with similar squirrel occupancy, soils, and vegetation. Baseline surveys would be conducted prior to the start of construction for the CLFRs and the DTR, and for two years prior to the MPMGR or the UAS facility. After a range is operational, surveys would be conducted once every 2 years for a period of 10 years to evaluate long-term trends in squirrel density. Vegetation surveys would also be conducted at each sampling location to help determine if any observed differences in squirrel density might be attributable to site conditions.

Each sampling location would be centered on a known, large Washington ground squirrel colony, assuming a sufficient number of large colonies are within the desired survey area. Based on Morgan and Nugent (1999), each sampling location would cover an area with a radius of 1,933 ft. (589 m), to account for the size of the colony (1,148 ft. [350 m]), plus a squirrel travel distance of 785 ft. (239 m). The survey area for each sampling location would be about 270 ac. (109 ha).

#### 7.4.4.2 Noxious Weed Surveys and Control

After a given range is operational, qualitative surveys would be conducted annually within the range footprint to identify noxious weeds (Morrow County list of noxious weeds) and address management objective 1c (detect and control noxious weeds annually within the identified affected areas). The purpose of these surveys is to detect noxious weeds so that they can be controlled immediately, most likely through targeted application of a glyphosate herbicide. These surveys would continue indefinitely and controls would be implemented as necessary. Objective 1c is effort-based; therefore, quantitative monitoring of noxious weeds is not proposed.

#### 7.4.4.3 Wildfire Monitoring

The causes, size, and location of all wildfires at NWSTF Boardman and associated suppression efforts would continue to be documented. This information would be reviewed after each wildfire to identify lessons learned and opportunities to improve fire prevention and suppression efforts.

### 7.4.5 Alternative Management Actions

Like any iterative decision process, decision making in adaptive management involves the selection of an appropriate management action at each point in time, given the status of the resources being managed at that time (Williams et al. 2009). Potential alternative management actions for NWSTF Boardman include:

- Review of ongoing training activities to determine if additional measures or BMPs, such as seasonal adjustments to training schedules could be implemented to avoid or minimize impacts on the resources of concern while still meeting training and readiness requirements.
- Modify or refine restoration methods. For example, use more aggressive invasive plant controls on restoration sites such as pre-emergent herbicides, alter planting strategies, or restore additional acreage.
- Refine fire prevention and suppression methods.
- Evaluate the feasibility of offsite mitigation by initiating a search for suitable properties to serve as a compensatory mitigation site that could be acquired under the Navy's Readiness and Environmental Protection Initiative or the Army's Compatible Land Use Buffer Program.

# 8 CONCLUSIONS

Table 20 summarizes the Navy's and ORNG's ESA determinations of effect for the Washington ground squirrel.

**Table 20: Endangered Species Act Determinations of Effect for the Washington Ground Squirrel**

| STRESSORS | | Endangered Species Act Determination of Effect for the Washington Ground Squirrel |
|---|---|---|
| **Major Stressor Category** | **Stressor Type** | |
| **Noise** | Aircraft | May affect, likely to adversely affect. |
| | Non-explosive Practice Munitions Impact | May affect, likely to adversely affect. |
| | Weapons Firing | May affect, likely to adversely affect. |
| | Land Demolitions | May affect, likely to adversely affect. |
| | Vehicles and Equipment | May affect, likely to adversely affect. |
| **Ground Disturbance and Habitat Alteration** | Non-explosive Practice Munitions | May affect, likely to adversely affect. |
| | Target and Fire Break Maintenance | May affect, likely to adversely affect. |
| | Construction | May affect, likely to adversely affect. |
| | Habitat Alteration by Wildfire and Invasive Plants | May affect, likely to adversely affect. |
| **Physical Strike** | Non-explosive Practice Munitions | May affect, likely to adversely affect. |
| | Aircraft | No effect. |
| | Vehicles and Equipment | May affect, likely to adversely affect. |
| **Electromagnetic Fields** | | May affect, not likely to adversely affect. |
| **Lasers** | | May affect, not likely to adversely affect. |

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# Appendix A

# Additional Biological Information

# Table of Contents

## Plant Species Known To Exist at NWSTF Boardman

| Common Name | Scientific Name |
|---|---|
| **Vascular Plants** | |
| Family Asteraceae (Aster) | |
| Annual agoseris | *Agoseris heterophylla* |
| Annual bursage | *Ambrosia acanthicarpa* |
| Diffuse knapweed | *Centaurea diffusa* |
| Big sagebrush | *Artemesia tridentata* |
| Bull thistle | *Cirsium vulgare* |
| Canadian thistle | *Cirsium arvense* |
| Carey's balsamroot | *Balsamorhiza careyana* |
| Chicory | *Chichorium intybus* |
| Cluster tarweed | *Madia glomerata* |
| Common cocklebur | *Xanthium strumarium* |
| Common dandelion | *Taraxacum officinale* |
| Common rabbitleaf | *Lagophylla ramosissima* |
| Common spikeweed | *Hemizonia pungens* var. *septentrionalis* |
| Columbia cut-leaf | *Hymenopappus filifolius* var. *filifolius* |
| Columbia coreopsis | *Coreopsis atkinsoniana* |
| False-yarrow | *Chaenactis douglasii* var. *achilleaefolia* |
| Gold stars | *Crocidium multicaule* |
| Gray rabbitbrush | *Chrysothamnus nauseosus* |
| Green rabbitbrush | *Chrysothamnus viscidiflorus* |
| Hairy golden-aster | *Chrysopsis villosa* |
| Hawkweed | *Hieracium* sp. |
| Hoary aster | *Machaeranthera canascens* |
| Horseweed | *Conyza canadensis* |
| Hounds-tongue | *Hieracium cynoglossoides* |
| Long-leaf hawksbeard | *Crepis acuminata* |
| Long-leaved aster | *Aster chilensis* |
| Low pussy-toes | *Antennaria dimorpha* |
| Nodding beggar-ticks | *Bidens cernua* |
| Northern wyethia | *Wyethia amplexicaulis* |
| Northwest balsamroot | *Balsamorhiza deltoidea* |
| Pineapple weed | *Matricaria matricarioides* |
| Prickly lettuce | *Lactuca serriola* |
| Scotch thistle | *Onopordum acanthium* |
| Shaggy daisy | *Erigeron pumilis* |
| Skeleton weed | *Stephanomeria paniculata* |
| Slender hawksbeard | *Crepis atrabarba* |
| Snakeweed | *Gutierrezia sarothrae* |
| Tall pussy-toes | *Antennaria anaphaloides* |
| Thread-leaf fleabane | *Erigeron filifolius* |
| White tidy tips | *Layia glandulosa* |
| Yarrow | *Achillea millefolium* |
| Yellow desert daisy | *Erigeron linearis* |
| Yellow salsify | *Tragopogon dubius* |
| Family Boraginaceae (Borage) | |
| Common cryptantha | *Cryptantha intermedia* |
| Slender popcorn flower | *Plagiobothrys tenellus* |
| Fiddleneck tarweed | *Amsinckia lycopsoides* |
| Family Brassicaceae (Mustard) | |
| Clasping peppergrass | *Lepidium perfoliatum* |
| Flixweed | *Descurainia sophia* |
| Jim-hill mustard | *Sysimbrium altissimum* |

| Common Name | Scientific Name |
|---|---|
| Prairie rocket | *Erysimum asperum* |
| Shepard's purse | *Capsella bursa-pastoris* |
| Whitlow-grass | *Draba verna* |
| Tall peppergrass | *Lepidium virginicum* |
| Tansy mustard | *Descurainia pinnata* |
| Tumble mustard | *Sisymbrium altissimum* |
| Family Cactaceae (Cactus) | |
| Prickly pear cactus | *Opuntia polyacantha* |
| Family Capparidaceae (Caper) | |
| Yellow bee plant | *Cleome lutea* |
| Family Carophyllaceae (Pink) | |
| Jagged chickweed | *Holosteum umbellatum* |
| Bouncing bett | *Saponaria officinalis* |
| Family Chenopodiaceae (Goosefoot) | |
| Black greasewood | *Sarcobatus vermiculatus* |
| Russian thistle | *Salsola kali* |
| Family Cupressaceae (Cypress) | |
| Western juniper | *Juniperus occidentalis* |
| Family Dipsacaceae (Teasel) | |
| Teasel | *Dipsacus sylvestris* |
| Family Euphorbiaceae (Spurge) | |
| Rattlesnake weed | *Euphorbia serpyllifolia* |
| Family Fabaceae (Pea) | |
| Alfalfa | *Medicago sativa* |
| Black locust | *Robinia pseudo-acacia* |
| Columbia milk-vetch | *Astragalus succembens* |
| Stalked-pod milk-vetch | *Astragalus sclerocarpus* |
| Hairy vetch | *Vicia villosa* |
| Lance-leaf scurf-pea | *Psoralea lanceolata* |
| Laurance's milk-vetch | *Astragalus collinus* var. *laurentii* |
| Licorice | *Glycyrrhiza leipdota* |
| Long-leaf locoweed | *Astragalus reventus* var. *reventus* |
| Lupine | *Lupinus* spp. |
| Pauper milk-vetch | *Astragalus misellus* |
| Shoestring psoralea | *Psoralea lanceolata* |
| Speckle-pod milk-vetch | *Astragalus lentiginosus* |
| Thread-stalk milk-vetch | *Astragalus filipes* |
| Tweedy's milk-vetch | *Astragulus tweedyi* |
| White clover | *Trifolium repens* |
| White sweet-clover | *Melilotus alba* |
| Pursh's milk-vetch | *Astragalus purshii* |
| Wyeth's lupine | *Lupinus wyethii* |
| Yellow deer-vetch | *Lotus corniculatus* |
| Yellow sweet-clover | *Melilotus officinalis* |
| Family Gentianaceae (Gentian) | |
| White-stemmed swertia | *Swertia albicaulis* |
| Family Geraniaceae (Geranium) | |
| Redstem filaree/storksbill | *Erodium circutarium* |
| Family Hydrophyllaceae (Waterleaf) | |
| Silver-leafed phacelia | *Phacelia hastata* |
| Thread-leaf phacelia | *Phacelia linearis* |
| Family Lamiaceae (Mint) | |
| Horehound | *Marrubium vulgare* |
| Family Liliaceae (Lily) | |

| Common Name | Scientific Name |
| --- | --- |
| Douglas' brodiaea | *Brodiaea douglasii* |
| Sagebrush mariposa | *Calochortus macrocarpus* |
| Panicled death-camas | *Zigadenus venenosus* |
| Yellow bells | *Fritillaria pudica* |
| Family Linaceae (Flax) | |
| Wild flax | *Linum perenne* |
| Family Malvaceae (Mallow) | |
| Orange globe mallow | *Sphaeralcea munroana* |
| Family Nyctaginaceae (Four-o'clock) | |
| White-sand verbena | *Abronia mellifera* |
| Family Onagraceae (Evening Primrose) | |
| Common evening primrose | *Oenethera strigosa* |
| Pale evening primrose | *Oenothera pallida* |
| Parched fireweed | *Epilobium paniculatum* |
| Family Plantaginaceae (Plantain) | |
| English plantain | *Plantago lanceolata* |
| Hairy plantain | *Plantago patagonica* |
| Family Poaceae (Grass) | |
| Barren fescue | *Festuca bromoides* |
| Bluebunch wheatgrass | *Agropyron spicatum* |
| Bottlebrush squirrel tail | *Sitanion hystrix* |
| Bulbous bluegrass | *Poa bulbosa* |
| Crested wheatgrass | *Agropyron cristatum* |
| Cheatgrass | *Bromus tectorum* |
| Thickspike wheatgrass | *Agropyron dasytachyum* |
| Dune wild rye | *Elymus mollis* |
| Foxtail barley | *Hordeum murimum* |
| Giant wild rye | *Elymus flavescens* |
| Idaho fescue | *Festuca idahoensis* |
| Indian ricegrass | *Oryzopsis hymenoides* |
| Junegrass | *Koeleria cristata* |
| Nevada bluegrass | *Poa nevadensis* |
| Nuttall's fescue | *Festuca microstachys* |
| Orchard grass | *Dactylis glomerata* |
| Saltgrass | *Distichlis stricta* |
| Sandberg's bluegrass | *Poa sandbergii* |
| Six-weeks fescue | *Festuca octoflora* |
| Thurber needle grass | *Achnatherum thurberianum* |
| Western needle-and-thread grass | *Hesperostipa comata* |
| Wheat | *Triticum aestivum* |
| Yellow wild rye | *Elymus cinereus* |
| Family Polemoniaceae (Phlox) | |
| Desert phlox | *Phlox austromontana* |
| Long-leaf phlox | *Phlox longifolia* |
| Microsteris | *Microsteris gracilis* |
| Small-flowered gilia | *Gilia minutiflora* |
| Family Polygonaceae (Buckwheat) | |
| Broom buckwheat | *Eriogonum vimineum* |
| Desert buckwheat | *Eriogonum compositum* |
| Snow buckwheat | *Eriogonum niveum* |
| Veiny dock | *Rumex venosus* |
| Wyeth eriogonum | *Eriogonum heracleoides* |
| Family Portulacaceae (Purslane) | |
| Common purslane | *Portulaca oleracea* |

| Common Name | Scientific Name |
|---|---|
| Family Ranunculaceae (Buttercup) | |
| Hornseed buttercup | *Ranunculus testiculatus* |
| Upland larkspur | *Delphinium nuttallianum* |
| Water buttercup | *Ranunculus aquatilis* |
| Family Rosaceae (Rose) | |
| Antelope bitterbrush | *Purshia tridentata* |
| Family Santalaceae (Sandalwood) | |
| Bastard toad-flax | *Comandra umbelleta* |
| Family Saxifragaceae (Saxifrage) | |
| Bulbet prairie star | *Lithophragma bulbifera* |
| Family Scrophulariaceae (Figwort) | |
| Common mullein | *Verbascum thapsus* |
| Sand dune penstemon | *Penstemon acuminatus* |
| Family Solanaceae (Potato or Nightshade) | |
| Cut-leaf nightshade | *Solanum triflorum* |
| Potato | *Solanum tuberosum* |
| Family Umbelliferae (Parsley) | |
| Bicolor biscuit root | *Lomatium leptocarpum* |
| Cous biscuit root | *Lomatium cous* |
| Biscuit root | *Lomatium macrocarpum* |
| Turpentine cymopterus | *Cymopterus terebinthinus* |
| Nine-leaved desert-parsley | *Lomatium triternatum* |
| Family Verbenaceae (Verbena) | |
| Bracted Verbena | *Verbena bracteata* |
| **Non-vascular Plants** | |
| (no common names) | |
| Mosses | |
| *Aloina pilifera* | |
| *Bryum* sp. | |
| *Ceratodon purpureus* | |
| *Didymodon australasii* | |
| *Didymodon brachyphyllus* | |
| *Encalypta cf. rhaptocarpa* | |
| *Funaria hygrometrica* | |
| *Grimmia montana* | |
| *Phascum cuspidatum* | |
| *Pseudocrossidium revolutum* | |
| *Pterygoneurum ovatum* | |
| *Tortula brevipes* | |
| *Tortula princeps* | |
| *Tortula ruralis* | |
| Lichens | |
| *Acarospora schleicheri* | |
| *Cladonia coniocraea* | |
| *Cladonia fimbriata* | |
| *Cladonia pyxidata* | |
| *Collema tenax* | |
| *Dermatocarpon hepaticum* | |
| *Diploschistes scruposus* | |
| *Lecanora muralis* | |
| *Leptogium californicum* | |
| *Leptogium lichenoides* | |
| *Nostoc* | |

| Common Name | Scientific Name |
| --- | --- |
| | *Polychidium albociliatum* |
| | *Psora luridella* |
| Liverworts | |
| | *Cephaloziella divaricata* |

[1] Sources: McClelland and Bedell (1987), Quade (1994).

WILDLIFE SPECIES THAT PRESENTLY OCCUR, POTENTIALLY OCCUR, OR HAVE OCCURRED IN THE PAST AT NWSTF BOARDMAN

| Species | Scientific Name |
|---|---|
| **Amphibians** | |
| Great Basin spadefoot toad | *Scaphiopus intermontanus* |
| **Reptiles** | |
| Common garter snake [1] | *Thamnophis sirtalis* |
| Gopher snake | *Pituophis melanoleucus* |
| Night snake [1] | *Hypsiglena torquata* |
| Northern sagebrush lizard | *Scleroporus graciosus* |
| Racer | *Coluber constrictor* |
| Rubber boa [1] | *Charina bottae* |
| Short-horned lizard | *Phrynosoma douglassi* |
| Side-blotched lizard | *Uta stansburiana* |
| Striped whipsnake [1] | *Masticophis taeniatus* |
| Western fence lizard | *Scleroporus occidentalis* |
| Western rattlesnake | *Crotalus viridis* |
| Western skink [1] | *Eumeces skiltonianus* |
| Western terrestrial garter snake [1] | *Thamnophis elegans* |
| **Birds** | |
| American crow | *Corvus brachyrhynchos* |
| American goldfinch | *Carduelis tristis* |
| American kestrel | *Falco sparverius* |
| American robin | *Turdus migratorius* |
| Bald eagle [1] | *Haliaeetus leucocephalus* |
| Barn owl | *Tyto alba* |
| Barn swallow | *Hirundo rustica* |
| Black-billed magpie | *Pica pica* |
| Black-crowned night heron | *Nycticorax nycticorax* |
| Black-throated sparrow | *Amphispiza bilineata* |
| Blue-winged teal | *Anas discors* |
| Brown-headed cowbird | *Molothrus ater* |
| Brewer's blackbird | *Euphagus cyanocephalus* |
| Brewer's sparrow | *Spizella breweri* |
| Bullock's oriole | *Icterus bullockii* |
| Burrowing owl | *Athene cunicularia* |
| California gull | *Larus californicus* |
| California quail | *Callipepla californica* |
| Caspian tern | *Sterna caspia* |
| Chipping sparrow | *Spizella passerina* |
| Chukar | *Alectoris chukar* |
| Cliff swallow | *Hirundo pyrrhonota* |
| Common nighthawk | *Chordeiles minor* |
| Common poorwill | *Phalaenoptilus nuttallii* |
| Common raven | *Corvus corax* |
| Cooper's hawk | *Accipiter cooperii* |
| Dark-eyed junco | *Junco hyemalis* |
| Eastern kingbird | *Tyrannus tyrannus* |
| European starling | *Sturnus vulgaris* |
| Ferruginous hawk | *Buteo regalis* |
| Fox sparrow | *Passerella iliaca* |
| Golden-crowned kinglet | *Regulus satrapa* |
| Golden eagle | *Aquila chrysaetos* |

| Species | Scientific Name |
|---|---|
| Grasshopper sparrow | *Ammodramus savannarum* |
| Gray flycatcher | *Empidonax wrightii* |
| Gray partridge | *Perdix perdix* |
| Horned lark | *Eremophila alpestris* |
| House sparrow | *Passer domesticus* |
| Killdeer | *Charadrius vociferus* |
| Lark sparrow | *Chondestes grammacus* |
| Lewis's woodpecker | *Melanerpes lewis* |
| Loggerhead shrike | *Lanius ludovicianus* |
| Long-billed curlew | *Numenius americanus* |
| Long-eared owl | *Asio otus* |
| Macgillivray's warbler | *Oporornis tolmiei* |
| Mallard | *Anas platyrhynchos* |
| Merlin | *Falco columbarius* |
| Mountain bluebird | *Sialia currucoides* |
| Mourning dove | *Zenaida macroura* |
| Northern flicker | *Colaptes auratus* |
| Northern harrier | *Circus cyaneus* |
| Northern pintail | *Anas acuta* |
| Northern rough-legged hawk | *Buteo lagopus* |
| Northern rough-winged swallow | *Stelgidopteryx serripennis* |
| Orange-crowned warbler | *Vermivora celata* |
| Peregrine falcon [1] | *Falco peregrinus* |
| Prairie falcon | *Falco mexicanus* |
| Red-tailed hawk | *Buteo jamaicensis* |
| Red-winged blackbird | *Agelaius phoeniceus* |
| Ring-billed gull | *Larus delawarensis* |
| Ring-necked pheasant | *Phasianus colchicus* |
| Rock wren | *Salpinctes obsoletus* |
| Sage grouse [2] | *Centrocercus urophasianus* |
| Sage sparrow | *Amphispiza belli* |
| Sage thrasher | *Oreoscoptes montanus* |
| Savannah sparrow | *Passerculus sandwichensis* |
| Say's phoebe | *Sayornis saya* |
| Sharp-shinned hawk | *Accipiter striatus* |
| Sharp-tailed grouse [2] | *Tympanuchus phasianellus columbianus* |
| Short-eared owl | *Asio flammeus* |
| Snowy owl | *Nyctea scandiaca* |
| Spotted sandpiper | *Actitis macularia* |
| Spotted towhee | *Pipilo maculatus* |
| Swainson's hawk | *Buteo swainsoni* |
| Townsend's solitaire | *Myadestes townsendi* |
| Turkey vulture | *Cathartes aura* |
| Upland sandpiper | *Bartramia longicauda* |
| Vesper sparrow | *Pooecetes gramineus* |
| Violet-green swallow | *Tachycineta thalassina* |
| Western kingbird | *Tyrannus verticalis* |
| Western meadowlark | *Sturnella neglecta* |
| Western sandpiper | *Calidris mauri* |
| Western tanager | *Piranga rubra* |

| Species | Scientific Name |
|---|---|
| White-crowned sparrow | *Zonotrichia leucophrys* |
| Wilson's warbler | *Wilsonia pusilla* |
| Yellow-headed blackbird | *Xanthocephalus xanthocephalus* |
| **Mammals** | |
| Badger | *Taxidea taxus* |
| Belding's ground squirrel [1] | *Spermophilus beldingi* |
| Big brown bat [1] | *Eptesicus fuscus* |
| Bison [2] | *Bison bison* |
| Black-tailed jackrabbit | *Lepus californicus* |
| Bobcat [1] | *Lynx rufus* |
| Bushy-tailed wood rat [1] | *Neotoma cinerea* |
| Columbian ground squirrel [1] | *Spermophilus columbianus* |
| Coyote | *Canis latrans* |
| Deer mouse | *Peromyscus maniculatus* |
| Elk | *Cervus elaphus* |
| Golden-mantled ground squirrel [1] | *Spermophilus lateralis* |
| Great Basin pocket mouse | *Perognathus parvus* |
| House mouse | *Mus musculus* |
| Little brown myotis [1] | *Myotis lucifugus* |
| Long-tailed weasel | *Mustela frenata* |
| Merriam's shrew [1] | *Sorex merriami* |
| Montane vole | *Microtus montanus* |
| Mountain lion [1] | *Felis concolor* |
| Mule deer | *Odocoileus hemionus* |
| Northern grasshopper mouse | *Onychomys leucogaster* |
| Northern pocket gopher | *Thomomys talpoides* |
| Norway rat [1] | *Rattus norvegicus* |
| Nuttall's cottontail | *Sylvilagus nuttallii* |
| Ord's kangaroo rat | *Dipodomys ordii* |
| Little pocket mouse [1] | *Perognathus longimembris* |
| Porcupine | *Erethizon dorsatum* |
| Pronghorn [2] | *Antilocarpa americana* |
| Pygmy rabbit [1] | *Brachylagus idahoensis* |
| Raccoon [1] | *Procyon lotor* |
| Red fox | *Vulpes vulpes* |
| Sagebrush vole | *Lemmiscus curtatus* |
| Silver-haired bat [1] | *Lasionycteris noctivagrans* |
| Townsend's ground squirrel [1] | *Urocitellus townsendii* |
| Vagrant shrew | *Sorex vagrans* |
| Washington ground squirrel | *Urocitellus washingtoni* |
| Western harvest mouse | *Reithrodontomys megalotis* |
| White-tailed jackrabbit | *Lepus townsendii* |
| Wolf [2] | *Canis lupus* |

[1] Species that hypothetically could occur at NWSTF Boardman, but it unlikely in most cases.
[2] Species with historical ranges overlapping NWSTF Boardman.

**DRAFT - Revegetation Plan for Areas Disturbed by Construction and Operation of Weapons Training Ranges and Other Facilities on Naval Weapons Systems Training Facility Boardman**

Prepared
August 2011

**Species.** Revegetation of disturbed areas on NWSTF Boardman would consist of three actions:

1. Cryptogammic crust (aka biological soil crust) would be collected from facility sites prior to construction and stored. Collected crust material would be screened to produce a homogenous material that would be applied to disturbed areas after completion of construction, either dry or in slurry, to innoculate the soil.

2. A mixture of the following grass would be broadcast onto disturbed sites, at a rate of 12.71 pounds pure live seed per acre:

| Species | Native? (y/n) | Noxious? (y/n) | Wildlife value (cover/forage) | Mature height (cm) | Life cycle | # Pure Live Seeds per square meter (PLS/$m^2$) | Seeding rate in grams/hectare (g/ha) | Seeding rate in pounds PLS per acre (lbs/ac) |
|---|---|---|---|---|---|---|---|---|
| bluebunch wheatgrass, *Pseudoroegneria spicatum* (= *Agropyron spicatum*) | Y | N | C/F | 30-60 | Perennial | 100 | 4,097 | 3.61 |
| Sandberg bluegrass, *Poa secunda* (= *Poa Sandbergii*) | Y | N | C/F | 30-60 | Perennial | 100 | 715 | 0.63 |
| *Festuca idahoensis* (Idaho fescue) | Y | N | C/F | 60+ | Perennial | 125 | 1,703 | 1.50 |
| needle and thread grass, *Hesperostipa comata* (= *Stipa comate*) | Y | N | C | 60+ | Perennial | 25 | 1,668 | 1.47 |
| bottlebrush squirrel-tail grass, *Elymus elymoides* (= *Sitanion hystrix*) | Y | N | C/F | 30-60 | Perennial | 50 | 1,589 | 1.40 |
| Indian ricegrass, *Achnatherum hymenoides* (= *Oryzopsis hymenoides*) | Y | N | C/F | 30-60 | Perennial | 100 | 4,654 | 4.10 |
| TOTALS | | | | | | 500 PLS/$m^2$ coverage | 14,426 g PLS/ha | 12.71 lbs PLS /ac |

3. Basin big sagebrush (*Artemesia tridentata* ssp *tridentata*) seed would be broadcast on selected focus areas, typically upwind and outside of weapons training range areas which have a higher potential to burn, at a rate of 1.6 pound per acre (lb/ac).

**Site Preparation and Application:** Preparation of areas for cryptogam inoculation and grass seeding will consist of finish soil grading. No site preparation is planned for basin big sagebrush seeding focus areas. Cyptogam innoculation would be accomplished by direct application of cryptogam material either in a dry form or in a slurry. Grass seed would be applied using a hydroseeder. The grass seed would be applied with SOIL-GUARD™ or cellulose mulch with tackifier. Fertilizer would not be used with this seed mixture. Basin big sagebrush seed would be hand broadcast onto firm, but not compacted, ground and pressed, rolled or dragged to improve seed-to-soil contact, with the goal of leaving the seed at a depth of about 1/16 inch. Fertilizer would not be applied to basin big sagebrush seeding areas.

**Schedule:** Cryptogam inoculation and grass seeding would be conducted between October 1 and January 31. Cryptogam inoculation would be conducted before grass seeding. Sagebrush seeding would be conducted between November 1 and December 31.

**Revegetation Success Criteria:** Cryptogam inoculation will be considered successful upon completion of the action. Grass revegetation would be considered successful if seeding results in a stand of grass providing a uniform coverage of at least 80% density of a representative bunchgrass stand area within two to three years of seeding. If an acceptable stand of grass is not achieved, then the area would be re-seeded between October 1 and January 31. Sagebrush revegetation would be considered successful if one seedling per square meter is established over a 10 square meter area in each seeding focus area after one year. Seeding will be repeated if needed to meet the success criteria.

## APPENDIX C. Washington Ground Squirrel Studies

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# Effects of 1998 wildfire on Washington Ground squirrels and their habitat at Naval Weapons Systems Training Facility, Boardman, Oregon

Submitted to Oregon Department of Fish and Wildlife
Heppner, Oregon
September 2001

Verne Marr
P. O. Box 606,
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## Introduction

Human activities have altered large areas of the Columbia Basin of Oregon and Washington (Franklin and Dyrness 1988; Daubenmire 1970). Few large blocks of shrub-steppe vegetation remain and though these are relatively safe from development, they are susceptible to degradation via invasion of non-native annual grasses and weeds especially in areas averaging less than 356 mm (14 in.) of annual precipitation (Sanders 1994). Subsequent loss of heterogeneity results in reduced resilience in populations of creatures that inhabit degraded ecosystems (Erlich 1988).

Patchily distributed species or species that utilize a range of microhabitats are especially vulnerable to extirpation on landscapes that have undergone a loss of heterogeneity. They often disappear from habitat fragments far in excess of their minimum home range sizes suggesting that factors other than home range limitations must be responsible (Wilcove et al. 1986). Regardless of initial population size, decreases in habitat quantity and/or quality can initiate a series of decimating events that can reduce a population by orders of magnitude bringing it to a state where random failure of recruitment may result in extirpation or extinction (Gilpin and Soule' 1984). Annual grasslands are capable at times of supporting high densities of Townsend's ground squirrels (*Spermophilus townsendi*) but those populations undergo wider size fluctuations in response to climate than do populations inhabiting shrub and perennial bunchgrass communities (Nydegger and Smith 1986). I think it reasonable to assume the same for populations of Washington ground squirrels.

Washington ground squirrels have inhabited the Columbia Basin for more than 13,000 years (See Spencer 1989) depending on assemblages of plants that evolved without large herding herbivores. These shrub-steppe plant communities hosted fire return intervals of 17-41 years with longer intervals favoring dominance by shrubs, intermediate intervals favoring dominance by perennial bunchgrasses, and shorter intervals favoring dominance by annual grasses (Housten 1973). Recovery of bunchgrasses following fire depends on season of burn and moisture distribution after the burn (Wright et al. 1979). Introduction of non-native weeds and annual grasses has altered this process by encouraging earlier, hotter, more frequent fires and providing serious competition against recruitment of native plants (Ganskopp and Bedell 1991; Humphrey and Schupp 2001). Aided and abetted by human activities, an insidious shift from heterogeneous native plant communities to homogeneous non-native annual plant communities has been ongoing for over 100 years in western North America (Huenneke 1999).

The Naval Weapons Systems Training Facility, Boardman is 18,688 Ha (73 Sq. Mi.) of shrub-steppe situated between 119 m (390 ft.) and 296 m (970 ft.) above mean sea level. Annual precipitation averages about 200 mm (7.9 in.) in the north part to about 280 mm (11 in.) in the higher southern part (McClelland and Bedell 1987). This area has been identified as important Washington ground squirrel habitat since their "rediscovery" as reported by Rohweder et al. (1979). Concern for the long-term viability of Washington ground squirrel populations (Betts 1990; 1999) has led to their listing by Oregon Department of Fish and Wildlife as endangered (Jan. 2000) and the U. S. Fish and Wildlife Service has been petitioned to list them under the Endangered Species Act.

On July 30, 1998, lightning ignited a wildfire that consumed about 9,700 Ha (~20,000 Ac) encompassing about two thirds of Washington ground squirrel sites then known on the Naval Weapons Systems Training Facility. The purposes of this study were to revisit and sample vegetative cover at 44 Washington ground squirrel sites first sampled in 1996-97 by Greene (1999), assess size and status of each site and mark them for future reference.

## Methods

I conducted fieldwork between March and June in both 2000 and 2001. Site status and size were established using criteria developed in 1996 (Greene 1999; Morgan and Nugent 1999). Locations of sites were determined by use of Global Positioning System (Conus; NAD 27) and each was mapped onto U. S. G. S. 7.5' topographic maps. I placed metal markers with numbered metal tags corresponding to the Oregon Department of Fish and Wildlife database reference number at each site.

I estimated availability of each soil type by placing a 600-dot grid onto a soils map of the site (Mclelland, and Bedell 1987) counting the numbers of dots falling onto each mapped soil type, and calculating the proportions of each soil type represented. I plotted Washington ground squirrel sites onto the soils map and calculated the proportions occupying each soil type.

I estimated distance between sites I found established sites from which I surmised they had originated. Direction between sites was placed into one of four categories (N-S, E-W, NE-SW, NW-SE) because in some cases I was not sure which site should be considered a nucleus.

I used a semiquantitative plot technique (Daubenmire 1959) as modified by Bailey and Poulton (1968) to evaluate vegetative cover and line intercept (Pieper 1973) to estimate shrub cover. From sample points established by Greene (1999), I moved five meters in a randomly chosen direction and laid out two intersecting 50 meter lines oriented north-south and east-west. For each line, a random starting point between zero and four was selected and sampling conducted at five meter intervals (10 points per line). I made ocular estimates of percent cover within a 2dm x 5dm frame at each point and converted these estimates to one of seven cover categories: 1. 0-1%; 2. >1-5%; 3. >5-10%; 4. >10-25%; 5. >25-50%; 6. >50-75%; 6. >75%. I tallied alien and native plant species encountered within 50 meters of the sample point then calculated percent alien species and alien/native plant ratios.

Results and discussion: Status and size of sites

I revisited 67 sites documented by Greene (1999) and found in 2000 that 44 were occupied while 23 had apparently been vacated, a three year vacation rate of 11.4% per annum. In 2001, 38 were occupied and 29 apparently vacated, a four year vacation rate of 10.8% per annum. Of the 44 sites that had been occupied in 2000, nine (20.4%) were apparently vacated in 2001 but three (13%) of 23 vacated sites were reoccupied a net loss of six sites (one year vacation rate 13.6%; Tables 1 and 2). I documented 65 additional sites in 2000 16 of which had apparently been vacated by 2001, a one year vacation rate of 24.6%. I documented 32 additional sites during the 2001 field season (Table 2). Betts (1990; 1999) reported data that suggests the sites he visited were experiencing a vacation rate of about 8%, somewhat less than that I documented at Naval Weapons Systems Training Facility, Boardman. Most of his sites, however, lack suitable areas for recruitment of new sites via dispersing squirrels.

Though I made no specific effort to determine sitewise recruitment rate, a rough estimate can be made. A vacation rate of ~11% per year and an increase in the number of known sites of ~44% per year since 1997 suggests a net recruitment rate of ~55% per annum. The proportion of sites classified as "small" was larger in 2001 suggesting a relatively high rate of recruitment (Figure 1; Table 2). I doubt that the increase in the number of documented sites is due to increased search effort in 2000-2001 for several reasons: 1. A maximum of ~10 researchers was in the field in 1996-1997 three of which were studying ground squirrels. 2. A maximum of four researchers were in the field during 2000-2001 one of which was studying ground squirrels. 3. Repeated systematic surveys were conducted in 1996-1997 but not in 2000-2001.

I examined changes in subjective size classifications of 44 sites documented by Greene (1999; Figure 1). Greatest change occurred in small and medium size classes. Overall, 15% (3.8%/annum) increased in size, 18% (4.5%/annum) decreased in size, 43.2% (10.8%/annum) were vacated, and 24% (6%/annum) remained the same (Table 1). These size assessments are based on a combination of area occupied, level of activity, and numbers of holes all of which boils down to an assessment based primarily on observation of holes (but see Van Horne et al. 1997a). No inferences can be drawn about population densities except in the most general terms and no quantitative density estimates are possible.

Washington ground squirrels appear to prefer Warden and Royal series soils though significant numbers are found in other soil types (Figures 2, 3, and Appendix 1). Site status data show a lower rate of vacation on burned vs. unburned sites in Warden soils but a higher rate of vacation for burned vs. unburned sites in Sagehill + Koehler + Royal soils (Figure 4). Information from past investigations (Betts 1990, Quade 1994, Greene 1999) suggests that recovery of squirrel populations from the drought induced lows of the late 1980's began earlier, was stronger, and was less variable in areas with Warden soils than in areas underlain by other soil types (Table 3, Figure 3). Warden soils occupy the higher south portion of the Naval Weapons Systems Training Facility where there is more annual precipitation (Mclelland, and Bedell 1987) and they contain more fines (Greene 1999) which allows them to maintain green vegetation later into the season. The higher fines content also means that burrows in Warden soils are less prone to collapse than are burrows in sandier soils. Obstructions such as stony layers or caliche tend to be deeper in Warden soils more consistently allowing the construction of burrows deeper than two meters. I suggest that the benefits of these factors are cumulative explaining why there are more squirrel sites in Warden soils than in other soil types. Sagehill, Koehler, Quincy, and Royal soils also support an increasing number of sites, some of which have been occupied as consistently as Warden soil sites suggesting that the importance of these areas should not be minimized. I have observed that heavy clay, layers of stone or caliche often occurs near the surface in these sandier soils apparently rendering some areas difficult for ground squirrels to exploit. No soils work has been reported that included information collected from deeper than 90 centimeters (Betts 1990, Greene 1999) but I suggest that the condition of soils to depths of two meters may influence ground squirrel use. Vegetation in Sagehill, Quincy and Koehler, soils tends to cure earlier and I think it likely that reproductive curtailment and lower rates of persistence occur more often and are more pronounced in these areas (see Van Horne et al. 1997b) than in areas with Warden soils.

Distance between established and derived sites averaged about 340m and ranged from 90m to 1180m, which I present as a rough estimate of dispersal distance by Washington ground squirrels at Naval Weapons Systems Training Facility, Boardman. Average distances in each category differ by less than one standard deviation and are somewhat greater than the mean maximum distances moved that were determined from live trapping studies (Carlson et al. 1980, Greene 1999). The number of cases was about the same in each directional category suggesting that dispersals occur in random directions (Table 4). Nothing has been reported about dispersal of Washington ground squirrels though possible scenarios have been based on information reported for other species and trapping data suggest that dispersal is male biased (Quade 1994, Greene 1999).

Vegetation

Since 1997, the most obvious difference in the vegetative cover between burned and unburned sites is decreased shrub cover on burned sites. Annual and perennial grass cover decreased whereas bare ground and microbiotic crust increased in most cases. These changes appear to be unrelated to the fire (Table 5). Small mammal populations that can retreat to underground burrows are seldom affected by summer wildfire, and precipitation regimes can confound efforts to assess fire-related impacts (Hedlund and Rickard 1981). Fire destroys shrubs but understory plants recover during the following growing season (Uresk et al. 1980) unless other factors interfere with the recovery process (Wright et al. 1979, Huenneke 1999, Ganskopp and Bedell 1991, Humphrey and Schupp 2001).

Plant species diversity and proportions of alien plants (Appendix 2) appear to be similar between 1997 and 2001 but a difference in methods of tallying plant species makes comparison difficult. In 1997 only species that were sampled at points were tallied whereas I tallied species present within 50 meters of the sampling point. As a result, my data include more plants that comprise a miniscule percentage of the vegetative cover than do data from Greene (1999).

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Table 1. Changes in size and status of 67 Washington ground squirrel sites between 1997 and 2001 at Naval Weapons Systems Training Facility, Boardman, OR.

| SIZE | No. % | SITES CHANGED INCREASERS | DECREASERS | VACATED | TOTAL CHANGED | SITES STATIC |
|---|---|---|---|---|---|---|
| 5 Large | n | -- | 2 | 2 | 4 | 1 |
| | % | -- | 40 | 40 | 80 | 20 |
| 28 Med. | n | 1 | 10 | 9 | 20 | 8 |
| | % | 4 | 36 | 32 | 71 | 29 |
| 34 Small | n | 9 | -- | 18 | 27 | 7 |
| | % | 26 | -- | 53 | 79 | 21 |
| 67 Total | n | 10 | 12 | 29 | 51 | 16 |
| | % | 15 | 18 | 43 | 76 | 24 |

Table 2. Numbers and proportions of Washington ground squirrel sites in each of three size classifications at Naval Weapons Systems Training Facility, Boardman, Oregon, 1997, 2000, and 2001.

| | 1997 (67 occupied) | | | 2000 (44 occupied, 23 Vacant) | | | 2001 (37 occupied, 30 vacant) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Large | Medium | Small | Large | Medium | Small | Large | Medium | Small |
| N | 5 | 28 | 34 | 4 | 17 | 23 | 3 | 18 | 16 |
| % | 7.5 | 41.8 | 50.6 | 9.1 | 38.6 | 52.3 | 8.1 | 48.6 | 43.2 |
| | | | | (65 new sites) | | | (49 occupied, 16 vacant) | | |
| n | | | | 1 | 26 | 38 | 0 | 18 | 31 |
| % | | | | 1.5 | 40.0 | 58.5 | 0 | 36.7 | 63.3 |
| | | | | (109 occupied, 13 vacant) | | | (31 new sites) | | |
| n | | | | 5 | 43 | 61 | 0 | 3 | 28 |
| % | | | | 4.6 | 39.4 | 56.0 | 0 | 9.7 | 90.3 |
| | | | | | | | (117 occupied, 46 vacant) | | |
| n | | | | | | | 3 | 39 | 75 |
| % | | | | | | | 2.6 | 33.3 | 64.1 |

Table 4. Rough estimate of dispersal distances and directions by Washington ground squirrels at Naval Weapons Systems Training Facility, Boardman, Oregon, 1997- 2001.

Warden soils

| Directional category | Number | Ave. dist. (m) | sd (m) | Range (m) |
|---|---|---|---|---|
| North-South | 23 | 311 | 233 | 100-1000 |
| East-West | 22 | 324 | 205 | 90-0820 |
| Northeast-Southwest | 17 | 294 | 222 | 100-0840 |
| Northwest-Southeast | 20 | 240 | 128 | 90-0550 |
| All combined | 82 | 294 | 201 | 90-1000 |

Koehler, Sagehill, Quincy, Royal, Ellum and Burbank soils

| Directional category | Number | Ave. dist. (m) | sd (m) | Range (m) |
|---|---|---|---|---|
| North-South | 6 | 473 | 291 | 180-1000 |
| East-West | 10 | 367 | 313 | 150-1180 |
| Northeast-Southwest | 12 | 609 | 295 | 200-1160 |
| Northwest-Southeast | 10 | 381 | 293 | 110-0850 |
| All combined | 38 | 464 | 305 | 110-1180 |

All soils combined

| Directional category | Number | Ave. dist. (m) | sd (m) | Range (m) |
|---|---|---|---|---|
| North-South | 30 | 337 | 249 | 100-1000 |
| East-West | 32 | 338 | 239 | 90-1180 |
| Northeast-Southwest | 30 | 419 | 292 | 100-1160 |
| Northwest-Southeast | 30 | 287 | 205 | 90-0850 |
| All combined | 122 | 345 | 249 | 90-1180 |

Appendix 2. UTM coordinates, habitat type, and size activity rating for Washington ground squirrel colonies on Boardman Bombing Range, 1996-1997.

| | UTMs | | | Land | | | |
|---|---|---|---|---|---|---|---|
| Site | E | N | VegTn!e | Use | Soil T;y e | Sizea | Activit;ya |
| 1 | 295190 | 5062390 | Sagebrush | Grazed | Warden | 3 | 4 |
| 2 | 295725 | 5063000 | Bunchgrass | UnGrazed | Warden | 1 | 2 |
| 3 | 295600 | 5063200 | Bunchgrass | UnGrazed | Warden | 3 | 3 |
| 4 | 294860 | 5063190 | Sagebrush | Grazed | Warden | 2 | 3 |
| 5 | 295230 | 5062860 | Sagebrush | Grazed | Warden | 1 | 1 |
| 6 | 294700 | 5063070 | Sagebrush | Grazed | Warden | 3 | 4 |
| 7 | 295400 | 5062820 | Sagebrush | UnGrazed | Warden | 1 | 1 |
| 8 | 288420 | 5057810 | Sagebrush | Grazed | Warden | 5 | 5 |
| 9 | 285950 | 5058080 | Sagebrush | Grazed | Warden | 3 | 3 |
| IO | **288890** | 5060700 | Sagebrush | UnGrazed | Warden | 2 | 2 |
| 11 | 288400 | 5061700 | Bunchgrass | UnGrazed | Warden | 2 | 3 |
| 12 | 288090 | 5061410 | Bunchgrass | Grazed | Sagehill | 3 | 2 |
| 13 | 287300 | 5056960 | Sagebrush | Grazed | Warden | 2 | 1 |
| 14 | 287908 | 5057013 | Sagebrush | Grazed | Warden | 3 | 3 |
| **15** | 286483 | 5060905 | Sagebrush | Grazed | Warden | 3 | 3 |
| 16 | 288460 | 5061780 | Bunchgrass | UnGrazed | Warden | 2 | 2 |
| 17 | **289180** | 5061530 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| **18** | 288470 | 5061510 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| 19 | **288215** | 5061220 | Bunchgrass | UnGrazed | Warden | 4 | 4 |
| 20 | **288840** | 5062020 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| 21 | 291540 | 5057220 | Annual Grass | Grazed | Royal | 5 | 5 |
| 22 | 291700 | 5058730 | Annual Grass | Grazed | Royal | 5 | 5 |
| 23 | 292634 | 5059710 | Sagebrush | Grazed | Warden | 2 | 2 |
| 24 | 292210 | 5061450 | Sagebrush | Grazed | Royal | 3 | 5 |
| 25 | 294280 | 5067800 | Low Shrub | Grazed | Koehler | 2 | 2 |
| 26 | 295120 | 5072150 | Low Shrub | Grazed | Quincey | 2 | 3 |
| 27 | 294980 | 5072430 | Low Shrub | Grazed | Quincey | 4 | 3 |
| **28** | 292080 | 5059985 | Sagebrush | Grazed | Warden | 3 | 3 |
| 29 | 290840 | 5060100 | Sagebrush | Grazed | Warden | 3 | 3 |
| 30 | 294670 | 5069700 | Sagebrush | Grazed | Koehler | 3 | 2 |
| 31 | 294130 | 5058090 | Sagebrush | Grazed | Warden | 1 | 3 |
| 32 | 295000 | **5058180** | Low Shrub | Grazed | Warden | 3 | 4 |
| 33 | 294920 | 5058630 | Low Shrub | Grazed | Warden | 2 | 2 |
| 34 | 292190 | 5057530 | Sagebrush | Grazed | Warden | 1 | 2 |
| 35 | 292300 | 5058340 | Sagebrush | Grazed | Warden | 3 | 4 |
| 36 | 294420 | 5059500 | Sagebrush | Grazed | Warden | 5 | 5 |
| 37 | 294820 | 5059410 | Sagebrush | Grazed | Warden | 5 | 5 |
| 38 | 287740 | 5071100 | Bunchgrass | Grazed | Quincey | 2 | 2 |
| 39 | 291100 | 5073360 | Low Shrub | Grazed | Quincey | 3 | 2 |
| 40 | 294700 | 5060200 | Annual Grass | Grazed | Warden | 3 | 3 |
| 41 | 293180 | 5060360 | Sagebrush | Grazed | Warden | 2 | 2 |
| 42 | 289020 | 5058060 | Sagebrush | Grazed | Warden | 4 | 4 |

## Appendix 2 (Continued)

| Site | UTMs E | N | VegType | Land Use | Soil Type | Sizea | Activitya |
|---|---|---|---|---|---|---|---|
| 43 | 289385 | 5059445 | Sagebrush | Grazed | Warden | 3 | 3 |
| 44 | 289740 | 5059457 | Sagebrush | Grazed | Warden | 3 | 3 |
| 45 | 290020 | 5056960 | Sagebrush | Grazed | Warden | 2 | 4 |
| 46 | 290020 | 5057500 | Sagebrush | Grazed | Warden | 2 | 3 |
| 47 | 288950 | 5061100 | Sagebrush | UnGrazed | Warden | 2 | 3 |
| 48 | 287660 | 5061290 | Bunchgrass | Grazed | Warden | 3 | 2 |
| 49 | 291815 | 5059700 | Sagebrush | Grazed | Warden | | 3 |
| 50 | 292030 | 5060260 | Sagebrush | Grazed | Warden | | 3 |
| 51 | 291480 | 5061810 | Sagebrush | UnGrazed | Warden | 3 | 2 |
| 52 | 294270 | 5065650 | Annual Grass | Grazed | Royal | 4 | 4 |

a - Size/Activity Rating: 5 = large/most active; 1 = small/least active

**Incedental Sightings**

| Site | E | N | VegType | Land Use | Soil Type |
|---|---|---|---|---|---|
| 53 | 295130 | 5063135 | Sagebrush | Grazed | Warden |
| 54 | 292180 | 5060835 | Sagebrush | Grazed | Warden |
| 55 | 291020 | 5060865 | Sagebrush | Grazed | Warden |
| 56 | 292175 | 5060170 | Sagebrush | Grazed | Warden |
| 57 | 289510 | 5060500 | Sagebrush | Grazed | Warden |
| **58** | 291395 | 5061470 | Sagebrush | Grazed | Warden |
| 59 | 288520 | 5071730 | Bunchgrass | Grazed | Quincey |
| 60 | **288510** | 5069170 | Bunchgrass | Grazed | Koehler |
| 61 | 289555 | 5070300 | Bunchgrass | Grazed | Koehler |
| 62 | 286835 | 5070190 | Bunchgrass | Grazed | Koehler |
| 63 | 288150 | 5056125 | Bunchgrass | UnGrazed | Warden |
| 64 | Not Available | | Bunchgrass | UnGrazed | Warden |
| 65 | 290500 | 5059710 | Annual Grass | Grazed | Warden |
| 66 | 289820 | 5059550 | Annual Grass | Grazed | Warden |
| 67 | 294600 | 5074270 | Annual Grass | Grazed | Quincey |
| 68 | 287860 | 5063965 | Low Shrub | Grazed | Warden |
| 69 | 287860 | 5068332 | Low Shrub | Grazed | Koehler |

**STATUS AND HABITAT USE OF THE WASHINGTON GROUND SQUIRREL *Spermophilus washingtoni* ON STATE OF OREGON LANDS, SOUTH BOEING, OREGON IN 1999**

## EXECUTIVE SUMMARY

We examined presence, relative abundance, distribution, and habitat use by Washington ground squirrels on 7,827 hectares (19,333 acres) of State of Oregon lands, leased to the Boeing Company, near Boardman, Oregon. A total of 104 Washington ground squirrel sites were identified on 62 of 128 quarter-section survey grids across the project area. Squirrels were found in all of the major vegetative communities, but were most commonly found in the sagebrush-dominated community. Sixty five percent of the detections were in areas underlain by Warden soils indicating a preference for this soil type. General distribution and habitat associations of squirrels on the study area are similar to adjacent property owned by the U.S. Navy.

## BACKGROUND

### The issue

The historic range of the Washington ground squirrel has been severely reduced in the Oregon portion of the Columbia Basin, primarily as a result of habitat loss through conversion of native grassland and sagebrush habitat to agriculture (Betts 1990). Remaining significant tracts of habitat for Washington ground squirrels are now limited to state-owned lands known as the Boeing lease lands, the U.S. Navy – Boardman Bombing Range (hereafter referred to as Bombing Range), and a small tract of Bureau of Land Management land (Horn Butte) to the west of Willow Creek. There are only a few small private-land habitat areas including the Lindsay Prairie Preserve, owned by Nature Conservancy, located south of the Bombing Range. However, a recent survey of Washington ground squirrels on private lands by Betts (1999) revealed a significant decrease in active colonies compared with a decade ago and suggests an overall downward trend in Oregon's Washington ground squirrel populations.

In July 1962 the state of Oregon entered into a 77-year agreement with the Boeing Company to lease 99,000 acres of state-owned land. The Department of Administrative Services administers the lease. In 1974 Boeing, with the consent of the State of Oregon, assigned rights and duties to the Boeing Agricultural Industrial Company and much of the land was later subleased to private agricultural companies. The Oregon Water Resources Department is currently considering orders to extend water use permits that would allow for conversion of more than 19,379 acres of native grasslands and shrubsteppe on the Boeing lease lands to agriculture. This land was historically considered important habitat for Washington ground squirrels, but until now, no formal surveys for the species were conducted.

In January 1999 the Northwest Environmental Defense Center, Defenders of Wildlife and the Oregon Natural Desert Association filed a petition with the Oregon Fish and Wildlife Commission to list the Washington ground squirrel pursuant to ORS 496.176 (5) and OAR 635-100-0110 and ORS 496.176(7) and OAR 635-100-0115. The petition called for an emergency listing of the Washington Ground Squirrel as endangered. The Commission did not list the species on an emergency basis at that time. In February, however, the Commission concluded that the evidence presented warranted the initiation of the regular Endangered Species Act rulemaking process.

An agreement was reached in spring 1999 between ODFW and the current leasee of South Boeing (Inland Land Co) for access to South Boeing for the purposes of surveying for the presence of Washington ground squirrels and mapping their distribution. The results of this survey work would be helpful to the Fish and Wildlife Commission in making a determination of whether or not to list the species. In addition, it would provide a better understanding of the species' distribution, biology, habitat use, and the importance of the South Boeing tract in the conservation of the Washington ground squirrel.

### The Washington ground squirrel

The Washington ground squirrel measures 185-245 mm in total length, with a pale smoky-gray pelage and a blackish tip on its tail (Rickart and Yensen 1992, Verts and Carraway 1998). It is distinguished from other members of the subgenus *Spermophilus* primarily by its smaller size and distinct white dorsal spotting. The ground squirrel is endemic to the Columbia Plateau of Oregon and Washington. In Oregon, it occurs in the Columbia Basin at elevations up to 300 meters (984 feet ) in grasslands and shrubsteppe lying south of the Columbia River, east of the John Day River, and west of Milton-Freewater. In addition to its current classification as a "critical" sensitive species by the Oregon Department of Fish and Wildlife, the Washington ground squirrel is classified as a "species of concern" by the U.S. Fish and Wildlife Service, a "state monitor species" by the Washington Department of Wildlife, and a "globally imperiled" species by the Oregon Natural Heritage Program (ONHP 1998, ODFW 1996b).

Washington ground squirrels inhabit grasslands and shrub steppe habitat dominated by big sagebrush (*Artemesia tridentata)*, bluebunch wheatgrass (*Agropyron spicatum*), needle-and-thread grass (*Stipa comata*), Idaho fescue (*Festuca idahoensis*), and Indian ricegrass (*Oryzopsis hymenoides*) (Carlson et al. 1980). These grassland and shrubsteppe habitats are considered some of the rarest ecosystems in the Oregon portion of the Columbia Plateau. Washington ground squirrels play a number of important roles in these ecosystems, as a prey species for raptors and other predators, by influencing plant community composition and structure through selective feeding, and in the creation and use of burrow habitats used by other species. Washington ground squirrels are a prey item for two state sensitive species, the ferruginous hawk and Swainson's hawk.

## SPECIFIC OBJECTIVES

The objectives of this survey project are as follows:

1. Characterize presence, relative abundance, and distribution of Washington ground squirrels on South Boeing.

2. Investigate general habitat use of Washington ground squirrels, on South Boeing.

# METHODS

## Project Area

The survey area was conducted on the 7,827-hectare (19,333 acre) tract known locally as South Boeing. It is located approximately 23 km (14 mi) southeast of Boardman, Oregon (Figure 1). Elevation ranges from 162 m (531 ft) to 308 m (1,010 ft) and annual precipitation is approximately 22 cm (8.6 in), mostly arriving in winter and spring months. Summer months are generally hot and very dry, and winds are frequent – often exceeding 45 kph (28 mph).

The area was formed by the Missoula floods and is primarily composed of flood deposited and subsequent wind re-deposited silts and loams. The area has a mosaic of vegetative types arranged into four broad categories. The big-sagebrush community is the primary shrub community and has varying amounts of cryptogamic crust, cheatgrass, bunchgrass, and other species in the understory. Understory coverage of cryptogamic crust and bunchgrass generally indicates a more native-like condition. The bunchgrass community is composed of two dominant species, bluebunch wheatgrass and Western needle-and-thread grass in variable levels of condition. Sandberg's bluegrass (*Poa sandbergii*) is a common understory associate with both bunchgrass types. The open-low shrub community is characterized by variable amounts of rabbitbrush (*Chrysothamnus* spp.) and matchweed (*Gutierrezia sarothrae*) in the overstory with non-native cheatgrass (*Bromus tectorum*) generally dominating the understory. It is generally a highly impacted habitat and is not reflective of native habitat condition. The annual grass and forb community is dominated by cheatgrass and other weed species with few shrubs. It is indicative of the most degraded sites on the area. Both the annual grass and the open-low shrub habitats are a result of historically heavy grazing and frequent fire intervals.

## Study Period

This survey project was conducted from April 12, 1999 to June 11, 1999. This corresponds to the time when juvenile squirrels emerge from the burrows and are most active. This is also the period that alarm calls are most frequent. The bulk of the surveys were conducted during April and May, but due to a later start date than anticipated some surveys had to be conducted in June.

## Field Personnel

The Department contracted a 12-person field crew from Resources Northwest Consultants (RNC) to conduct the transect surveys for squirrels. Each contracted survey-crew member was hearing tested to determine the extent of any high frequency hearing loss – an important qualification as squirrel vocalizations are very high frequency. The Department provided up to six additional personnel at times to assist with transect surveys and oversee the project. A list of all personnel that worked on the project is provided in Appendix 1.

Department personnel provided orientation and in-depth training to all field surveyors on April 12th and 13th, 1999. This was accomplished by using known squirrel colony sites at the adjacent Boardman Bombing Range. Squirrel biology, life history, and identification by sight and sound was covered. All personnel observed squirrels and heard squirrel vocalizations during the training. In addition, training was provided on habitat characterization and data recording procedures.

**Transect Surveys**

To determine squirrel presence, the study area was divided into USGS ¼ section (64.8 ha/160 ac) grids for transect surveys. Some grids surveyed were smaller than 64.8ha if their USGS boundaries were partly outside the study area. Each grid was surveyed in its entirety for presence of squirrels at least one time during the survey period. If squirrels were confirmed as occurring in a grid, then no follow-up surveys were conducted. If, however, squirrels were not detected on the first survey then the grid was to be re-surveyed at least one time. Figure 1 shows the status of each grid surveyed.

Line transect surveys were conducted on each grid by teams of two or more people walking parallel transects 60m (197 ft) apart. This distance assumes a maximum squirrel alarm call detection distance of 30m (98 ft) and was the protocol used by Eric Greene during his 1996 and 1997 study of Washington ground squirrels on the adjacent Boardman Bombing Range (Greene 1999). In this project the method was modified slightly by allowing survey personnel the ability to stray from the transect to investigate squirrel sign or other evidence of squirrel presence. This was necessary, as our objective was to detect squirrels if present and not to determine individual squirrel or colony density. In those grids that were re-surveyed (no detections on the first survey), transects were walked at 90 degrees to the original transects for that grid – to increase the total area covered and reduce the chance of missed detections.

Confirmed detections of squirrels were made by auditory and/or visual observations. In addition, any evidence of squirrel sign (droppings, holes, trails, etc.) was investigated when encountered and a confirmation of squirrel presence (or not) was made. All detections of squirrels, or squirrel sign were immediately investigated by all surveyors of the grid – they would simply mark their position along their individual transect and converge at the detection site.

Surveys were conducted during the morning hours between 6AM and noon on most days, but were extended into the afternoon if weather conditions were optimal. High winds occurred regularly and deterred survey efforts on many days. Generally, if the wind was stronger than 9-24 km/h (6-15 mph) then surveys were halted.

## Data Collection

One member of the survey team recorded all data for each grid/survey day on a standardized data form. A list and description of field data collected is given in Appendix 2. In addition to collecting squirrel location, colony status, and habitat data, each detection area was mapped using USGS 7.5 minute quadrangle maps carried in the field. Field Global Positioning System (GPS) locations were collected in Universal Transverse Mercator (UTM) coordinates using NAD27 map datum. Some UTM coordinates could not be differentially corrected using conventional correction software systems. Thus, coordinates for each site entered into the database were compared to the field-mapped site locations. If there was a discrepancy, the field map was presumed to be the best data, and the database was corrected using field locations if any of the following conditions applied:

1. If the GPS-plotted site was >200 meters (656 ft) from the mapped site.
2. If the GPS-plotted site was shown to occur in a different ¼-section grid than that of mapped location.
3. If the GPS-plotted site was shown to occur on a different side of an obvious topographical feature.

Field personnel were instructed to record data for all detections – even those that had some evidence of squirrels but could not be immediately confirmed as squirrel sites. Department personnel subsequently revisited all unconfirmed detection sites at least once and a determination was made as to the status of the site. Only confirmed squirrel sites were entered onto the final database. A recorded squirrel detection was considered a 'site' (and entered into the database) only if it had at least one of the three following characteristics:

1. Positive auditory observation. An alarm call given by a squirrel, if heard clearly, cannot be mistaken and was considered adequate evidence that a squirrel was present. The species is considered to be allopatric in this area and therefore no other related ground squirrel species are known to occur.

2. Positive visual observation. Similar to squirrel vocalizations, a positive ground squirrel sighting was considered adequate evidence of a squirrel site.

3. Squirrel droppings (scat) associated with hole. Recent studies on the adjacent Boardman Bombing Range has shown that squirrel droppings are uniquely identifiable and are not confused with other rodent species of the area (N. Verne Marr and Eric Greene, pers. comm). Thus, a hole or series of holes with droppings were considered adequate evidence of an occupied Washington ground squirrel site. Any squirrel droppings collected were subsequently inspected and confirmed by Department personnel before accepting the site as a positive squirrel site – unless other visual or auditory data that indicated squirrel presence was collected at the same site. Where droppings were used as the primary evidence of detection, the droppings were collected and most were catalogued. In some cases single dropping were collected and dissected to identify texture and food content.

Rodent burrow holes were extremely common across the study area, and many had characteristics that indicated use by squirrels. Even so, the variation among holes and the propensity for squirrels to appropriate holes made by other rodent species (N. Verne Marr, pers. comm.) made it difficult to be certain of squirrel presence based on hole characteristics alone. Thus, in no cases were sites confirmed as Washington ground squirrel sites based on holes only.

### Analysis

Completed data forms and maps were regularly collected by the Department and were checked for accuracy. Confirmed squirrel location data were then entered from the data forms onto an *Excell* (Microsoft Corp. 1996) spreadsheet for analysis (Appendix 3a). An *ArcInfo* (Environmental Systems Research Institute, Inc. 1998) GIS was used to investigate distribution and habitat relationships of squirrels on the survey area.

To investigate actual use-areas (area of expected squirrel movements around the detection site) of squirrel colonies and the distribution and abundance of potentially independent colonies, we used a combination of the estimated size of each site and maximum known travel distances of the species. Though all squirrel sites detected by field observers were recorded, confirmed, and entered into the database, not all sites were considered as separate and independent colonies for analysis. Use-areas for sites recorded as “individual” squirrels or “small” were determined by using a known maximum travel distance of 239 meters as described in Carlson et al. (1980) as a radius around the mapped location. For sites recorded as “medium” sites, we added a mean (n=12) radius of 60.5 meters (198 ft) to 239 (784 ft) meters to give an estimated use area of 299.5 meters (982) -- to reflect the actual geographical size of the site. For “large” sites (n=10) we used the actual field-estimated maximum dimensions of the site and added 239 meters (784 ft). No dimension estimates were recorded for three of the large sites and a mean radius (n=7) of 350meters (1,148 ft) was used. To analyze the distribution of squirrel colonies, we considered sites with overlapping use areas as connected “colonies” in which a regular interchange of squirrels occurs. A description of the size classifications that were assigned in the field is given in Appendix 3b.

## RESULTS

### Presence, abundance, and distribution of squirrels on South Boeing

A total of 104 Washington ground squirrel sites were confirmed. The complete database for these sites is included in Appendix 3a. Table 1 shows the number of confirmed squirrel sites and their estimated size. Most squirrel sites were detected during the first survey of each grid (91), but a small number of sites (13) were detected during the second survey. A schedule of grids surveyed, squirrels detected, and repeated grid surveys are included in Appendix 3. Squirrels were confirmed on 49 (38.3%) of 128 grids during the first survey. Re-surveys were conducted on 52 of the 79 remaining grids and squirrels were detected on 13 (25%) of the re-survey grids (Figure 2). Twenty-seven grids were not surveyed due to the late start of the project and the resulting shortened field season. The numbers of squirrel site detections were made in each of the survey months as follows: April (56), May (45), and June (3).

**Table 1.**

| Estimated Colony Size | Number of Confirmed Sites |
|---|---|
| Individual squirrel site | 9 |
| Small site | 61 |
| Medium site | 24 |
| Large site | 10 |
| **Total Sites** | **104** |

Evidence used to detect and confirm squirrel sites are listed in Table 2. Sight and/or sound were used for 62 percent of detections. Four of the sites were discovered incidentally (not on transect surveys) by project personnel while travelling on the project area, and one site was discovered by an area rancher during livestock operations.

**Table 2.**

| Primary Evidence to Detect and Confirm Site | Number of Sites |
|---|---|
| Holes with squirrel droppings | 42 |
| Sighting and/or sound detection | 62 |
| **Total** | **104** |

High winds often hindered survey efforts by reducing the effectiveness of field personnel to detect squirrel alarm calls. Table 3 shows the initial detection survey conditions (defined in Appendix 3b) for all but five of the confirmed sites squirrel sites.

**Table 3.**

| Survey Condition Rating | Number of Sites |
|---|---|
| Ideal conditions (1) | 46 |
| Not ideal, but moderate conditions (2) | 40 |
| Relatively poor conditions (3) | 13 |
| **Total** | **99** |

Figure 4 shows the squirrel detection locations with their associated use areas. By delineating expected use areas it appears that there is a minimum of 37 distinct squirrel colonies on South Boeing.

## Habitat Use by Ground Squirrels on South Boeing

1. Vegetation

Squirrels were detected in all major vegetative community types found on South Boeing (Table 4). Sagebrush, however, comprised the single-most commonly used habitat with 42.3% of the sites found in this community. It should be noted, however, that these are broadly categorized vegetation assessments and there is much overlap between types.

**Table 4.**

| Dominant Vegetation at Site | Number of Sites | Percent of total |
|---|---|---|
| Sage | 44 | 42.3% |
| Annual grass (generally cheatgrass) | 26 | 25% |
| Open-low shrub | 20 | 19.2% |
| Bunchgrass | 14 | 13.5% |

2. Soil relationships

Warden and Sagehill soils dominate South Boeing and comprise 94.2% of the total soil base (Figure 5). The Warden soil series is characterized by very deep loam with a high-silt content. The Sagehill soil series is characterized by deep silt loam mixed with calcareous lacustrine sediments. Squirrel locations are given by soil type in Table 5.

Table 5.

| Soil Type | Squirrel Detections | Percent of total detections |
|---|---|---|
| Warden (4,492 ha, 57.4% of total area) | 68 | 65.4 |
| Sagehill (2,881 ha, 36.8% of total area) | 27 | 26.0 |
| Other soils (454 ha, 5.8% of total area) | 9 | 8.7 |

# DISCUSSION

## Squirrel distribution and abundance

The general distribution pattern of Washington ground squirrel colonies recorded on South Boeing in 1999 closely reflects that found by Greene (1999) on the adjacent Bombing Range. On a large scale, squirrel sites were widely distributed and scattered across South Boeing (Figure 1). The majority (67%) of squirrel detections were made on the east half (east of Fourmile canyon) of the project area. This may be explained by a larger proportion of the land underlain by Warden soils – a habitat variable found to be positively correlated with Washington ground squirrel occupancy on the Bombing Range (Greene 1999). The thirty-four squirrel detections (33%) west of Fourmile canyon appear to have a more clumped distribution – primarily in, and northeast, of the Schoolhouse Canyon drainage.

At a finer scale there were three notable portions of the project area on which no squirrels were detected: 1) northwest – Willow Creek canyon; 2) most of the old Halvorson wheat field; and 3) Carty riparian corridor (Figure 6).

Sagehill soils make up most of the Willow Creek canyon area (Figure 5). Even so, twenty six percent of the total squirrel detections on South Boeing were found in Sagehill soils. Therefore, it is likely that other factors besides soils alone are playing a role in the low number of squirrel detections in this area. Three possible factors are slope, inadequate deep soil profiles, and proximity to the agriculturally developed bottomlands. Slope and aspect, however, were not found to be significant factors in the distribution of squirrels on the Bombing Range (Eric Greene, pers.comm). However, no portions of his study area exhibited the topographical relief similar to that of the Willow Creek canyon. In addition, some portions of the canyon have exposed rock outcroppings, indicating a layer of basalt close to the soil surface. This basalt layer or lack of the deep soil characteristic associated with it may make this area less suitable for squirrel occupancy.

It is unknown if the proximity to the Willow Creek agricultural bottomlands and associated farmsteads influences the occupancy of the shrubsteppe canyon by squirrels. Clearly, there is a difference in the number and type of predators in this area compared with occupied squirrel habitats on the remainder of South Boeing. For example, red fox (*Vulpes vulpes*), feral cats, domestic dogs, red-tailed hawk (*Buteo jamaicensis*), and a variety of other species associated with these developed habitats occur regularly in the canyon but not across the entire South Boeing tract. In addition, the paved road and the human activity associated with it (and the farms) may also affect overall habitat quality. Although we did not perform detailed vegetative assessments of South Boeing, observations of the canyon area indicate that vegetative differences do exist, most notably with plant species composition (e.g., bitterbrush, *Purshia tridentata*, in the northwest portion of the project area), and differences in vegetative cover and density (north-facing slopes).

It is important to note that the Willow Creek canyon, as shown in Figure 3, had no re-survey efforts. The fact that 25% of the grids re-surveyed on South Boeing were found to have squirrels indicates some probability that squirrels occupy some of the Willow Creek canyon area.

The dryland wheat field located on the east-central portion of South Boeing (Figure 6), referred to as the Halvorson field was abandoned approximately 9 years ago. It still shows old plow marks and drill rows, and has an assemblage of annual forbs and is dominated on many portions by yellow-star thistle (*Centaurea solstitialis*). It provides very little vegetative cover and food source for squirrels and many portions of it still show bare ground. In addition, soil disturbance and loss of topsoil from moldboard plowing is still evident and squirrels may have difficulty maintaining burrow systems in the field. A squirrel site detected along the east edge of this field ( ID# 2324ne1) showed evidence of fresh-dug holes extending approximately 40 meters (131 ft) into the old field from the grassland along the field's edge. Further investigation is required to assess if this is the beginning stage of re-occupancy of the abandoned farm field.

No squirrels were detected within 400 meters (1,312 ft) of the south boundary of Carty Reservoir (Figure 6). This could be a result of several factors. First, the soils are predominately Sagehill which, based on the discussion above, would be expected to have fewer detections than areas underlain with Warden soils. Second, there was evidence of heavy grazing pressure, especially in the draw bottoms, by cattle as they tended to gather near the water (the reservoir is unfenced along much of the southern edge and cattle were allowed to freely occupy the area during our project). Greene (1999) and Carlson (1980) noted that heavy cattle grazing and the resulting reduction of vegetation by grazing or trampling could adversely affect squirrels. Lastly, the large riparian corridor around the reservoir is inhabited by a variety of species not occurring elsewhere on South Boeing – many of which are predatory. The effects of this changed biological system are expected to be similar to the Willow Creek canyon area. It is probable that a combination of all three of these factors play a role with the lack of squirrels near the reservoir area.

It is unknown exactly which configuration of squirrel sites constitute functional "colonies" from a biological aspect. However, the thirty-seven "colonies" delineated in Figure 4 represent likely possibilities based on distances that can be traveled by squirrels. Known inter-colony travel distances and the propensity for the species to occupy a variety of vegetative types within and around colony sites indicates that vegetative type or condition alone is not a factor in predicting colony connectedness. Instead, it is expected that given proper soil types on relatively undisturbed landscapes Washington ground squirrels within 239 meters (784 ft) of each other are both genetically and socially connected. Therefore, squirrel colonies may be as small as a few individuals or a large assemblage of sites covering large expanses – and that actual colony size may simply be a function of the distance between individual squirrel sites. One example of this is the very large colony consisting of 27 detection sites and extending over 3km (1.8 mi) in the Sixmile Canyon area south of Carty Reservoir.

The degree to which entire ground squirrel colonies on South Boeing are connected to (or isolated from) other sites in close proximity to South Boeing is unknown as no formal studies of dispersal have been conducted. Based on observed squirrel distribution, however, it does not appear that dispersal is a limiting factor for squirrels within the South Boeing area (or the Bombing range) in its current condition. Furthermore, it is probable that many of the individual squirrel detections on South Boeing, especially those later in the season, were dispersing juveniles.

Betts (1999) and Quade (1994) have suggested that reduced source habitats, colony isolation, predation, and barriers to dispersal are all probable causes of the loss of squirrels from historical habitats. Based on known locations of remaining squirrels in the Oregon portion of the Columbia Basin it is clear that the Bombing Range and South Boeing together act as the single largest intra-connected habitat, and may be the only remaining significant source habitat for the species in Oregon.

**Habitat Associations**

Distribution of squirrel sites on South Boeing with relation to habitat types is consistent with findings by Greene (1999) and Quade (1994) in that most sites occur in Warden soils with a sagebrush component. The energetic cost of digging burrow systems is likely an important factor in squirrels' preference for Warden soils over other loam soils with a high clay content (Greene 1999). In a study on pocket gophers (*Thomomys bottae*) Vleck (1979) showed a significant energy cost of digging in high-clay soils. Greene (1999) also noted that the apparent preference to high-silt soils may reflect an avoidance of sandy soils, as burrows in soils with a high sand content are more likely to collapse.

The preference of squirrels for the Warden soil types may also be strongly influenced by vegetative parameters associated with that soil type. VanHorne (1997) found that sagebrush habitat was more suitable in drought years for the closely related Townsend's ground squirrel (*Spermophilus townsendii)*. During such periods Townsend's ground squirrels maintained higher body masses and rates of persistence than in grassland habitats. Adult survival was also higher in sagebrush habitats. The shade provided by sagebrush may allow a more stable food source by maintaining succulence of forage and lower soil temperatures (Bintz 1984).

Though most squirrel detections occurred disproportionately in areas of Warden soils and sagebrush on South Boeing it should be noted that 34.7% of the 104 detections occurred in other soil types and vegetative communities. This includes one relatively large site in a needle-and-thread grass flat near the northern boundary of the project area (ID# 2311sw1). Greene (1999) found that Washington ground squirrels in native bunchgrass habitat had higher body masses, but this finding may have been due to the above-average precipitation during his study. However, Bintz (1984) indicated that body mass just prior to the inactive season was important to the survival of ground squirrels and that body mass is highly dependent on forage quality. Therefore, during non-drought years, these other soil and vegetative types may provide important strongholds and are important for the long-term persistence of the species. These findings also indicate that the southern portion of the Bombing Range and the southern portion of the Boeing lease lands represent one of the most important remaining intact habitat areas for the species.

**Negative data**

The survey methodology used for this project was recently used in similar habitats on the adjacent Bombing Range (Greene 1999) and is considered by the Department of Fish and Wildlife to be the best available method for sampling Washington ground squirrels. Even so, it is expected that some squirrel colonies remained undetected during this investigation. Several possible causes of missed detections are given as follows.

1. **Squirrels not detected due to inactivity (above ground), topography, weather, dense vegetation, or lack of calling during the specific time of survey**. This species is known to spend much of its time below ground in burrow systems and above ground activity may not always coincide with survey times. In addition, one observer noted a squirrel actively plugging its own burrow (much like the pocket gopher regularly does) reducing its detectability. This is more likely to occur later in the season as a means of thermal regulation within the burrow system. Visual and acoustic barriers such as topography and vegetation could also reduce detectability. Greene (1999) and Quade (1994) both noted that adult squirrels are more likely to give alarm calls when the young emerge from the burrows. Although the level of breeding success was unknown in 1999, not all detectable squirrels had young and therefore did not call as readily as squirrels with young.

2. **Burrows were found but no other confirming evidence**. In many instances, we observed previously detected active squirrel sites and noted the lack of any accumulation of droppings around used holes. In fact it was often noted that fewer droppings were present than during previous visits to the same sites. On two separate occasions we observed droppings being carried away by ants. On another site, droppings appeared to have been blown by wind from around the holes and deposited in shallow wind-protected depressions some distance away. These observations lend strong support to the idea that holes that look like squirrel holes, but lack the confirming droppings, may be occupied by Washington ground squirrels. It was common throughout the project to find holes that showed proper characteristics of squirrel holes. Lacking any other confirming evidence, however, these sites were not considered to be occupied. Some of them, however, may have been. On one occasion, a suspected site with convincing holes was revisited three times before squirrels were heard and droppings were found.

3. **Low density sites or sites too small to be detected from a transect line**. It is conceivable that small active squirrel sites were missed solely because they were not close to the transect line. This could explain the detection of squirrels on 25% of the re-survey grids in which transects were walked perpendicular to the original transect lines. None of the 13 squirrel sites detected on re-surveys were categorized as large sites. This would suggest, intuitively, that smaller sites are more easily missed than large ones.

4. **Predators altering activity patterns, inducing dispersal, or causing direct mortality.** The response of squirrels to the immediate threat of predators is relatively unknown. Evidence of recent badger (*Taxidia taxus*) activity was common around many of the detected squirrel sites and on some occasions badgers appeared to devastate all squirrel holes at a site. Clearly, badgers play an important role in the ecology of ground squirrels. The closely related Townsend's ground squirrel (*Spermophilus townsendi)* was found in 70% of badger stomachs at the Snake River Birds of Prey Area (Messick and Hornocker 1981). On several occasions a suspected squirrel site showed evidence of active use by the long-tailed weasel (*Mustela frenata*) and in no case were squirrels active, or was there evidence of recent activity. This

The limitations of conducting a one-season survey for a rodent species are many. Most notably, it gives only a snapshot of squirrel locations at a single point in time and does not consider normal ground squirrel (and other rodent species) population dynamics for which populations increase and decrease in response to natural environmental variables, especially climate. Smith and Johnson (1985) noted a 50% population decline in Townsend's ground squirrels as a response to drought in 1977. In addition, densities of desert heteromyid rodent species are known to fluctuate dramatically with climate changes (Brown and Harney 1993). Greene (1999) noted that his Washington ground squirrel research on the Bombing range was conducted during (and following) high precipitation years and thus, he found a number of colony sites (54) in many of the same areas that apparently had none when Quade looked for them in 1994. Quade was searching for them during a drought cycle, and she found very few sites. It is expected, based on previous work done on the species (Quade 1994 and Greene 1999), that this year's survey on South Boeing is reflecting a higher population than would occur during drought years. Furthermore, it is expected that the number of colony sites on South Boeing would be naturally reduced in the event of drought. The specific sites that would persist through drought cycles are unknown.

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THESIS APPROVAL

The abstract and thesis of Jodie Leanne Delavan for the Master of Science in Biology were presented February 11, 2008, and accepted by the thesis committee and department.

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ABSTRACT

An abstract of the thesis of Jodie Leanne Delavan for the Master of Science in Biology presented February 11, 2008.

Title: The Washington Ground Squirrel (*Spermophilus washingtoni*): Home Range and Movement by Habitat Type and Population Size in Morrow County, Oregon.

At least two–thirds of the Washington ground squirrel's historic range has been removed or degraded. Current populations are vulnerable to several threats, including habitat destruction and modification and the effects of natural stochastic events on fragmented populations. Consequently, this species is listed as state–endangered in Oregon, a candidate species in Washington, and a candidate for threatened or endangered Federal listing. The continued decline of the Washington ground squirrel's range underscores the need to assess its biology and ecology, and to proactively apply this knowledge to conservation efforts.

This is the first study to estimate adult and yearling Washington ground squirrel space requirements using radio–telemetry. I tracked the movements of 46 females and 34 males at six sites near Boardman, Oregon in 2004 and 2005. I described each squirrel's home range, core area, distances moved, and movement rates, and compared these measurements among the following six factors: site, sex, year, population size, presence of shrub cover, and vegetation type.

Home range sizes varied from 435 $m^2$ to 77,021 $m^2$ with 95% Fixed Kernel Estimates (FKE); core areas ranged from 46 $m^2$ to 8,181 $m^2$ using 50% FKE estimates. There was extensive seasonal and monthly home range overlap, but little core area overlap. Fixed kernel home ranges and core areas were significantly larger for males than females ($p < 0.01$), and for squirrels at medium–sized compared to large–sized populations ($p = 0.04$). Fixed kernel home ranges were smaller in 2004 than in 2005 ($p = 0.03$), possibly due to the higher precipitation levels in 2003 and 2004. Mean and maximum hourly distances moved were significantly larger for males than females ($p < 0.01$) and in 2005 compared to 2004 ($p = 0.05$). Minimum distances moved were significantly larger at sites with large–sized populations compared to medium populations ($p = 0.05$).

Results from this study are directly applicable to Washington ground squirrel conservation efforts. Information regarding their space use can help determine: 1) the minimum habitat necessary for individual survival, 2) the colonization potential of areas, and 3) appropriate buffer zones around occupied sites.

# THE WASHINGTON GROUND SQUIRREL

# (*SPERMOPHILUS WASHINGTONI*):

# HOME RANGE AND MOVEMENT

# BY HABITAT TYPE AND POPULATION SIZE

# IN MORROW COUNTY, OREGON

by

JODIE LEANNE DELAVAN

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
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# CHAPTER 1

# INTRODUCTION

The Washington ground squirrel (*Spermophilus washingtoni*) is endemic to the Deschutes–Columbia Plateau sagebrush–steppe and grasslands in eastern Oregon and south–central Washington. Although considered widely abundant historically (Bailey 1936), recent surveys suggest contraction toward the center of its historic range (Betts 1990, 1999; Dobkin and Sauder 2004). Wisdom et al. (2000) estimated that the Washington ground squirrel's historic (*ca.* 1850–1890) range has declined 50 to 69 percent to current (*ca.* 1985–1995) levels. Overall habitat loss has been disproportionate, with the largest loss occurring in the Blue Mountains, followed by the Columbia Plateau, Northern Cascades, and the North Glacial Mountains (Wisdom et al. 2000). The type of habitat lost has also varied range–wide. For example, in Oregon, big sagebrush–steppe habitats, which are considered primary Washington ground squirrel habitat, have declined 86 percent whereas sandy grasslands have declined 52 percent from historic (*ca.* 1850) levels (Kagan et al. 2000).

Current populations are vulnerable to several threats, including continued habitat loss and degradation, and the effects of isolation and natural stochastic events on fragmented populations. They are therefore listed as state–endangered in Oregon, as a candidate species in Washington, and as a candidate species for threatened or endangered Federal listing under the Endangered Species Act. Information on the life history requirements of Washington ground squirrels is lacking; therefore, increased understanding of their habitat requirements and biology, and application of that knowledge to restoration efforts is needed to help conserve and manage this species.

**Past Research and Monitoring Efforts**

Washington ground squirrels were thought to be extirpated in Oregon until they were rediscovered on the Naval Weapons Systems Training Facility–Boardman (NWSTF) in 1978 (Rohweder et al. 1979). Since 1978, several studies have been undertaken on this species at the NWSTF, including investigations of their current distribution, ecology, habitat requirements, and dispersal abilities (Carlson 1980; Quade 1994; Greene 1999; Klein 2005).

Betts (1990) demonstrated the geographic extent of this species' range–wide decline between 1987 and 1989 when he determined that squirrels were extirpated from 74 to 77 percent of previously occupied sites in Washington and Oregon. In 1998, Betts (1999) resurveyed most of the sites that were occupied during his first survey, finding squirrels at only nine Oregon and 37 Washington sites.

The Oregon Department of Fish and Wildlife (ODFW) systematically surveyed the Boardman Conservation Area (BCA) in 1999 (Morgan and Nugent 1999), and The Nature Conservancy (TNC) currently monitors BCA sites regularly. The ODFW has surveyed known NWSTF sites regularly for the past several years, but the entire facility has not been thoroughly surveyed for Washington ground squirrels.

In Washington, the Bureau of Land Management (BLM), Columbia National Wildlife Refuge (CNWR), and Washington Department of Fish and Wildlife (WDFW) monitor populations on Federal, state, and some private lands. The WDFW has also investigated how landscape composition affects site occupancy (Germaine et al. 2007). Additionally, there are ongoing studies addressing diet requirements (Tarifa and Yensen 2003, 2004), demography and behavior (Sherman and Shellman Sherman 2007), and population dynamics and genetics (J. Morgan, Washington State University, pers. comm. 2006).

Past studies provide some indication of Washington ground squirrels' space requirements (Carlson et al. 1980; Greene 1999; Klein 2005; Sherman and Shellman Sherman 2006). Sherman (2000) observed that males defended territories of 370 to 930 $m^2$, with the burrows of up to six females that were located within the territory of each male. Klein (2005) studied juvenile male dispersal, and found that 72 percent of her study sample dispersed a median distance of 880 m (range 40–3521 m). Sherman and Shellman Sherman (2005, 2006) also documented dispersal distances of up to 1300 m in juvenile males during their mark–recapture studies. They noted that short–range male dispersal (<400 m) occurs, but long–range (≥700–1700 m) male dispersal is very rare, and possibly non–existent (Sherman and Shellman Sherman 2006). They also inferred rare short–range adult female dispersal after they captured unmarked adult females in mark–recapture grids that had been previously trapped out (Sherman and Shellman Sherman 2007).

**Research Needs/Significance of Study**

Despite the recent increase in research and monitoring efforts, very little is known about Washington ground squirrels' space requirements. The study described herein is the first to estimate Washington ground squirrel home range and core area sizes, and the second study to use radio–telemetry to evaluate their space movement. More specifically, I compared movement, home range, and core area sizes of squirrels in shrub–, cheatgrass–, and bunchgrass–dominated habitats. This was a two–year study, occurring between January to June in 2004 and 2005, concurrent with squirrel emergence and immergence.

Information gathered in this study on adult and yearling home ranges, core areas, and movements is directly applicable to the conservation of this species. First, this information can help delineate the minimum habitat area necessary for individuals to survive and persist as a population. Secondly, data on adult and yearling dispersal, in combination with data on habitat requirements, can help determine the colonization potential of areas and potentially further the understanding of Washington ground squirrel population dynamics.

Increased knowledge of the space requirements and dispersal capabilities of members of this species can help prioritize where to develop or enhance dispersal corridors in fragmented habitat. Information on movement patterns can also be used to better delineate buffer zones at occupied sites, by determining the potential for individuals to shift their home ranges. Finally, the extent of individual and/or population shifting can be incorporated into a search radius for resurveying sites that have not been visited for a period of time.

## Home Range Dynamics

Burt (1943) first described home range as the "area traversed by the individual in its normal activities for food gathering, mating, and caring for young." He noted that occasional movements outside the primary area should not be included in a home range estimate (Burt 1943). A more recent definition describes home range as the probability of occurrence of an animal in a given time period (Kernohan et al. 2001). Hayne (1949) introduced the notion of a "center of activity," or area of most concentrated use, within a home range, which is now referred to as the core area.

Many factors can affect the size and distribution of home ranges, core areas, and an individual's movement. Generally, home range sizes are greater for carnivores and larger species (McNab 1963; Sanderson 1966; Harestad and Bunnel 1979; Swihart et al. 1988). Range sizes change with an individual's resource needs, resource abundance, distribution, and habitat productivity (e.g., food, cover), as well as population density and individual body mass (McNab 1963; Harestad and Bunnell 1979; Hanski et al. 2000; Harris and Leitner 2004).

For many mammals, space use and range size varies between the sexes, age classes (Harestad and Bunnell 1979) and reproductive status (Michener and McLean 1996; Benson and Chamberlain 2007; Grignolio et al. 2007). Harestad and Bunnell (1979) found that sex–related differences in home ranges were largely attributable to sex–related differences in body weight. However, home range sizes may differ between sexes due to varying resource needs, since females depend on nest resources, whereas males are driven by female distribution (Ostfeld 1990; Hanski et al. 2000), and both sexes need access to similar resources insofar as trophic and space resources are concerned.

Generally, home range sizes decrease with increasing resources and food availability (Boutin 1990; Hubbs and Boonstra 1998; Harris and Leitner 2004). There are exceptions, such as when Harris and Leitner (2004) documented smaller ranges during drought years for Mohave ground squirrels (*S. mohavensis*). The authors reasoned this was due to a lack of reproduction in the drought year, in turn causing squirrels, particularly females, to require fewer resources for survival.

Home ranges are estimated with a variety of models including bounded areas or polygons (e.g., Minimum Convex Polygons [MCPs]; Mohr and Stumpf 1966), grid densities (Siniff and Tester 1965), harmonic mean (Dixon and Chapman 1980), and probability methods such as ellipses (e.g., Jennrich–Turner [JT]; Jennrich and Turner 1969) and kernel home range methods (Worton 1989). Each estimator has strengths and weaknesses related to the sample size, degree of sensitivity to autocorrelation, and sensitivity to outliers among other categories of major assumptions.

The Minimum Convex Polygon method, or MCP analysis, is the oldest and simplest method. It creates a polygon using the outermost locations and calculates the area within the polygon as the home range. It is problematic because it incorporates potentially unused habitat within its estimate. Also, the MCP method is sensitive to small sample sizes, meaning there is a tendency to underestimate an individual's home range size when the individual has a small number of location fixes. However, MCPs are less sensitive to autocorrelation and are still the most commonly used method, which makes them more readily comparable among studies.

Probabilistic methods, or utilization distributions, such as fixed kernel estimates (FKE) and JT analyses can better describe how animals use an area within their home range (Jennrich and Turner 1969; Worton 1989). Both methods are more reliable than the MCP method at smaller sample sizes (Hooge et al. 1999). A disadvantage of probabilistic methods is that they can be sensitive to serial autocorrelation (Hooge et al. 1999), although it appears that FKEs are less sensitive to autocorrelated data than JT estimates (Millspaugh and Marzluff 2001). Specifically, if the time interval between two successive fixes is too short then the fixes may not be statistically independent, which can underestimate home range size (White and Garrott 1990). Swihart and Slade (1985) proposed Schoener's (1980) ratio statistic, $t^2/r^2$, as a tool to determine the time interval needed between two consecutive locations to obtain statistical independence. However, corrections for autocorrelation may lead to more bias than autocorrelation itself (Anderson and Rongstad 1989; Gese et al. 1990; Reynolds and Laundré 1990), particularly when the time interval needed for statistical independence limits the total number of fixes obtained to estimate a home range. Alternatively, some researchers focus on whether two fixes are "biologically independent," meaning that the time between two consecutive fixes allows an animal to traverse its entire home range (Lair 1987; Ganey and Balda 1989). Generally, adequate sampling of movements over the course of a study is considered more important that determining the time interval needed to prevent or reduce autocorrelation (Millspaugh and Marzluff 2001).

## Research Objectives and Hypotheses

**Research Objectives.** I addressed the following research objectives:

1. Compare home range and core area sizes by site, sex, year, and site characteristics (i.e., population size, vegetation type, and presence of cover).
2. Compare distances and rates moved by site, sex, year, and site characteristics.

3. Determine whether radio–collared individuals disperse, and determine any other notable movements or trends.
4. Quantify the ground and cover vegetation at each site.
5. Collect and analyze mark–recapture data to determine population size and structure.
6. Determine the fates of radio–collared individuals.

**Null Hypotheses**. For objectives 1–3, this study addresses the following null hypotheses:

1. Home range and core area sizes are equal among sites, sexes, years, and site characteristics.
2. Distances moved and movement rates are equal among sites, sexes, years, and site characteristics.
3. If dispersal occurs, the percent of dispersers and distances moved will not differ among sites, sexes, years, or site characteristics.

CHAPTER 2

SPECIES REVIEW

## Taxonomy and Species Description

Washington ground squirrels belong to the family Sciuridae, subfamily Sciurinae, tribe Marmotini, subtribe Spermophilina, genus *Spermophilus,* and subgenus *Spermophilus*. They are one of five North American small–eared ground squirrels (Harrison et al. 2003; Yensen and Sherman 2003), along with Townsend's (*S. townsendii*), Idaho (*S. brunneus*), Merriam's (*S. canus*), and Piute (*S. mollis*) ground squirrels. They are most closely related to Idaho and Townsend's ground squirrels (Howell 1938; Nadler 1966; Harrison et al. 2003).

Washington ground squirrels are distinguished from other ground squirrels by the combination of their smaller size, light eye ring, small pinnae, shorter tail, and their white speckled dorsum (Howell 1938; Carlson et al. 1980; Yensen and Sherman 2003). They range from 185 to 245 mm in length, and their mass fluctuates throughout the season (Rickart and Yensen 1991). In the subgenus *Spermophilus*, only the Columbian (*S. columbianus*) and Belding's ground squirrels (*S. beldingi*) are sympatric with Washington ground squirrels (Rickart and Yensen 1991).

The Washington ground squirrel is a diurnal and semi–fossorial rodent that is active only four to five months per year. Adults emerge from hibernation between January and early March, depending on elevation and microhabitat conditions (Sherman 2000). Males usually emerge before females (Bailey 1936), and adults emerge before yearlings (Sherman 2000). Adults begin dormancy, estivating (in the summer) and hibernating (in the winter), starting late May to early June. Juveniles enter dormancy in late June to July (Carlson et al. 1980).

Washington ground squirrels have one litter per year, averaging 5 (Carlson et al. 1980) to 8 (Scheffer 1941) pups per litter. Breeding occurs in January and early February (Verts and Carraway 1998), shortly after females emerge from hibernation (Sherman 2000). Males appear polygamous, but this observation has not been confirmed by DNA analysis (Sherman and Shellman Sherman 2005). Yearling females are sexually mature but males are not until they reach two years of age (Sherman 2000). Gestation and lactation take 49 to 50 days (Sherman 1999), and pups are weaned and emerge in mid–March to early April (Carlson et al. 1980; Sherman 1999). Most Washington ground squirrels live less than five years, but Sherman and Shellman Sherman (2006) documented a female that was at least eight years old.

Washington ground squirrels can be solitary (Yensen and Sherman 2003) or occur in colonies of a few or up to 250 individuals (Bailey 1936; Csuti et al. 1997). Females are exceptionally social, forming coalitions of two to four females within their semi–isolated communities (Sherman and Shellman Sherman 2005, 2006).

Males defend territories with up to six females in their territory (Sherman 2000). Male territories are maintained throughout the active season and males appear more mobile and/or dispersive than females (Greene 1999; Sherman and Shellman Sherman 2005). Klein (2005) determined the dispersal status of 102 juvenile males in Oregon, finding that 72 percent dispersed distances from 40 to 3521 (median = 880) m. Juvenile males only dispersed to sagebrush (*Artemisia* sp.) and annual grasslands, instead of low shrub and perennial grasslands. One caveat is that low shrub and perennial grasslands were much less common than sagebrush and annual grassland habitats in the study area. Squirrels appeared to select sites with silt–loam texture soils and sites closer to primitive roads and historically occupied areas. Primitive roads were not dispersal barriers but land in agricultural production likely altered dispersal patterns (Klein 2005).

## Geographic Distribution

**Historic Range.** Washington ground squirrels are endemic to the Columbia Plateau, south of the Columbia River and east of the John Day River (Howell 1938; Hall 1981; Csuti et al.1997; Verts and Carraway 1998; Figure 1). They were considered widely abundant historically (Bailey 1936), and their range may have been contiguous (Verts and Carraway 1998) or patchy. Their distribution was likely driven by foraging (Vander Haegen et al. 2001) and soils needs. Historic records of this species exist in the following counties: Franklin, Douglas, Adams, Grant, Lincoln, Walla Walla, Spokane, Garfield, Columbia, and Whitman counties in Washington and Gilliam, Morrow, Umatilla, and possibly Sherman counties in Oregon.

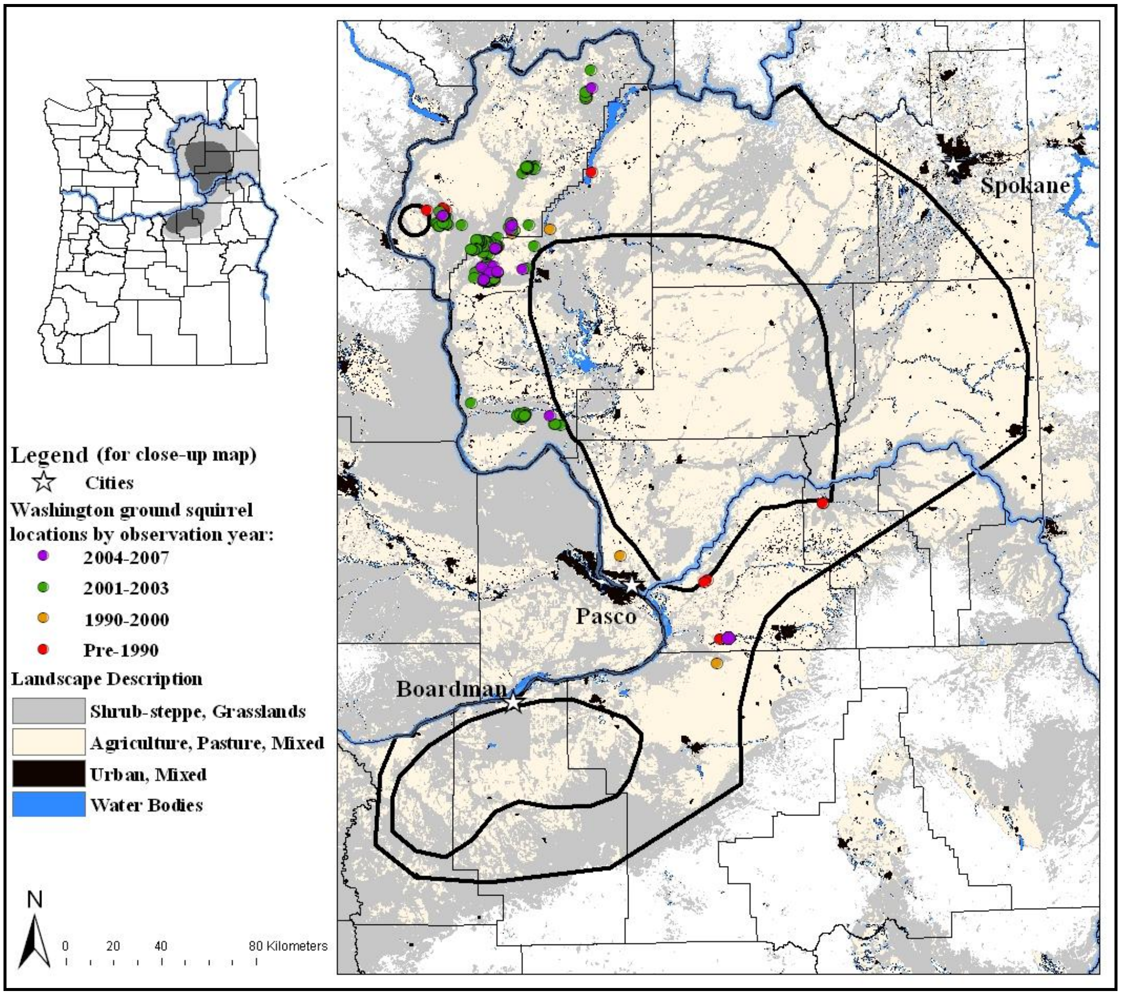



**Figure 1**. A comparison of the historic and current range of the Washington ground squirrel. The Washington ground squirrel's historic range (outer perimeter) has been reduced to three areas (circles within the outer perimeter; after Betts 1990) in Washington and Oregon. Washington ground squirrel sightings that have been reported[1] *outside* of Betts' estimated current range are shown, suggesting the potential need to reevaluate what is considered the Washington ground squirrel's current range. Major landscape types within their current and historic ranges are depicted; white areas include all other landscape descriptions (Northwest Habitat Institute 2002).

[1] All point data was based on information reported to the Oregon and Washington Heritage Programs with the exception of the estimated location of one colony (State–Line Wind Farm) in Washington. Points may represent small or large colonies, or single individuals, and are not intended to represent an occupied unit of area. Post–1990 observations within Betts' (1990) range are not shown. No warranty is made as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Additional locations, if they exist, that were not reported to the state heritage programs were unavailable to evaluate. Spatial information may not meet National Map Accuracy Standards.

**Current Range.** Washington ground squirrels occur east of the Columbia River generally in two clusters in Washington and one south of the Columbia River in Oregon (Betts 1990, 1999). Betts (1990) described these three areas as disjunct, separated by more than 50 km of unoccupied land. However, based on information provided in Finger et al. (2007), the two Washington clusters may only be separated by 10 to 20 km of unoccupied land. Washington ground squirrel locations that were reported after Betts' 1990 range map was published show more recent (post–1990) detections in Douglas and Grant Counties outside of Betts' (1990) approximated range, suggesting a potential need to reassess the current status of the Washington ground squirrel's distribution.

Badger Mountain, in Douglas County, Washington, is the smallest and most northwesterly population. The Columbia Basin population in southeast Washington includes colonies on private, TNC, BLM, state (Seeps Lakes Wildlife Management Area), and U.S. Fish and Wildlife Service (USFWS; Columbia National Wildlife Refuge) land. Many of the colonies within this population occur in isolated fragments of suitable habitat, with little or no chance of genetic interchange.

The Oregon population is centered almost entirely on the Naval Weapons System Training Facility–Boardman (NWSTF) and the adjacent Boardman Conservation Area (BCA). There are few known Washington ground squirrel sites apart from the BCA and NWSTF in Oregon, making these lands essential to the long–term viability of Washington ground squirrels in Oregon. Furthermore, the Oregon population is the most densely occupied area of contiguous habitat within the entire range.

**Habitat and Diet**

Washington ground squirrels occupy shrub–steppe and steppe habitat in the Interior Columbia Basin ecosystem (Verts and Carraway 1998; Dobkin and Sauder 2004). While historically associated with sagebrush and bluebunch wheatgrass (*Pseudoregneria spicata*) macrohabitats, much of the native vegetation has been removed or altered such that cheatgrass (*Bromus tectorum*) and rabbitbrush (*Chrysothamnus* sp.) have replaced most of the original flora in areas of nonagricultural land (Verts and Carraway 1998).

Squirrels inhabit areas with deep, tillable, sandy and silt loam soils that are capable of maintaining burrow systems (Greene 1999; Yensen and Sherman 2003). On the BCA, most squirrels are found in Warden and Sagehill soil series, which incidentally are also the dominant soil associations on the BCA (Morgan and Nugent 1999). Squirrels also occupy other soil types including Royal, Quincy, Koehler, Burbank, and Ellum soil series (Greene 1999; Morgan and Nugent 1999; Marr 2001). Their burrows are small, inconspicuous, and often located under obstructions (e.g., brush, bunchgrass, or wood, rock piles, or other debris). Soil excavated from burrows is typically scattered without forming mounds (Yensen and Sherman 2003), and vegetation around entrances is often removed or clipped (Greene 1999). Washington ground squirrel burrows have been described as simple, with few branches (Bailey 1936; Quade 1994).

Washington ground squirrels rarely construct burrows in areas of heavily disturbed soils, such as areas affected by activities including plowing, discing, and crop production, and are known to utilize vacated burrows from other species (Betts

1990, 1999; Greene 1999). Squirrels have been observed in areas previously used for agriculture, such as farmland enrolled in the Natural Resources Conservation Service's Conservation Reserve Program (CRP). The CRP is a voluntary program that provides technical and financial assistance to eligible farmers to address natural resources concerns by temporarily taking highly erodible or environmentally sensitive land out of agricultural production, potentially providing wildlife habitat. Although Washington ground squirrels have been observed on CRP lands, observers have not documented whether squirrels observed on CRP lands were dispersers, individuals from established colonies, or individuals with home ranges that overlapped both agricultural and non–agricultural land.

Washington ground squirrels tend to occupy areas with greater grass and forb cover (Betts 1990; Greene 1999). While transect surveys and capture–recapture data found higher squirrel densities in sagebrush, followed by grassland habitat, adult and juvenile weight was highest in bunchgrass, followed by sagebrush, and low–shrub habitats. Recruitment was highest in sagebrush, followed by bunchgrass, and then low–shrub habitat (Greene 1999). This suggests that both quality of food and cover are important habitat components for the species.

Washington ground squirrels have a diverse diet that includes stems, buds, leaves, flowers, roots, bulbs, and seeds of a variety of forbs and grasses (Greene 1999). They will also eat insects (Carlson et al. 1980) and crops such as cabbage, peas, corn, oats, wheat, rye, barley, and alfalfa when available (Bailey 1936; Howell 1938). Diverse diets enable them consume enough protein for reproduction and store fat for survival during dormancy (Tarifa and Yensen 2004; Sherman and Shellman

Sherman 2005). Although their diets are varied, they are selective feeders, and Sandberg's bluegrass (*Poa sandbergii*) appears to be a particularly important species in their diet (Tarifa and Yensen 2004).

**Ecological Significance**

Washington ground squirrels are an important component of the sagebrush–steppe ecosystem. They are a crucial prey base for several carnivore species, including ferruginous hawks (*Buteo regalis*), Swainson's hawks (*B. swainsoni*), and badgers. Furthermore, the holes excavated by badgers pursuing ground squirrels provide habitat for other species including snakes, lizards, ground squirrels, insects, and burrowing owls (Greene 1999). By creating and maintaining burrows, Washington ground squirrels also reduce soil compaction, loosen and aerate soils, and increase the rate of water infiltration into soil. They also increase soil fertility, plant productivity, and plant diversity by bringing nutrients and buried seeds to the surface, thereby increasing microhabitat diversity (Vander Haegen et al. 2001; Yensen and Sherman 2003).

**Population Estimates**

Range–wide and often local–level population dynamics of Washington ground squirrels are poorly understood (ODFW 1999). A cost–effective and scientifically sound method to estimate long–term population size and status in this species has yet to be developed and implemented. Mark–recapture studies have addressed local sex–ratios, age structure, and Washington ground squirrel abundance in Oregon (Carlson et al. 1980; Quade 1994; Greene 1999; Klein 2005) and Washington (Sherman and Shellman Sherman 2007). Populations appear to fluctuate widely at a local scale, but long–term monitoring of populations is needed to understand long–term population dynamics at local and range–wide scales.

## Threats to Survival

Various threats impact Washington ground squirrel populations, but the type and degree of threats are not uniform throughout their range (Finger et al. 2007).

**Habitat Alteration and Fragmentation.** Historic and current destruction and degradation of Washington ground squirrel habitat is the largest threat to the survival of the species. Approximately two–thirds of their historic range has been destroyed or modified, mostly by agricultural development (Vander Haegen et al. 2001; Tarifa and Yensen 2004). Historically, agricultural development has been more common in areas with tillable, deep soil, resulting in a disproportionate loss of deep soil communities that support Washington ground squirrels (Vander Haegen et al. 2001). Habitat loss and modification from agricultural, power, and residential/urban development, as well as overgrazing, among other activities, continue throughout much of its range.

Invasive Plants. A large–scale threat is the establishment and spread of invasive plant species throughout the Washington ground squirrel's range. Cheatgrass dominates most of the Columbia Basin shrub–steppe, occurring in large, dense, continuous patches in both inter–shrub and below–shrub spaces. Cheatgrass often outcompetes native bunchgrasses and forbs that are important for Washington ground squirrel diets. It can eliminate sensitive species from sites such as native bunchgrasses and forbs, decrease the nitrogen available to perennials, and shade out biological crusts that fix nitrogen (Ypsilantis 2003). Squirrels consume cheatgrass, but its nutritional value is uncertain and it is considered an inferior food source (Vander Haegen et al. 2001; Tarifa and Yensen 2003, 2004). Washington ground squirrels may enter dormancy earlier when food supply is low, which can be detrimental if the squirrels have not achieved adequate weight to survive until emergence the following spring (Carlson et al. 1980). Inter–year mortality can be very high in Washington ground squirrel populations (Sherman and Shellman Sherman 2006), thus, ensuring that populations have adequate forage throughout their active season to assure maximal year–to–year survival rates is of great conservation concern.

Altered Fire Intervals. Increased fire frequency is another large–scale threat to this species. In squirrel habitat, fires and other ground disturbing activities are usually followed by cheatgrass establishment. Cheatgrass increases the natural fire hazard, changing fire recurrence intervals from 20 to 100 years to 3 to 5 years. It also increases fire intensity, size, and rate of spread (Ypsilantis 2003). Increased fires that occur early in growing season allow cheatgrass to further outcompete native species (Yensen et al. 1992; Marr 2001; Vander Haegen et al. 2001). Wildfires also kill sagebrush, and shortened fire intervals often kill sagebrush seedlings before they reach a reproductive age, thereby eliminating sagebrush from the community.

Fragmented Landscapes. Habitat isolation and fragmentation further affects species, such as the Washington ground squirrel, by increasing their vulnerability to a variety of natural and anthropogenic factors (e.g., fire, disease, drought, predation, invasive plants, incompatible land use practices; Quinn 2004). Isolation and fragmentation also limit genetic exchange and reproduction, decrease genetic diversity, and can cause genetic drift (Gavin et al. 1999; Garner et al. 2005). Although the existence of isolated colonies can hinder the spread of disease, isolation makes it unlikely that colony sites will be repopulated if they did become extinct (Betts 1990). Although male dispersal distances have been documented in Oregon up to 3,521 (median = 880) m, dispersal over 400 m in Washington is considered rare (Sherman and Shellman Sherman 2006), suggesting that rates of recolonization and range expansion are low (Wolff and Sherman 2007).

**Lethal Control.** Washington ground squirrels are often viewed as agricultural pests and are shot or poisoned to reduce impacts to agricultural crops (ODFW 1999; WDFW 2005). Sport shooting and poisoning can be devastating to species when populations are small and isolated (Yensen and Sherman 2003). This species' steep population decline from 1948 to 1970 was attributed to years of control by poisoning and/or shooting, in addition to significant habitat loss (ODFW 1999).

**Disease.** One of the most potentially devastating diseases to Washington ground squirrels is plague, which can invade rapidly, have large impacts, and lead to local extirpation (Biggins and Kosoy 2001). While ectoparasites (e.g., fleas, mites) are frequently observed on Washington ground squirrels, they rarely appear problematic (Carlson et al. 1980; Sherman 1999, 2000; Sherman and Shellman Sherman 2005). Plague has been documented within the Washington ground squirrel's range (Svihla 1939). Although there was no direct evidence of plague–cased mortality, Svhila (1939) reasoned that it caused colony extirpations in the region where the disease was documented. Additionally, a colony of Townsend's ground squirrels, a closely related species, was seriously reduced by an outbreak of sylvatic plague in Washington in 1936 (Betts 1990).

**Predation.** A major cause of mortality is predation (Betts 1990, 1999). Known predators include badgers (*Taxidea taxus*), various birds of prey, long–tailed weasels (*Mustela frenata*), gopher snakes (*Pituophis melanoleucus*), and western rattlesnakes (*Crotalus viridis*; Carson et al. 1980; Greene 1999; Verts and Carraway 1998; Sherman 1999, 2000; Klein 2002, 2003; Sherman and Shellman Sherman 2005). Badgers and raptors commonly prey on Washington ground squirrels and are a particular threat to small, isolated colonies because they may cause local extirpations (Betts 1999; Morgan and Nugent 1999).

**Natural Stochastic Events.** Weather also threatens this species, by altering the availability of food resources and affecting the timing of emergence and/or dormancy. Weather and climate fluctuations occur naturally, but adverse effects of drought may be more significant when considered in combination with other threats (ODFW 1999). Drought limits vegetation quality and quantity, which in turn reduces survival and reproduction. During drought years, leaves desiccate and seeds mature early, leaving squirrels with fewer food resources at the end of their growing season. Additionally, winter drought can cause late emergence of females, reducing the amount of time available to fatten and reproduce. Studies on other rodent populations have documented fluctuations in population densities with climate conditions, mainly by impacting food availability which can affect survival and/or reproduction (Smith and Johnson 1985; Brown and Heske 1990; Quade 1994; Sherman and Runge 2002; Getz et al. 2007). Unpublished studies have also noted decreased squirrel activity after drought years (Quade 1994), and increased abundance following years with above–average rainfall (Greene 1999).

**Competition.** Columbian and Belding's ground squirrels appear to currently occupy areas that formerly supported Washington ground squirrels (Carlson et al. 1980). Both squirrel species are larger and may outcompete Washington ground squirrels for available resources in disturbed habitats. It is not known whether they could or will further encroach upon Washington ground squirrel habitat in disturbed areas.

**Inadequate Regulatory Protection.** Current regulations do not adequately protect Washington ground squirrels in Oregon and Washington. Although they are a Federal candidate species (USFWS 2007), Federal regulations and policies do not protect them, as "candidate species" carries no regulatory implication. They are also a candidate species in Washington, but their status does not give them the same legal protection afforded to listed species. They receive some protection since they are listed as "other protected wildlife" in Washington, which prohibits hunting, malicious killing, and possession of the animals on all lands, including private property. Washington ground squirrels are state–endangered in Oregon, and are therefore protected from "take" (to kill or obtain possession or control) on state–owned, leased, or managed lands. They are generally not protected on private property in Oregon, except when there is a potential for take associated with an action involving the state of Oregon. While they are protected from hunting, shooting, killing, or possession as a "nongame species" on all Oregon land, an exemption allows landowners to kill any rodent by poisoning, trapping, or other means.

# CHAPTER 3

# SITE DESCRIPTION

Shrub–steppe is among the largest natural grasslands in North America (O'Conner and Wieda 2001), and it historically covered 54 to 63 million ha in the western states (O'Conner and Wieda 2001; Knick et al. 2003). The Columbia Plateau Ecoregion, which covers approximately 30 million ha in California, Idaho, Nevada, Oregon, Washington, Utah, and Wyoming, (TNC 1999), currently has about 14 million ha of sagebrush communities (Knick et al. 2003). Knick et al. (2003) estimate that 50 to 60 percent of native shrub–steppe has either exotic annual grass in the understory or has been converted completely to non–native annual grasslands, making it among the most imperiled ecosystems in North America.

Northwest shrub–steppe belongs to the interior Columbia Basin, or Columbia Basin Ecoregion, which covers two–thirds of eastern Washington and north–central Oregon (O'Conner and Wieda 2001). Shrub–steppe historically occupied 89 percent of the Columbia Basin Ecoregion, but now only occupies 32 percent (O'Conner and Wieda 2001). Much of the native shrub–steppe has been removed or degraded in the past 150 years by agriculture and, most recently, by urban development, intensive grazing, introduction of non–native plants, and altered fire regimes. The remaining native habitat is fragmented and vulnerable to ongoing development and the persistence and spread of invasive plants.

## Study Area

This study was conducted in north–central Oregon on the 9,163 ha, TNC–managed Boardman Conservation Area (BCA) and the adjacent 19,182 ha Naval Weapons System Training Facility–Boardman (NWSTF; Figure 2). The BCA and NWSTF are located in the Umatilla Plateau section of the Columbia Plateau Ecoregion (Clark and Bryce 1997; TNC 1999), south of Boardman, about 275 km east of Portland, Oregon.

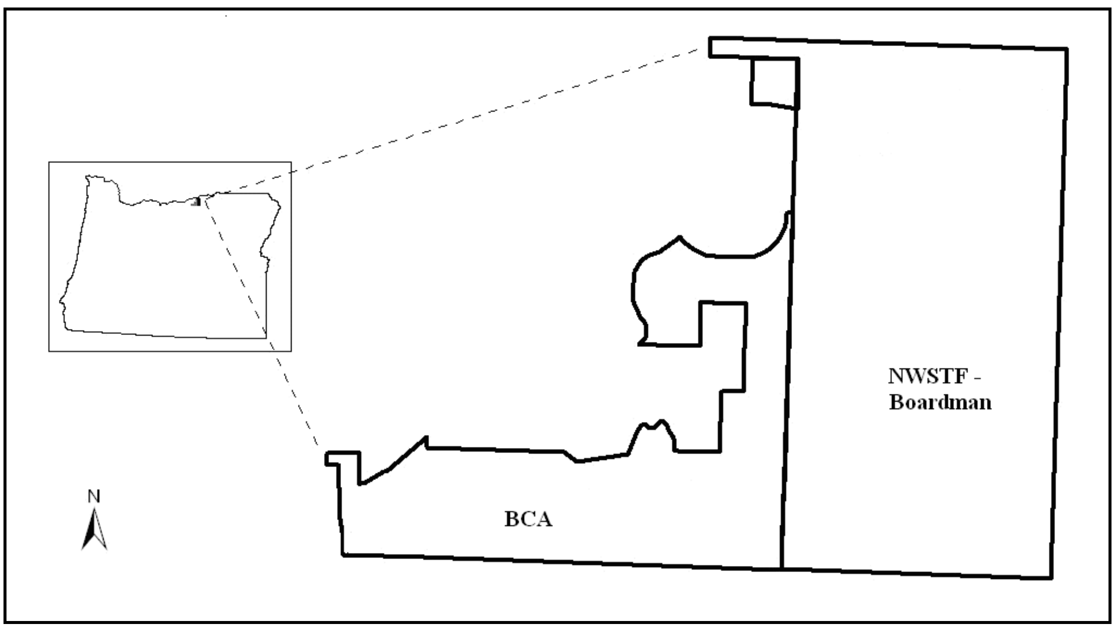



**Figure 2.** Location of study in Morrow County, Oregon on the Boardman Conservation Area and Naval Weapons Systems Training Facility–Boardman. This area contains a large portion of native shrub–steppe and grasslands considered significant for conservation by The Nature Conservancy, among others (Nelson 2004).

The climate is semi–arid with hot, low–precipitation summers and cold winters. Monthly mean temperatures vary between 5 and 19$^{o}$C, with lows below freezing in the winter and highs above 38$^{o}$C in the summer. Average annual precipitation varies from 230 mm on the north part of the study area to 280 mm on the southern portion, with about half of the annual precipitation falling as snow. January typically receives the most precipitation, and summers receive less than ten percent of the total annual precipitation. The study area is windy throughout the year, especially from March to July when winds often exceed 40 kph (Nelson 2004).

The study area was formed by a series of cataclysmic floods during the Pleistocene epoch (10 KYA to 1.8 MYA), the Missoula floods, and the development of prehistoric lakes (Lake Condon; Allen et al. 1986). Lake Condon rose to an elevation of approximately 305 m and covered approximately 401,448 ha in The Dalles and Umatilla Basins (Allen et al. 1986). The elevation in the study area ranges from 122 to 305 m, with the greatest topographic relief on the southern third of the area. The most distinctive topographic features in the study area include Juniper, Well Springs, Sixmile, Fourmile, and Schoolhouse Canyons.

Quincy–Koehler, Sagehill–Taunton, and Warden are the dominant soil associations in the study area (U.S. Department of Agriculture 1983). Quincy–Koehler association soils are moderately deep, loamy, fine sand soils, located mainly on the northern portion of the BCA and NWSTF where two of my study sites, Stipa 112 and Spigot 190, are located. Sagehill–Taunton association soils occur immediately south of the Quincy–Koehler association, and are very deep with a sandy loam or fine sandy loam surface. The southern portion of the BCA and NWSTF, where the remaining four study sites were located consists of mostly Warden Association, with some Sagehill–Taunton soils. Warden soils are very deep and well–drained soil with a silt loam surface. There are also areas with alkaline soils near Tub and Well Springs on the NWSTF.

Plant communities include sagebrush, bitterbrush (*Purshia tridentata*), bunchgrass (e.g., bluebunch wheatgrass, western needle–and–threadgrass; *Heterostipa comata*), low shrub, and annual grass/forb habitats. Sagebrush, bitterbrush, and bunchgrass communities are most representative of native conditions, but still contain some invasive, non–native plants. Sagebrush and bitterbrush communities both generally contain an understory of bunchgrasses and forbs with cryptogamic crusts. Bunchgrass communities typically include bluebunch wheatgrass, needle–and–threadgrass, and Sandberg's bluegrass. Low shrub communities contain rabbitbrush and matchweed (*Gutierrezia sarothrae*) with a cheatgrass understory, and annual grass communities contain mostly cheatgrass and other invasive annuals, with few shrubs and native bunchgrasses. Low shrub and annual grass communities occur in areas with intense grazing, recent fire, or similar land disturbance. There are also scattered junipers in the study area, with some of the largest and most dense patches in the north section of the BCA.

The study area supports an array of wildlife, including breeding populations of ferruginous hawks, Swainson's hawks, western burrowing owls (*Speotyto cunicularia*), grasshopper sparrows (*Ammodramus savannarum*), sage sparrows (*Amphispiza belli*), loggerhead shrikes (*Lanius ludoviciamus*), and long–billed curlews (*Numenius americanus*). The area also contains northern sagebrush lizards (*Sceloporus g. graciosus*), and migration and winter habitat for bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*).

The BCA is managed by TNC to protect, maintain, and restore the native bunchgrass and shrub–steppe ecosystems and their associated at–risk species. This includes maintaining and, as possible, recovering populations of the Washington ground squirrel, ferruginous hawk, loggerhead shrike, and sage sparrow. Cattle and sheep grazing occurred on the BCA for many years, but ceased in 2006. TNC is currently involved with vegetation mapping and monitoring, and conducts squirrel monitoring and vegetation treatments to determine the appropriate habitat restoration methods for the site.

The NWSTF is used by the Navy for military training exercises, but 1,922 ha are Research Natural Areas. The NWSTF was grazed heavily in the past but does not currently have a grazing lease. The property's natural resources are currently managed according to the Navy's Integrated Natural Resource Management Plan.

# CHAPTER 4

# MATERIALS AND METHODS

## Site Selection and Classification

Sites were selected in January and February 2004 if they were accessible, contained active colonies since 2002, and met the size and vegetation requirements of my proposal. Specifically, I selected sites that allowed me to compare movements among sites with different population sizes (i.e., small, medium, or large) and habitat types (native versus non–native vegetation; shrub–dominated versus sites with little shrub cover). Two sites contained smaller populations (under 20 individuals), two were medium–sized (21–49 individuals), and two had larger populations within the study area's mark–recapture grid (50–100+ individuals). Sites represented shrub, cheatgrass, and bunchgrass–dominated habitat types.

The Naval Weapons System Training Facility–Boardman (NWSTF) sites included the Cemetery (large squirrel population, non–native vegetation, no shrub cover), Stipa 112 (small, native, no shrub cover), and Spigot 190 (small, non–native, no shrub cover) locations. Boardman Conservation Area (BCA) sites included the Sage (large squirrel population, native vegetation, with shrub cover), Open low shrub (OLS; medium, non–native, with shrub cover), and Large Stipa (medium, native, no shrub cover) locations. Site locations are displayed in Figure 3 and photographs of sites are displayed in Figures 4a to 4f.

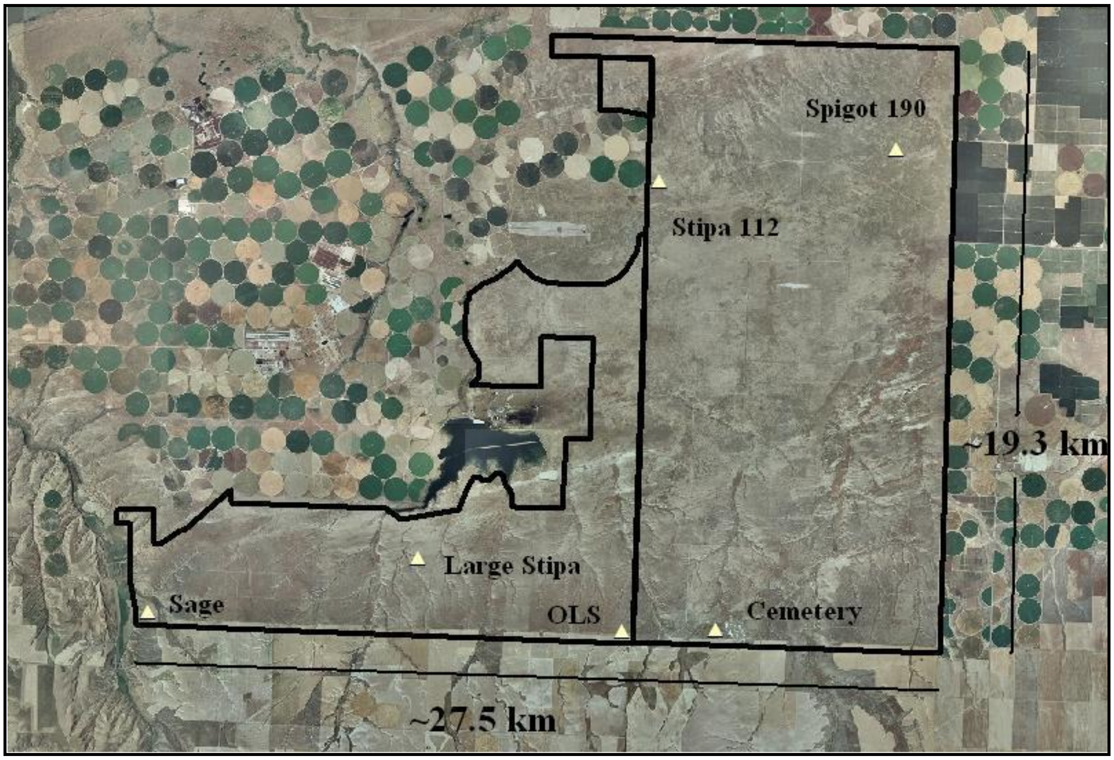



**Figure 3.** Distribution of study sites. Sage, Large Stipa and OLS sites were located on the BCA. The Cemetery, Stipa 112, and Spigot 190 sites were located on the NWSTF.


**Figure 4.** 2004 Photographs illustrating vegetation communities by site: a) Cemetery, b) Sage, c) OLS, d) Large Stipa, e) Stipa 112, and f) Spigot 190.

**Vegetation Analysis**

I sampled vegetation using a step–point method (BLM 1996) to verify my original vegetation classifications. The step–point method measures individual species, total cover, and species composition by cover. It involves making observations from a 100–meter transect at specified intervals using a pin to record basal and cover hits. Ten sub–transects were placed perpendicularly, centered along the 100–meter transect and randomly starting between zero and nine meters at ten meter intervals. I took twenty samples along each sub–transect, recording data every two paces. Ground–level basal hits (i.e., litter, soil, crust, rock, fecal matter, and live vegetation by species) and any canopy/foliar cover hit combinations by species were recorded. If no ground–level basal vegetation was directly hit, then the nearest vegetation type within 30 cm was recorded.

**Climate**

Climate data for the general area (Hermiston, Oregon's "HRMO" weather station) was available from the United States Bureau of Reclamation's (BOR) Agrimet web site (BOR 2005). I compared the area's precipitation, temperature, and wind speed between 2004 and 2005, and compared 2004 and 2005 data to historic (1993/1994–2005) levels.

**Mark–Recapture**

Mark–recapture was used to confirm my initial population size classifications and to determine the population structure of sites. I used the saturation trapping method, by trapping sites until there were no new captures during two sequential trap sessions. I assumed that population estimates, densities, and population structures within the grid were representative of the entire colony. Trapping grids were placed over the estimated center of colonies, and their configurations varied according to the shape of each study site. All traps were placed 25 meters apart in the following configurations: Sage (4x12), OLS (7x7), Large Stipa (5x10), Cemetery (12x4), Spigot 190 (5x10), and Stipa 112 (5x10).

Study animals were captured using apple–baited Tomahawk 48x15x15 cm live traps (Tomahawk, Tomahawk, WI). Traps were covered with brush, board, or other available materials to provide shade and prevent dehydration. Hair at the end the tail was trimmed (without tail clipping) in a straight line to distinguish previously captured animals. This appeared to be an effective way to identify individuals over a short time–interval since hair at the end of the tail grows to a circular or triangular tip. Individuals were also sexed, aged, and weighed to the nearest 1 g with a spring scale (Avinet, Inc., Dryden, NY) before they were released. Squirrels were either classified as juveniles or adults/yearlings based on body weight. Sites were trapped as soon as possible after juveniles emerged when their masses were still noticeably smaller than adults and yearlings.

**Collaring and Radio–Tracking**

Individuals were trapped and radio–collared between January and March at six sites in 2004 and four sites (i.e., Cemetery, Sage, OLS, and Large Stipa) in 2005. The same trapping grids and bait used for mark–recapture were used in 2004 to capture individuals for radio–collaring. In 2005, traps were placed near holes within and adjacent to the trapping grid to expedite the trapping process. Study animals were weighed to the nearest gram, sexed, aged, and collared with 3.8–gram radio–transmitter packages (Holohil Systems, Ltd., Canada). I collared squirrels weighing at least 76 grams, to ensure collar weight did not exceed 5 percent of the individual's total body mass (Animal Care and Use Committee 1998). I collared a combination of adults and yearlings and did not distinguish between the two age classes. I attempted to mark six squirrels (three male, three female) per site each year by collaring the first females and males captured, regardless of their location on the grid. At some sites, the sex ratio of captured individuals was skewed and, due to time constraints, I collared more females than males in 2004. I attempted to even the sex ratio of the collared animals by collaring more males than females in 2005.

Squirrels were tracked between February and June of 2004 and 2005. I located squirrels using the homing method (White and Garrott 1990) with a hand–held three element antenna and one 100–channel Fieldmaster ™ receiver (Advanced Telemetry Systems, Isanti, Minnesota). Squirrels were usually tracked to burrows below ground. If a squirrel was sighted above ground then the location at which they were sighted during radio–tracking was recorded. The point at which the signal was strongest or the burrow entrance was marked with UTM coordinates (Nad27 CONUS datum) established by a Garmin 76 GPS unit (WAAS enabled to an accuracy of +/–3 m). Locations were recorded when the accuracy was at least +/–5 m. I monitored individuals until their signal was lost, collar was retrieved, or the signal was tracked to same location underground for more than five consecutive tracking sessions. If the signal was lost, an area approximately 1 to 1.5–km in diameter was searched on foot. Study animals were captured periodically to check collar fit.

I tried to obtain 30 to 50 independent locations per squirrel (tracking all squirrels at least 2–3 times per week) for home range and core area analyses. I varied the order in which I tracked sites to ensure that each squirrel had fixes that were representative of their movement patterns over the entire day. I typically visited two sites per day to reduce the travel time between sites. On several occasions I located squirrels hourly to obtain an estimate of hourly movement distances and rates.

Due to the high proportion of squirrels lost to predation in 2004, I increased the sampling effort early in 2005. To balance the need to reduce autocorrelation and obtain adequate minimum sample sizes, the minimum sampling interval was approximately one–hour.

**Determination of Fate**

Fates (i.e., predation, survival, or unknown) were determined when possible. Squirrels were presumed to have survived and to have entered dormancy when the individual was tracked to the same burrow for several days toward the end of the season. Predation was assumed when collars were found with squirrel remains or sufficient circumstantial evidence to implicate predation as the cause of their fate (e.g., collar location and condition). Collars that stopped moving underground were not retrieved since digging was prohibited on the NWSTF and in the native vegetation communities on the BCA. Therefore, these squirrels had unknown fates, but I determined probable fates for some of these collars.

**Home Range and Core Area Estimation**

Home range was defined as the area occupied by Washington ground squirrels throughout their active season (approximately January/February to May/June). I used the Animal Movement Extension Analysis (AMEA) program (Hooge and Eichenlaub 2000) to determine whether site fidelity exists, test sample size and analysis assumptions, assess the possibility of autocorrelation, and calculate home range and core area sizes.

Home ranges and core areas were calculated for all squirrels exhibiting site fidelity. The site fidelity test in AMEA is an extension of the Monte Carlo random walk test developed by Spencer et al. (1990). The program generates the number of user–specified random walks (100), and calculates for each walk the mean squared distance from the center of activity and the linearity of the path. Actual movement paths are compared to the ranked values of random walks to determine significance. To have site fidelity the animal's movement should not exhibit dispersion or linearity (Hooge et al. 1999).

Only home ranges and core areas with an adequate sample size were used in statistical comparisons. I considered sample sizes to be adequate when home ranges stabilized (i.e., did not increase with additional sampling effort), or where home ranges did not increase by more than five percent of their overall size (Gese et al.1990; Harris et al. 1990). I plotted 95% MCP (MCP95) home ranges against sample size in Biotas 1.03.1 to determine where home range sizes stopped increasing with increasing sample size. For FKEs a minimum of 30, preferably 50, samples is considered an acceptable sample size (Seaman et al. 1999).

Home range was calculated using 95 percent of each squirrel's mark–recapture and radio–telemetry locations, and five percent were removed as outliers. Fixes that were clearly dispersal locations or locations where collars were retrieved after they were taken by predators were removed from the analysis of home range and core area size.

I analyzed seasonal home ranges with three estimators including MCP95 (Mohr and Stumpf 1966), 95% FKEs (FKE95) with Least Squares Cross Validation (LSCV; Worton 1989), and 95% JT (JT95; Jennrich and Turner 1969) utilization distributions. This was done in part to make my results more easily comparable to other studies. Also, certain home ranges may better describe one species or individual than others and this method provided an opportunity to determine which estimator had the best fit. I also used Biotas 1.03.1 to calculate monthly MCP95 home ranges to compare home range overlap at a monthly–scale.

The core area was defined as the area of most concentrated use within the home range, and was calculated using 50 percent of the squirrel's locations. Core areas were calculated with 50% MCP, FKE, and JT (MCP50, FKE50, and JT50) analyses.

In addition to home range and core area size, I looked at home range and core area overlap, home range: core area size ratios, male: female home range ratios, potential squirrel dispersal, and home range shifting throughout the season. The widest length across a home range was also measured and compared among sites, sexes, years, and site characteristics.

### Movement Estimation

Squirrels were tracked at approximately one–hour (45–74 minute) intervals during the day. These data were used to determine the minimum, mean, and maximum distance moved and movement rates between consecutive squirrel locations. Hourly movement rates were calculated by dividing the distance moved between two consecutive locations by the time interval (m/hr). Distances and rates moved were pooled by individual since the information was more applicable to the individual. Distances between the initial capture point or core areas and the final location for dormancy or predation also were measured.

**Statistical Analysis**

I summarized home range and core area sizes, distances moved, and movement rates with descriptive statistics. I then compared movements by six factors including site, sex, year, presence of shrub cover, population size, and vegetation type. All distances, rates, home ranges, and core areas were plotted by these factors to determine the distribution of the data, identify outliers, and to determine whether to report results using parametric or nonparametric methods. I compared differences in movements using both Mann–Whitney Rank Sum (MW) and Kruskal Wallis (KW) tests in Systat 10 (Systat Software, Inc., San Jose, CA). I analyzed differences in ln–transformed home range and core area data with t–tests and ANOVA to stabilize the variance of the sample. Furthermore, I applied a corrected version of Akaike's Information Criterion (AICc) models to account for smaller sample sizes (i.e., number of individuals), to compare the relative fit of models for movements, home ranges, and core areas (Bedrick and Tsai 1994; Shi and Tsai 1998).

The relationship between initial capture mass and both ln–transformed home range and core area size was analyzed using Pearson correlation. The relationship between weather conditions and/or initial capture mass with movement data was analyzed using Spearman rank analysis. I also compared fates among the sites, sexes, years, and site characteristics using Fisher's exact and Chi–square tests.

For all analyses, differences were considered statistically significant when $p < 0.05$. To minimize the likelihood of error, I also reported p–values that were marginally significant ($0.05 < p < 0.10$), and p–values that, while not significant, were appreciably smaller than other p–values.

CHAPTER 5

RESULTS

## Ground and Cover Vegetation

Soil and litter comprised sixty–two to eighty–four percent of ground hits at each site (Figure 5). Sites characterized as having predominately non–native vegetation (i.e., OLS, Cemetery, Spigot 190) had more litter and less bare ground in their basal material estimates, whereas native sites (i.e., Sage, Large Stipa, and Stipa 112) contained more soil or nearly equal amounts of bare soil and litter. Non–native sites also tended to have higher levels of non–native plants, including cheatgrass, in their basal vegetation than sites with predominantly native vegetation (Figure 6).

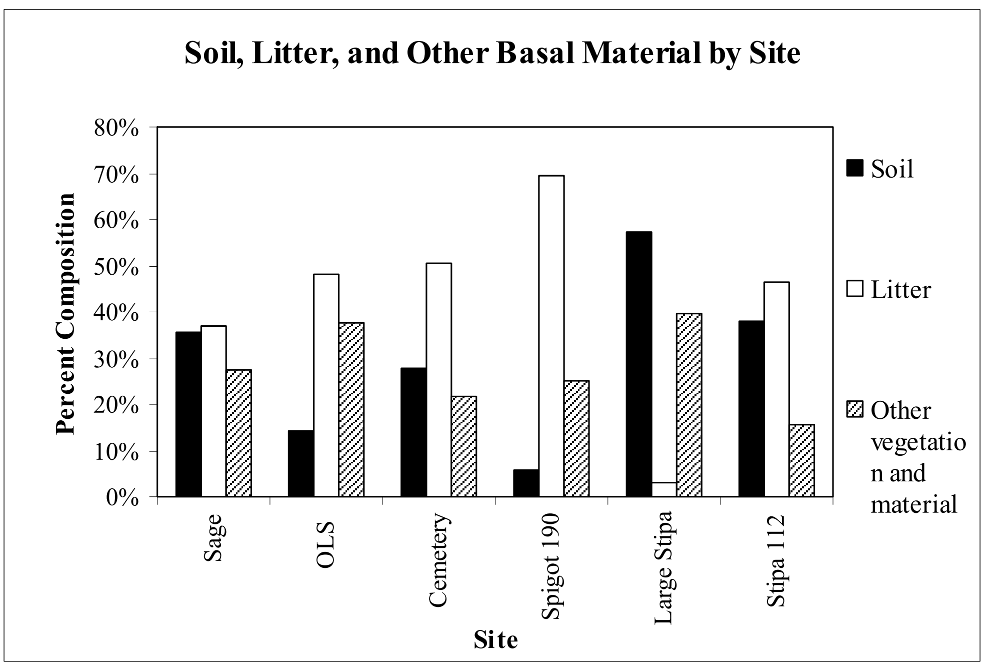



**Figure 5.** Soil, litter, and other basal material by site. Basal hits consisted primarily of soil and litter. Other ground material included vegetation, crust, rock, and scat. Cryptogamic crust was only detected at Large Stipa, Spigot 190, and Stipa 112 sites.

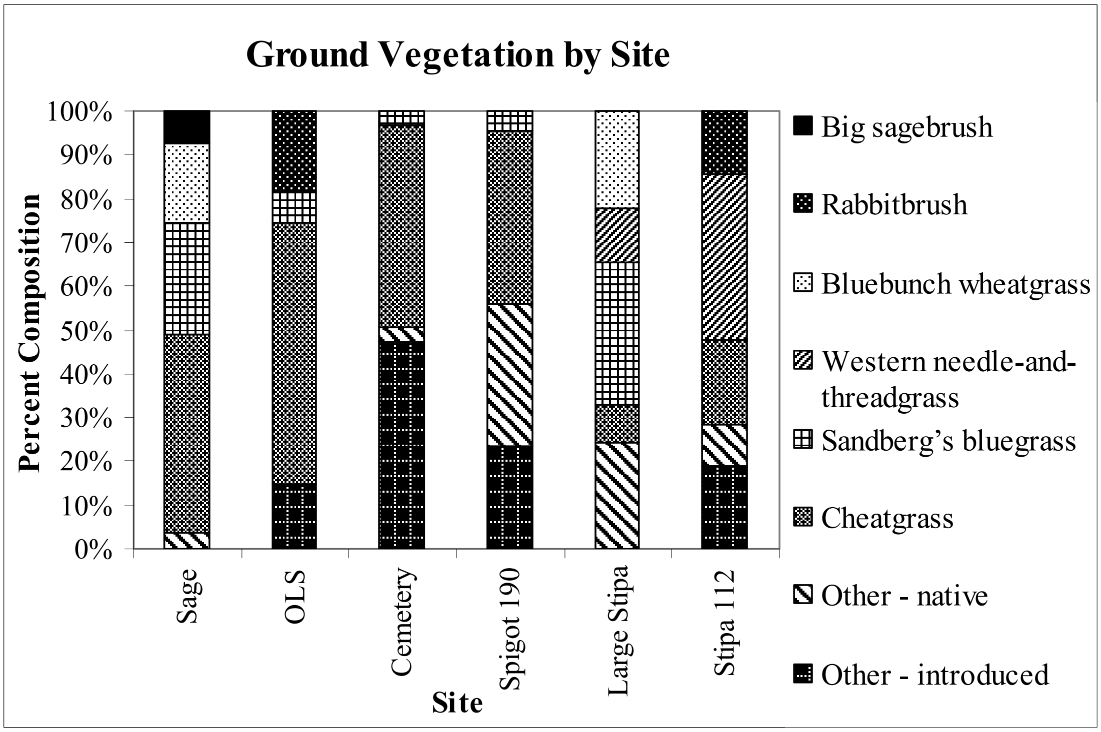



**Figure 6.** Ground vegetation by site. More infrequent vegetation was grouped into native and introduced (non–native) categories.

The greatest amount of shrub cover occurred at the Sage and OLS sites (Table 1). The Cemetery site contained the greatest amount of cover vegetation (mostly tumblemustard [*Sisymbrium sp.*] and cheatgrass), followed by Stipa 112, OLS, Spigot 190, Large Stipa, and Sage sites. The dominant cover type at the Stipa 112, and Large Stipa sites was western needle–and–threadgrass. Cheatgrass was a large cover and ground component at the OLS and Cemetery sites and, while a common ground cover component, it was less common in the cover layer at Sage and Spigot 190. The majority of the cover at Spigot 190 was a pea species, most likely lance–leaf scurf–pea (*Psoralidium lanceolatum*). The Large Stipa and Stipa 112 sites contained very little cheatgrass in the ground or cover layers.

**Table 1.** Type and percentage of cover vegetation documented at each site.

| Type | Sage | OLS | Cemetery | Spigot 190 | Large Stipa | Stipa 112 |
|---|---|---|---|---|---|---|
| Big sagebrush | 17.0 | 0.0 | 3.3 | 0.0 | 0.0 | 0.0 |
| Rabbitbrush | 0.0 | 9.1 | 0.0 | 0.0 | 0.0 | 3.4 |
| Bluebunch wheatgrass | 4.0 | 0.0 | 0.0 | 0.0 | 6.0 | 0.0 |
| Western needle–and–threadgrass | 0.5 | 0.0 | 0.0 | 0.0 | 27.0 | 34.1 |
| Sandberg's bluegrass | 1.0 | 2.0 | 0.0 | 0.0 | 3.5 | 0.0 |
| Cheatgrass | 5.5 | 26.1 | 12.6 | 7.3 | 0.0 | 1.4 |
| Tumblemustard | 0.0 | 1.0 | 16.6 | 1.7 | 0.0 | 0.0 |
| Other: Pea | 0.0 | 0.0 | 0.0 | 27.2 | 0.0 | 0.0 |
| Other: Non–native | 1.5 | 5.0 | 24.5 | 3.9 | 0.0 | 2.7 |
| Other: Native | 0.0 | 1.5 | 4.0 | 0.0 | 0.0 | 6.1 |
| **Total Cover** | 29.5 | 44.7 | 60.9 | 40.1 | 36.5 | 47.8 |

## Climate Data

The average of the mean daily air temperatures by month in 2004 and 2005 was similar to historic means (Figure 7). January was an exception, where 2004 and 2005 temperatures were 3.7 and 1.6 $^{o}$C below historic averages.

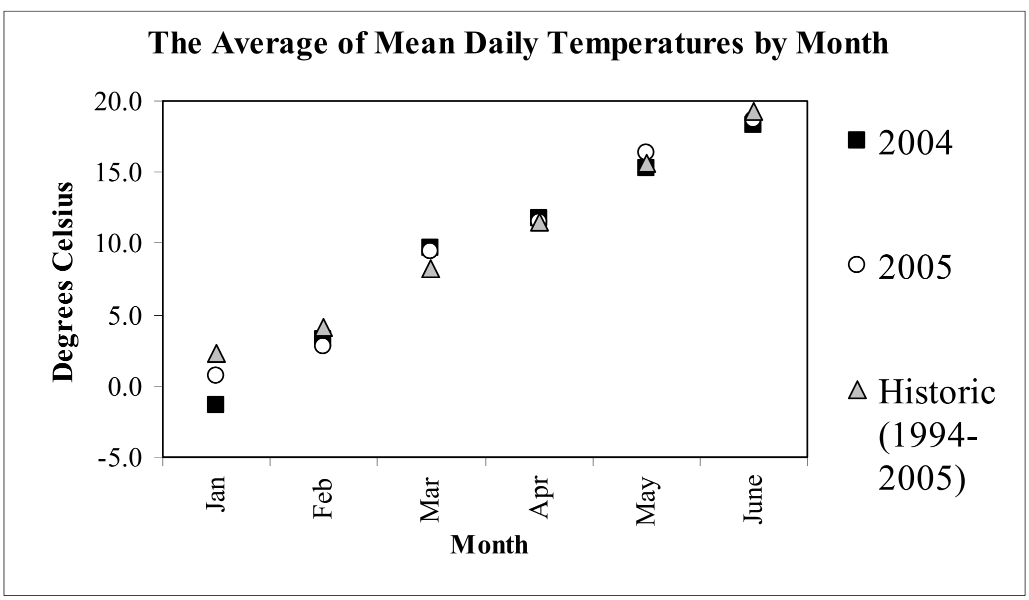



**Figure 7.** Average 2004, 2005, and historic mean daily temperatures (BOR 2005).

Total precipitation in during the Washington ground squirrel's 2004 active season was generally higher than the historic average, except in March when it was lower (Figure 8). Conversely, total precipitation in the squirrel's 2005 active season was lower than the historic average, except in April and May when it was nearly equal to historic levels. During the fall and winter months (September–December) preceding the squirrel's active seasons, about 73.7 mm of precipitation accumulated in 2003 whereas only 40.6 mm accumulated in 2004. Precipitation levels were similar between years in the months of October and November, but 2004 had higher levels of precipitation in September and December than 2005 levels.

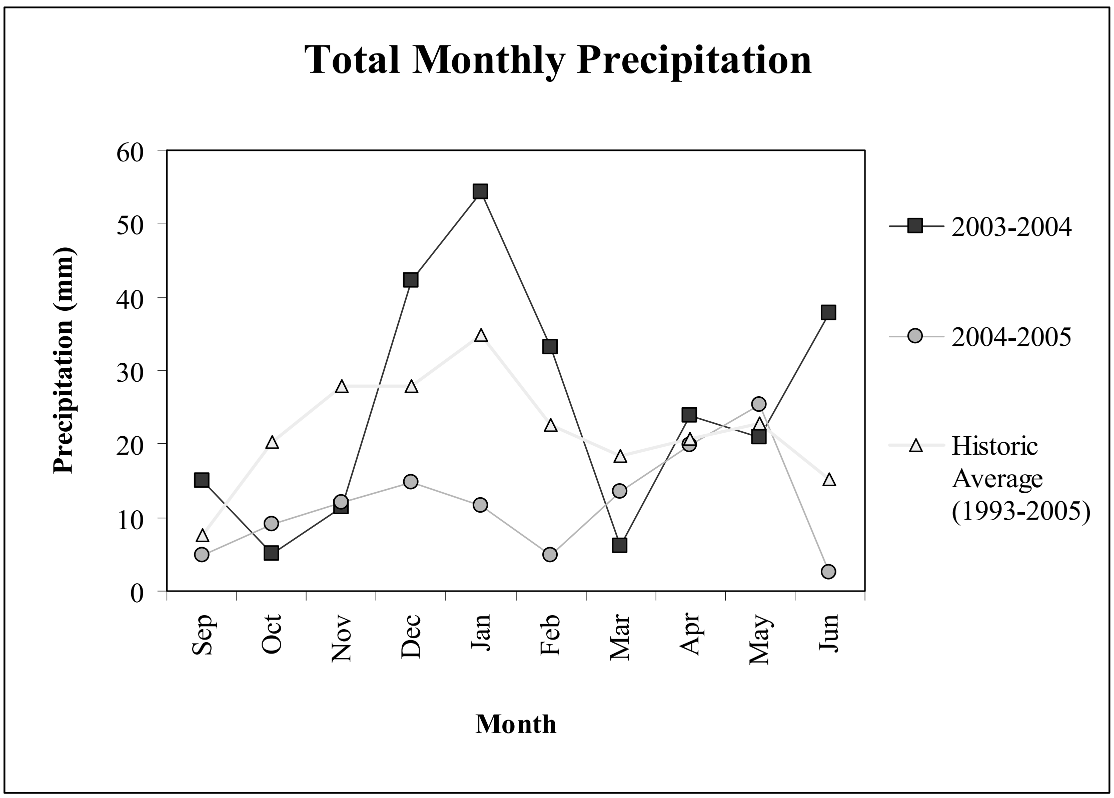



**Figure 8.** Monthly precipitation data from the Hermiston (HRMO) weather station, 2004 and 2005, compared to historic data (1993–2005; BOR 2005).

Wind speed fluctuated throughout the year (Figure 9). Generally, wind speeds appeared lowest in early– to mid– February and May. March through June had consistently higher peaks in wind speed. January and February had some of the highest peaks in average wind speed, but wind speeds were typically lower during these two months.

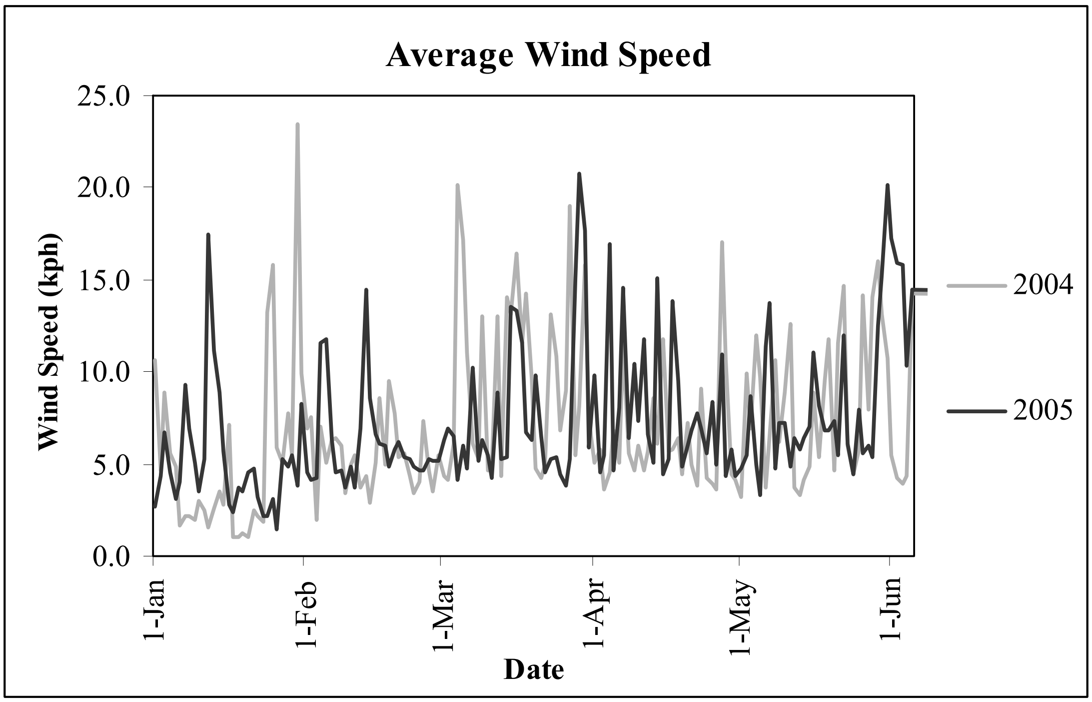



**Figure 9.** Wind speed data from the Hermiston (HRMO) weather station, 2004 and 2005 (BOR 2005).

## Mark–Recapture Data

**Capture Effort.** Sage, Cemetery, and OLS sites were trapped in April and May of 2004, and Large Stipa was trapped in April 2005. Capture effort varied by site since I continued trapping until no new captures were made in two sequential trap sessions (Table 2). One exception occurred at the Sage site, when I continued trapping after no new captures were made in two sequential afternoon trap sessions. I made this exception because it was late in the day when there was little squirrel activity at this site, meaning the reason new individuals were not trapped in two sequential sessions was due to the limited squirrel activity, and not because the population was completely marked within the grid at that time. I did not conduct mark–recapture at the two small sites (i.e., Spigot 190 and Stipa 112). However, based on the increased effort required to trap squirrels for radio–collaring and tracking at these sites, it is reasonable to infer that Spigot 190 and Stipa 112 had fewer than 20 squirrels within their mark–recapture grids.

**Table 2.** Mark–recapture effort detailed by site. Capture effort varied with the time needed to trap out the population within the mark–recapture grid.

| | Sage | Large Stipa | OLS | Cemetery |
|---|---|---|---|---|
| Trapping Period | Apr 7–13 | Apr 19–May 1 | Apr 27–May 6 | May 4–19 |
| # of Days Trapped | 5 | 6 | 6 | 7 |
| # of Trapping Hours | 36 | 18 | 28 | 28 |
| Hours w/ Captures | 35 | 18 | 19 | 28 |
| Hours w/ New Captures | 25 | 10 | 12 | 26 |
| %Sessions w/ New Captures | 69.4 | 55.5 | 42.9 | 92.8 |

**Population Size, Density, and Structure.** The Cemetery and then Sage sites had the largest population sizes and densities, followed by the Large Stipa and OLS sites (Table 3). Juvenile females were more commonly captured at the Cemetery site than juvenile males. Conversely, more juvenile males were captured than juvenile females at the Large Stipa site. Remaining sites had nearly equal juvenile sex ratios. Except for the Cemetery site, all sites had slightly more adult/yearling females than males. Sage and Cemetery sites had juvenile–biased age ratios, but Large Stipa and OLS contained nearly equal numbers of juveniles as adults/yearlings.

**Table 3**. Mark–recapture results for Sage, OLS, Cemetery, and Large Stipa by age class and sex. Numbers in parentheses include collared squirrels not captured in trapping sessions with home ranges that overlapped the trapping grid. Density (N/ha) was calculated by dividing population estimates by grid area (OLS and Large Stipa – 2.3 ha, Sage and Cemetery–2.1 ha).

| Age/Sex | Sage | | Large Stipa | | OLS | | Cemetery | |
|---|---|---|---|---|---|---|---|---|
| | *N* | *N/ha* | *N* | *N/ha* | *N* | *N/ha* | *N* | *N/ha* |
| Adult/Yearling Females | 7 (10) | 4.9 | 6 (9) | 4.0 | 2 (7) | 3.1 | 10 (13) | 6.3 |
| Adult/Yearling Males | 2 (3) | 1.5 | 4 (6) | 2.7 | 3(4) | 1.8 | 17 (20) | 9.7 |
| Juvenile females | 23 | 11.2 | 5 | 2.2 | 6 | 2.7 | 28 | 13.6 |
| Juvenile males | 22 | 10.7 | 9 | 4.0 | 7 | 3.1 | 21 | 10.2 |
| Unknown Females | 0 | | 0 | | 0 | | 9 | 4.4 |
| Unknown Males | 0 | | 0 | | 0 | | 5 | 2.4 |
| **Total** | 54 (58) | 28.1 | 24 (29) | 12. 9 | 18 (24) | 10.7 | 90 (96) | 46.6 |

**Mark–Recapture Weights.** P–values for mark–recapture weight comparisons are based on untransformed data using pooled variance t–tests and ANOVA. Sites were not trapped concurrently; therefore, differences in masses among the six factors should be interpreted and applied judiciously.

Juveniles weighed less (66–176 g) than adults/yearlings (135–270 g) (Table 4). Adult/yearling males weighed more than females ($t [47] = 3.02$, $p < 0.01$), but juvenile weights did not differ between sexes ($t [114] = 0.72$, $p = 0.48$). Adult/yearling weights were not significantly different between years ($t [47] = 1.55$, $p = 0.13$), cover types ($t [47] = 1.43$, $p = 0.16$) or population sizes ($t [47] = 1.62$, $p = 0.11$), but were greater at sites with non–native vegetation ($t [47] = 2.44$, $p = 0.02$). Juvenile weights were significantly greater between years ($t [114] = 2.79$, $p = 0.01$), at sites with without shrub cover ($t [114] = 6.89$, $p < 0.00$), at non–native ($t [114] = 10.25$, $p < 0.00$) sites, and at sites with large populations ($t [114] = 2.20$, $p = 0.03$).

With age classes combined, weights were significantly greatest at the Cemetery site, followed by Large Stipa and OLS, and then Sage sites ($F [3, 161] = 14.08$, $p < 0.00$). Separately, both adults/yearlings ($F [3, 45] = 2.33$, $p = 0.09$) and juveniles ($F [3, 112] = 45.94$, $p < 0.00$) were largest at the Cemetery site, followed by the approximately–equivalent OLS, Large Stipa and Sage sites.

**Table 4.** Mark–recapture masses by age and sex classes compared among sites. All squirrels were weighed to the nearest 1g. Juveniles varied from 66–176 g and adults/yearlings weighed 135–270 g. Squirrels of unknown age (n =14) were removed from statistical analyses.

| | | n | Mean | Median | Standard Deviation (σ) | Range |
|---|---|---|---|---|---|---|
| **Adult/Yearling Females** | Sage | 6 | 188.8 | 192.0 | 24.7 | 157–219 |
| | Large Stipa | 6 | 190.7 | 188.5 | 39.6 | 135–247 |
| | OLS | 2 | 199.5 | 199.5 | 10.6 | 192–207 |
| | Cemetery | 10 | 215.8 | 216.5 | 17.4 | 197–249 |
| **Adult/Yearling Males** | Sage | 2 | 235.5 | 235.5 | 5.0 | 232–239 |
| | Large Stipa | 4 | 216.0 | 211.0 | 18.5 | 200–242 |
| | OLS | 3 | 213.3 | 213.0 | 5.5 | 208–219 |
| | Cemetery | 16 | 224.5 | 221.5 | 24.7 | 190–270 |
| **Juvenile Females** | Sage | 22 | 96.9 | 99.0 | 16.9 | 67–122 |
| | Large Stipa | 4 | 96.5 | 96.0 | 3.4 | 93–101 |
| | OLS | 6 | 111.7 | 112.5 | 9.0 | 99–123 |
| | Cemetery | 28 | 140.2 | 142.0 | 17.6 | 103–168 |
| **Juvenile Males** | Sage | 21 | 107.9 | 111.0 | 17.5 | 66–133 |
| | Large Stipa | 9 | 105.1 | 101.0 | 8.4 | 98–121 |
| | OLS | 7 | 125.6 | 127.0 | 9.9 | 106–139 |
| | Cemetery | 19 | 143.9 | 143.0 | 21.0 | 104–176 |

## Radio–Collared Squirrels

I radio–collared 39 squirrels in 2004 and 41 in 2005 (Table 5). No individuals were tracked both seasons.

**Table 5.** Number of radio–collared squirrels by site, sex, and year**.** Eighty squirrels were collared at six sites in 2004 and 2005. The Stipa 112 and Spigot 190 sites were only tracked in 2004.

| | Cemetery | Sage | OLS | Large Stipa | Stipa 112 | Spigot 190 | Total |
|---|---|---|---|---|---|---|---|
| 2004 Males | 4 | 2 | 2 | 3 | 2 | 2 | 15 |
| 2004 Females | 4 | 5 | 6 | 3 | 3 | 3 | 24 |
| 2005 Males | 3 | 6 | 6 | 4 | 0 | 0 | 19 |
| 2005 Females | 8 | 6 | 4 | 4 | 0 | 0 | 22 |
| **Total** | 19 | 19 | 18 | 14 | 5 | 5 | 80 |

**Initial Capture Weights.** P–values for initial capture weight comparisons are based on ln–transformed data using pooled variance t–tests and ANOVA. The mean initial capture mass of squirrels captured in February and March was 152.5 g (SE = 3.5 g, n = 68, range 93–242 g). Weights did not differ among sexes (t [66] = – 0.67, p = 0.50), years (t [66] = 0.72, p = 0.48), sites (F [5, 62] = 1.98, p = 0.09), vegetation (t [66] = – 0.05, p = 0.96), or cover type (t [66] = – 1.78, p = 0.08). However, weights differed by population size. Squirrels at large and medium sites had similar initial capture weights that were larger than squirrels at small populations (F [2, 65] = 4.83, p = 0.01).

There were no strong correlations among initial capture weights and squirrel movement, home range, or core area sizes (Appendix A). However, initial capture weight was weakly correlated (r [27] = – 0.33, t = – 1.82, p < 0.10) with maximum rate moved.

**Rate of Weight Gain.** Only eight squirrels that were radio–collared between February and March were incidentally recaptured during mark–recapture sessions. They gained an average of 1.1 g/day (range 0.5–2.2 g) over an average 49.3 (range 33–63) days, meaning the mean weight gain per individual was 54.2 g. The sample size was too small to detect any potential differences in rate of weight gain by site, sex, year, or site characteristics.

**Fates.** Approximately one–third of all squirrels survived to dormancy (n = 26), one–third were taken by predators (n = 28), and one–third had an undetermined fate (n = 26). Unknown fates included squirrels that removed their collars, collars that stopped moving underground and had no sign of predation, and signals that were lost and could not be detected within a *ca.* 1.5–km search radius. Probable reasons for unknown fates are displayed in Figure 10. If collars that were removed by squirrels or failed during the tracking period are taken out of the sample, the total sample size is 71 squirrels (where 26 survived [36.6 percent], 28 eaten by predators [39.4 percent], and 17 with unknown fates [23.9 percent]).

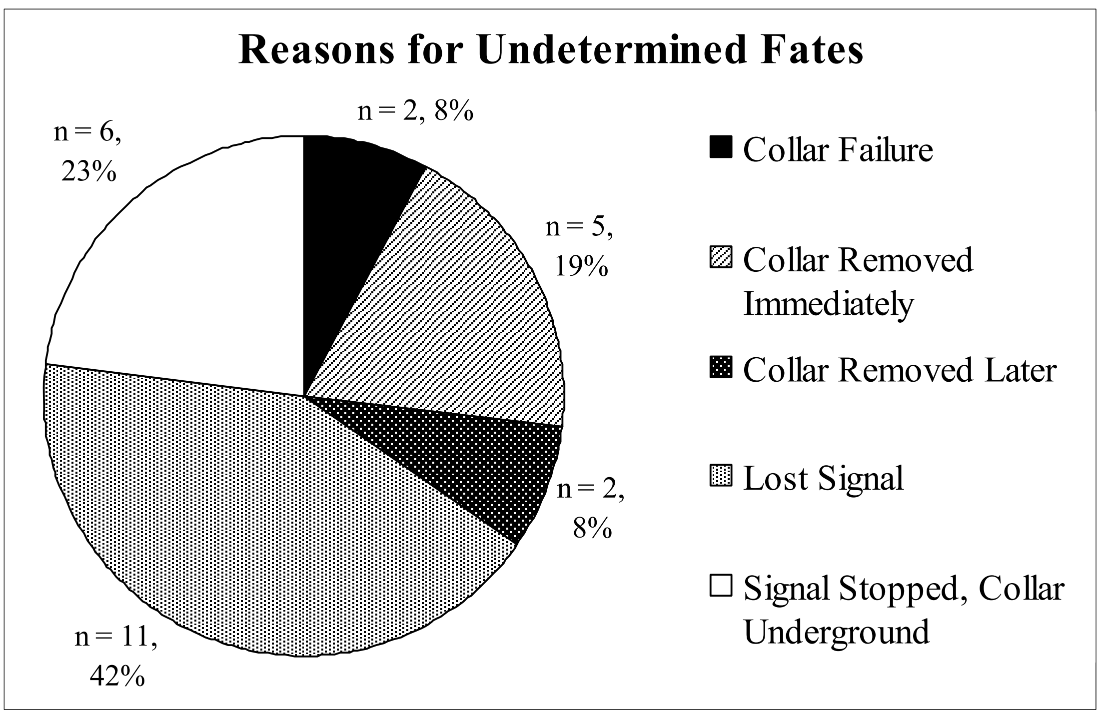



**Figure 10.** Reasons for undetermined fates.

Differences Among Sites, Sexes, Years, and Site Characteristics. Fates were determined for 29 females and 25 males. Due to a large number of unknown fates, the comparison of fates by site, sex, year, and site characteristics is anecdotal. Fates were similar between the sexes and between years. Considering only the known fates, the Cemetery site had the highest percentage of predation and lowest percentage of survival, followed by the OLS, Stipa 112, Sage, Spigot 190 and Large Stipa sites (Figure 11).

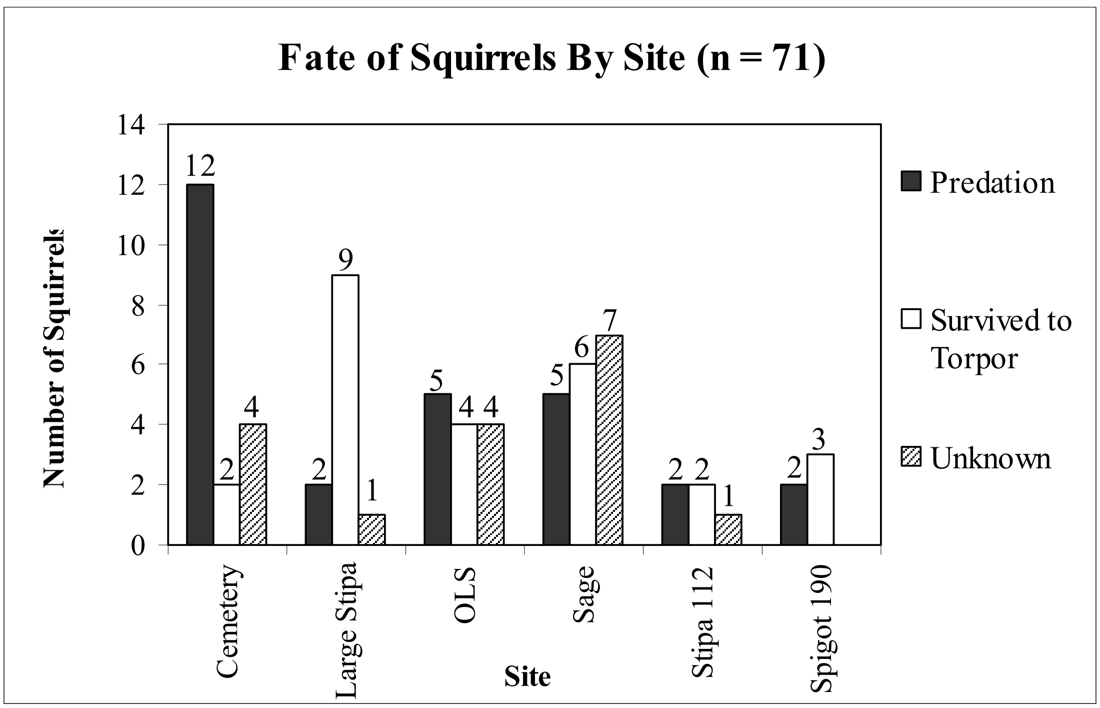



**Figure 11.** Fates of squirrels displayed by site. Predation was highest at the Cemetery site (86% of known fates), followed by the OLS (56%), Stipa 112 (50%), Sage (45%), Spigot 190 (40%), and Large Stipa (18%) sites.

Fates were similar between sites with shrub cover versus those without (p = 1.00, Fisher's exact test). Sites with predominantly non–native vegetation had higher percentages of predation and lower survival (p = 0.03, Fisher's exact test). Predation rates tended to be highest in large colonies and survival highest in the medium–sized sites (p = 0.08, Fisher's exact test; Table 6).

**Table 6.** A comparison of known fates by three site characteristics.

| | **Shrub Cover Dominant** | | | | **Native Vegetation Dominant** | | | | **Population Size** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Yes*** | | ***No*** | | ***Yes*** | | ***No*** | | ***Large*** | | ***Medium*** | | ***Small*** | |
| | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* |
| **Predation** | 10 | 50 | 18 | 53 | 9 | 35 | 19 | 68 | 17 | 68 | 7 | 35 | 4 | 44 |
| **Survived** | 10 | 50 | 16 | 47 | 17 | 65 | 9 | 32 | 8 | 32 | 13 | 65 | 5 | 56 |

Dormancy Timing and Location. Squirrels entered dormancy between May 11 and June 12 ($\bar{x}$ = May 25, n = 24). Two females were removed from estimates because the timing in which they entered dormancy could not be estimated. Comparisons of the timing of dormancy among sexes, years, sites, and site characteristics are anecdotal (Table 7).

**Table 7.** Timing of dormancy by site, sex, year, and site characteristics.

| | | **n** | $\bar{x}$ | **Range** |
|---|---|---|---|---|
| **Sex** | Males | 13 | May 22 | May 11 – June 10 |
| | Females | 11 | May 27 | May 19 – June 3 |
| **Year** | 2004 | 12 | May 28 | May 19 – June 3 |
| | 2005 | 12 | May 22 | May 11 – June 10 |
| **Cover** | Yes | 10 | May 23 | May 11 – June 1 |
| | No | 14 | May 27 | May 18 – June 10 |
| **Vegetation** | Native | 16 | May 23 | May 11 – June 10 |
| | Non–Native | 8 | May 27 | May 20 – June 3 |
| **Population Size** | Large | 7 | May 21 | May 11 – June 2 |
| | Medium | 12 | May 25 | May 18 – June 10 |
| | Small | 5 | May 28 | May 20 – June 3 |
| **Site** | Cemetery | 1 | June 2 | June 2 |
| | Sage | 6 | May 20 | May 11 – June 1 |
| | OLS | 4 | May 25 | May 23 – June 1 |
| | Large Stipa | 8 | May 25 | May 18 – June 10 |
| | Stipa 112 | 3 | May 26 | May 20 – June 2 |
| | Spigot 190 | 2 | May 29 | May 20 – June 3 |

Distance from initial capture point to the dormancy location of 26 squirrels ranged from 9.1 to 761.7 m ($\bar{x}$ = 122.9 m, median = 75.7 m). A comparison of ln–transformed initial capture weights among the six factors did not detect any significant differences: (sex, t [24] = – 0.54, p = 0.60; year, t [24] = – 0.27 , p = 0.79; cover, t [23] = 0.31, p = 0.76; native, t [23] = 1.52, p = 0.14; size, F [2, 22] = 0.26, p = 0.78, site, F [5, 20] = 0.48, p = 0.79). Distances from single core areas to dormancy locations of 12 squirrels varied between 3.6 to 102.6 m ($\bar{x}$ = 56.1 m, median = 54.1 m). There were no significant differences in the distance from single core areas to estivation location (based on untransformed data) between the sexes (t [10] = – 0.87, p = 0.41), years (t [10] = – 1.18, p = 0.27), sites with varying shrub cover (t [10] = – 0.48, p = 0.64), or sites with native vs. non–native vegetation (t [10] = 0.72, p = 0.49). Sample sizes were too small to compare distances between single core areas and sites or population sizes.

Predation Timing and Location. Predation by raptors and badgers occurred throughout the season. Of the 28 squirrels known to be taken by predators, 15 had collars that were retrieved within a week of predation. I compared the timing of their predation for these 15 collars by site, sex, year, and site characteristics. The average predation date for females (March 28) appeared earlier than males (April 18), and predation occurred earlier in 2005 ($\bar{x}$ = March 28) than 2004 ($\bar{x}$ = April 23). There did not appear to be any substantial differences in predation timing by site characteristics.

The distance from initial capture point to the predation location for 27 squirrels varied from 2.1 to 1056.8 m ($\bar{x}$ = 206.4 m, median = 145.2 m). This distance was compared among sexes, years, sites, and site characteristics using pooled variance t–test and ANOVA of ln–transformed data. Distances for males (n = 10, $\bar{x}$ = 291.9 m) was larger than females (n = 17, $\bar{x}$ = 156.1 m; t [25] = – 2.42, p = 0.02). Although distances appeared greater for squirrels at large– ($\bar{x}$ = 262.5 m) and small– ($\bar{x}$ = 249.7 m) sized populations compared to medium sites ($\bar{x}$ = 75.6 m), they were not significantly different (F [2, 24] = 2.21, p = 0.13). The distance from single core areas to predation points for 10 squirrels varied between 0.8 to 199.6 m ($\bar{x}$ = 60.3 m, median = 50.0 m), and the ln–transformed distances did not appear to differ by year, or site characteristics. However, the ln–transformed distance from a single core area to the location of predation was larger for males than females (separate variance t [8] = – 2.44, p = 0.04).

**Home Range and Core Area Estimation Overview**

**Tracking Effort.** 1,951 squirrel locations were collected between February and June of 2004 and 2005, with an average of 24.4 locations per squirrel (SE = 2.1, range 1–65). Home range and core area estimates for all squirrels with site fidelity are listed in Appendix B. Only 33 squirrels had home ranges based on at least 30 fixes, and of these, the minimum sample size needed for MCP–based home range estimates to stabilize ranged between 17 and 56 fixes ($\bar{x}$ = 36) (Appendix C).

**Home Range and Core Area Overlap.** Seasonal FKE95 home ranges overlapped 99 times, where each incident of overlap between two squirrels was considered one overlap event. For example, when a squirrel shared portions of its home range with two other individuals, I considered this as two incidents of home range overlap. Seasonal home range overlap occurred most often between the sexes (55 times) and equally often between males (17 times) and females (17 times). Monthly MCP95 home ranges overlapped most often between the sexes (37 times), followed by males (17 times), and females (7 times). Monthly overlap between females was equally common in February, March, and April (3 incidents per month) and was not documented in May or June. Monthly home ranges appeared to overlap between opposite sexes earlier in the season (17 times in February, 14 in March, 10 in April, and 6 in May). Male–male home range overlap followed a similar trend, with nine incidences of overlap in February, eight in March, five in April, and two in May (Table 8).

**Table 8.** Monthly home range overlap compared among sites. Nearly all individuals showed home range overlap, and overlap occurred most often between the sexes followed by males and females.

| | # Squirrels Tracked | $\bar{x}$ # of Days w/ Fixes | $\bar{x}$ Tracking Period | Year | Incidences of Monthly Home Range Overlap | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ***Feb*** | ***Mar*** | ***Apr*** | ***May*** | ***Jun*** |
| **Cemetery** | 10 | 12.8 | 43.3 | 2004 | NA | NA | NA | NA | NA |
| | | | | 2005 | 2 | 3 | 1 | 0 | 0 |
| **Sage** | 16 | 20.4 | 71.0 | 2004 | NA | 5 | 5 | 0 | 0 |
| | | | | 2005 | 17 | 3 | 8 | 1 | 0 |
| **OLS** | 12 | 17.9 | 57.8 | 2004 | NA | 2 | 1 | 1 | 0 |
| | | | | 2005 | 2 | 3 | 1 | 0 | 0 |
| **Large Stipa** | 11 | 25.0 | 86.9 | 2004 | NA | 2 | 1 | 1 | 0 |
| | | | | 2005 | 8 | 7 | 1 | 5 | 0 |

Seasonal FKE50 core areas overlapped 12 times, and the extent of overlap ranged from 25.5 to 1907.5 $m^2$. Core area overlap occurred between individuals that possessed both single and multiple core areas. Core area overlap was detected most often between males (6 times, $\bar{x}$ = 613.4 $m^2$), followed by opposite sexes (4 times, $\bar{x}$

= 1,085.7 m$^2$), and females (2 times, $\bar{x}$ = 40.5 m$^2$). The lower incidence of monthly home range and seasonal core area overlap between females than males or the sexes suggests the potential for females to maintain more exclusive use of space than males. However, core areas may be larger than the individual's defended territory; it is possible that, on a finer scale, males could be maintaining more or equally exclusive territories.

**Home Range and Core Area Shape.** Home ranges were asymmetrically shaped and distributed typically into 1–4 patches. About half of all squirrels had a single core area within their home range, and half had multiple (2–3) core areas. The number of core areas in a home range did not significantly differ by site, sex, year, or site characteristics (Table 9).

**Table 9.** Number of core areas by site, sex, year, and site characteristics.

| | | **Number of Squirrels Per Core Area (CA)** | | | ***Chi–Square Results*** |
|---|---|---|---|---|---|
| | | ***1 CA*** | ***2 CAs*** | ***3 CAs*** | |
| **Sex** | Female | 10 | 5 | 0 | *$\chi^2(2, n = 33) = 3.43$, $p = 0.18$* |
| | Male | 7 | 9 | 2 | |
| **Year** | 2004 | 2 | 6 | 1 | *$\chi^2(2, n = 33) = 4.30$, $p = 0.12$* |
| | 2005 | 15 | 8 | 3 | |
| **Cover** | Yes | 9 | 9 | 2 | *$\chi^2(2, n = 33) = 1.80$, $p = 0.41$* |
| | No | 8 | 5 | 0 | |
| **Vegetation Type** | Native | 13 | 9 | 0 | *$\chi^2(2, n = 33) = 4.77$, $p = 0.09$* |
| | Non–native | 4 | 5 | 2 | |
| **Population Size**[2] | Large | 9 | 6 | 0 | *$\chi^2(2, n = 33) = 2.09$, $p = 0.35$* |
| | Medium | 8 | 8 | 2 | |
| **Site** | Sage | 7 | 5 | 0 | *$\chi^2(6, n = 33) = 7.91$, $p = 0.25$* |
| | Cemetery | 2 | 1 | 0 | |
| | OLS | 2 | 4 | 2 | |
| | Large Stipa | 6 | 4 | 0 | |

[2] Spigot 190 and Stipa 112 had an insufficient number of location fixes to obtain home range and core area estimates; therefore small sites were removed from statistical analyses.

**Home Range Length.** Home range length was significantly greater for males, in 2005, and for squirrels in medium–sized colonies (Table 10).

**Table 10.** Length of home ranges compared among site, sex, year, and site characteristics. The greatest distance between any two fixes was considered the widest length across an individual's home range. P–values are based on pooled variance t–tests of untransformed data.

| | | n | $\bar{x}$ | Median | σ | Range | T– or F–Statistic (p) |
|---|---|---|---|---|---|---|---|
| **Sex** | M | 18 | 299.0 | 308.5 | 91.4 | 117.0–494.3 | t (31) = – 3.78, (<0.01) |
| | F | 15 | 181.0 | 156.0 | 86.6 | 52.8–360.1 | |
| **Year** | 2004 | 9 | 179.1 | 119.5 | 105.1 | 107.2–400.8 | t (31) = – 2.35, (0.03) |
| | 2005 | 24 | 270.2 | 278.9 | 97.4 | 52.8–494.3 | |
| **Cover** | Yes | 20 | 241.4 | 256.4 | 89.6 | 107.2–392.4 | t (31) = 0.26, (0.79) |
| | No | 13 | 251.5 | 285.2 | 131.5 | 52.8–494.3 | |
| **Vegetation** | Native | 22 | 245.5 | 229.1 | 108.6 | 107.1–494.3 | t (31) = – 0.01, (0.99) |
| | Non–Native | 11 | 245.1 | 285.2 | 106.4 | 52.8–379.2 | |
| **Population Size**[3] | Large | 15 | 202.8 | 207.2 | 93.7 | 52.8–392.4 | t (31) = – 2.23, (0.03) |
| | Medium | 18 | 280.9 | 305.9 | 105.2 | 119.5–494.3 | |
| **Site** | Cemetery | 3 | 151.7 | 117.0 | 120.0 | 52.8–285.2 | F (3, 29) = 1.92, (0.15) |
| | Sage | 12 | 215.6 | 207.5 | 87.5 | 107.2–392.4 | |
| | OLS | 8 | 280.2 | 304.5 | 83.1 | 119.5–379.2 | |
| | Large Stipa | 10 | 281.4 | 314.7 | 124.6 | 135.5–494.3 | |

**Core Area: Home Range Ratios.** Both sexes concentrated their activities in core areas that comprised 7.1–28.1 % of their home ranges ($\bar{x}$ = 12.2%, median = 10.8%). On average, female core areas were 12 % of their overall home range and males were 13 % of their home ranges. Using t–tests and ANOVA on untransformed data, I did not detect any differences in core area: home range ratios by site, sex, year, or site characteristics with fate. Most core areas were circular or elliptical, but some males had asymmetric core areas.

**Male: Female Home Range and Core Area Ratios.** The male to female FKE95 home range ratio was 3.8:1, and the male–female FKE50 core area ratio was

[3] Spigot 190 and Stipa 112 had an insufficient number of location fixes to obtain home range and core area estimates; therefore small sites were removed from statistical analyses.

4.4:1. Male: female FKE95 and FKE50 ratios are displayed by site, sex, year, and site characteristics in Table 11.

**Table 11.** Overall male: female home range and core area ratios, and comparisons among site, year, and site characteristics.

| Sites | n | $\bar{x}$ Male | $\bar{x}$ Female | FKE95 Ratio | $\bar{x}$ Male | $\bar{x}$ Female | FKE50 Ratio |
|---|---|---|---|---|---|---|---|
| **All** | 33 | 33,171.3 | 8,796.4 | 3.8 | 4,035.7 | 921.3 | 4.4 |
| **Large** | 15 | 23,151.7 | 8,642.9 | 2.7 | 2,842.9 | 837.5 | 3.4 |
| **Medium** | 18 | 39,547.4 | 8,972.0 | 4.4 | 4,794.7 | 1,017.0 | 4.7 |
| **Shrub** | 20 | 33,651.7 | 7,736.6 | 4.3 | 4,018.5 | 929.1 | 4.3 |
| **w/o Shrub** | 13 | 32,210.6 | 10,007.7 | 3.2 | 4,070.0 | 912.3 | 4.5 |
| **Native** | 22 | 31,768.9 | 7,122.9 | 4.5 | 3,969.6 | 794.5 | 5.0 |
| **Non–Native** | 11 | 35,375.2 | 13,398.7 | 2.6 | 4,139.4 | 1,269.9 | 3.3 |
| **2005** | 24 | 35,726.7 | 11,203.0 | 3.2 | 4,139.7 | 1,093.9 | 3.8 |
| **2004** | 9 | 24,227.6 | 3,983.4 | 6.1 | 3,671.6 | 576.1 | 6.4 |
| **Cemetery** | 3 | 2,933.8 | 15,211.3 | 0.2 | 327.0 | 1,086.6 | 0.3 |
| **Sage** | 12 | 26,521.4 | 6,453.4 | 4.1 | 3,262.2 | 754.5 | 4.3 |
| **OLS** | 8 | 40,782.0 | 11,586.2 | 3.5 | 4,774.8 | 1,453.1 | 3.3 |
| **Large Stipa** | 10 | 38,065.9 | 7,926.3 | 4.8 | 4,818.6 | 842.6 | 5.7 |

**Home Range and Core Area Details by Site**

Home ranges and core areas of 49 individuals with site fidelity and at least 10 locations were mapped (Figures 13 to 21).

**Cemetery Site.** Most home ranges were located along the bottom of the hollow (Figure 12). There was only one home range estimate in 2004 since most squirrels were taken by predators early in that season. In 2005, seasonal home ranges overlapped twice between the sexes and five times between females, but did not overlap between males. Monthly home ranges overlapped six times between six pairs of squirrels (where an individual may be part of one or more pairs). Core areas overlapped once between females (25.5 $m^2$) and once between opposite sexes (1907.5

m$^2$). Most core areas were fairly circular, except for one asymmetric male core area (Figure 14).

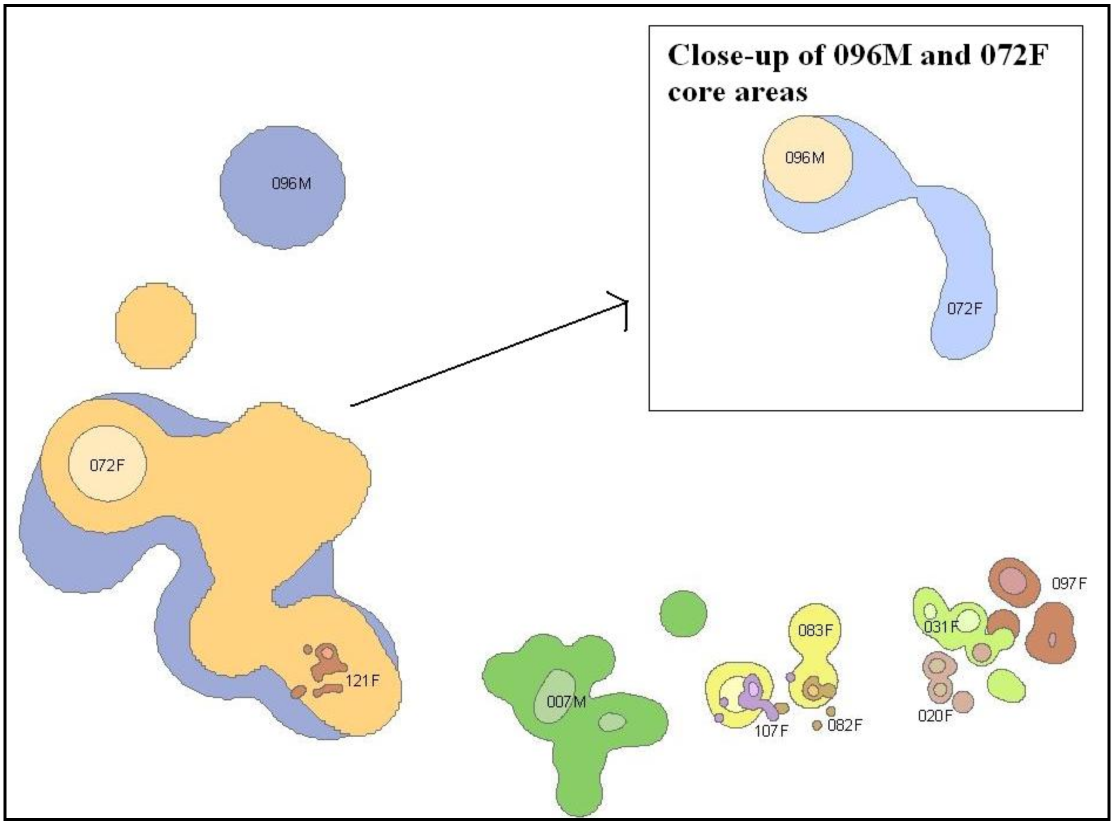



**Figure 12.** Fixed kernel estimates of home ranges and core areas at the Cemetery site, 2005. Most home ranges (outer perimeter) have some degree of overlap, but there is little core area (inner perimeter) overlap. Core areas overlapped twice between individuals with a single core area. The largest amount of overlap occurred between opposite sexes (05cem072 and 05cem096). Two females (05cem107 and 05cem083) also had overlapping core areas. Collar 04cem145m is not included in this diagram since it was tracked in 2004, but it had two, circular core areas.

**Sage Site.** In 2004, seasonal home ranges overlapped three times between females and three times between opposite sexes (Figure 13). Two male home ranges overlapped briefly in the middle of March. After March 17, one of them moved 249 m north of where it overlapped the other's home range. Its collar was tracked to, and remained at, a burrow that appeared inactive the rest of the season. Monthly home ranges overlapped 10 times between six pairs of squirrels. Core areas were mostly elliptical, and they only overlapped once between females in 2004 (55.5 $m^2$).

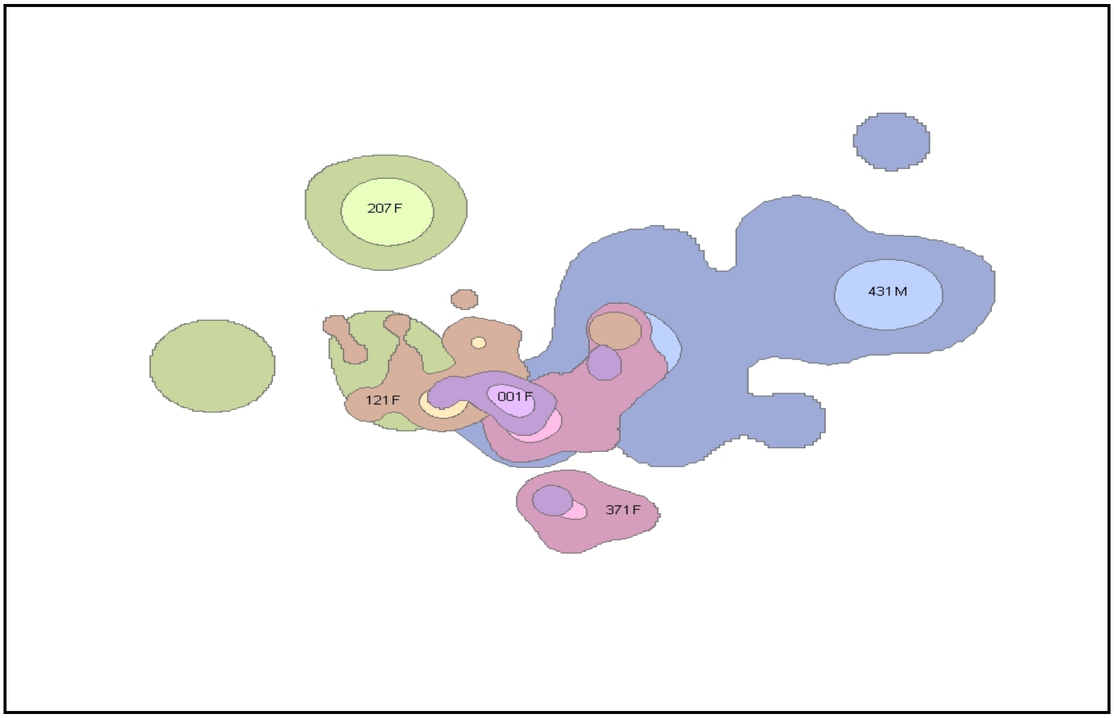



**Figure 13.** Fixed kernel estimates of home ranges and core areas at the Sage site in 2004.

In 2005, seasonal home ranges overlapped between females seven times, males five times, and opposite sexes 26 times (Figure 14). Monthly home ranges overlapped less often, occurring 29 times between 21 different pairs of squirrels. Core areas overlapped five times between males (106.3–1311.9 $m^2$) and two times between opposite sexes (68.2–469.5 $m^2$). Most core areas were circular or elliptical, but two males had asymmetrically–shaped core areas (Figure 15).

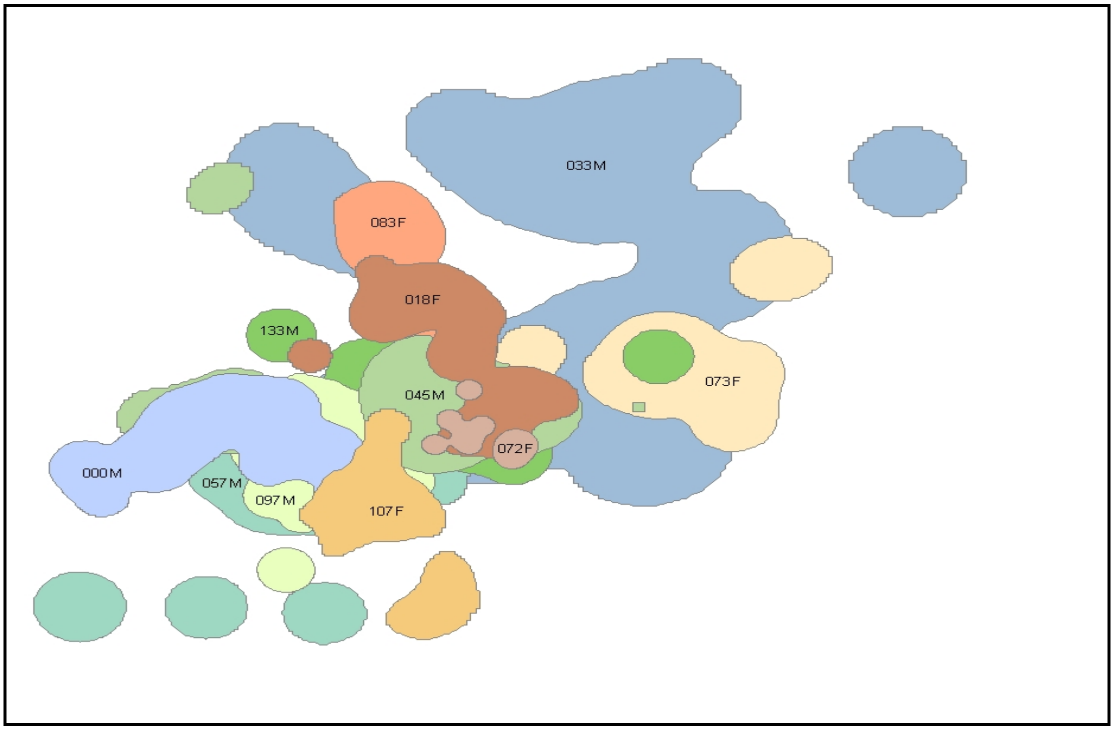



**Figure 14.** Fixed kernel home ranges for squirrels at the Sage site in 2005.

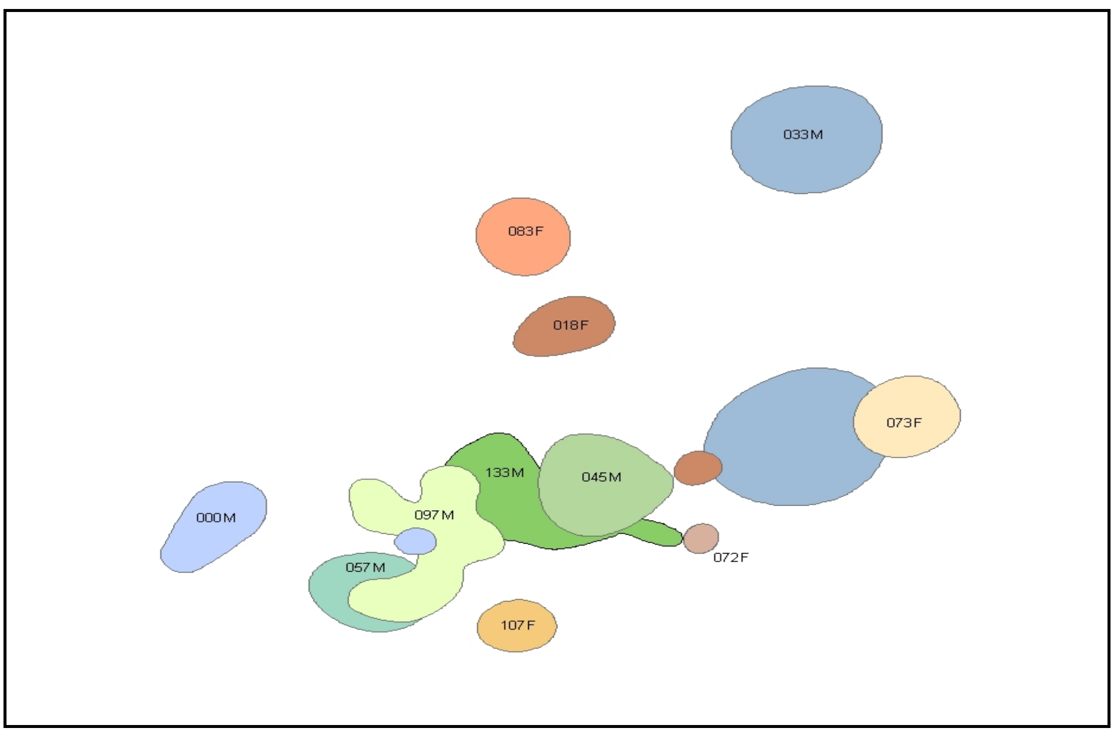



**Figure 15.** Fixed kernel core areas for squirrels at the Sage site in 2005.

**OLS Site.** In 2004, all but one (04ols307F) home range showed overlap (Figure 16). However, this individual was located further from the other collared squirrels and likely overlapped its range with other non–collared squirrels. Most seasonal home range overlap occurred between opposite sexes (three times), but overlap was also detected once between two females. Monthly home range overlap occurred four times between three pairs of squirrels. Core area overlap occurred once between opposite sexes.

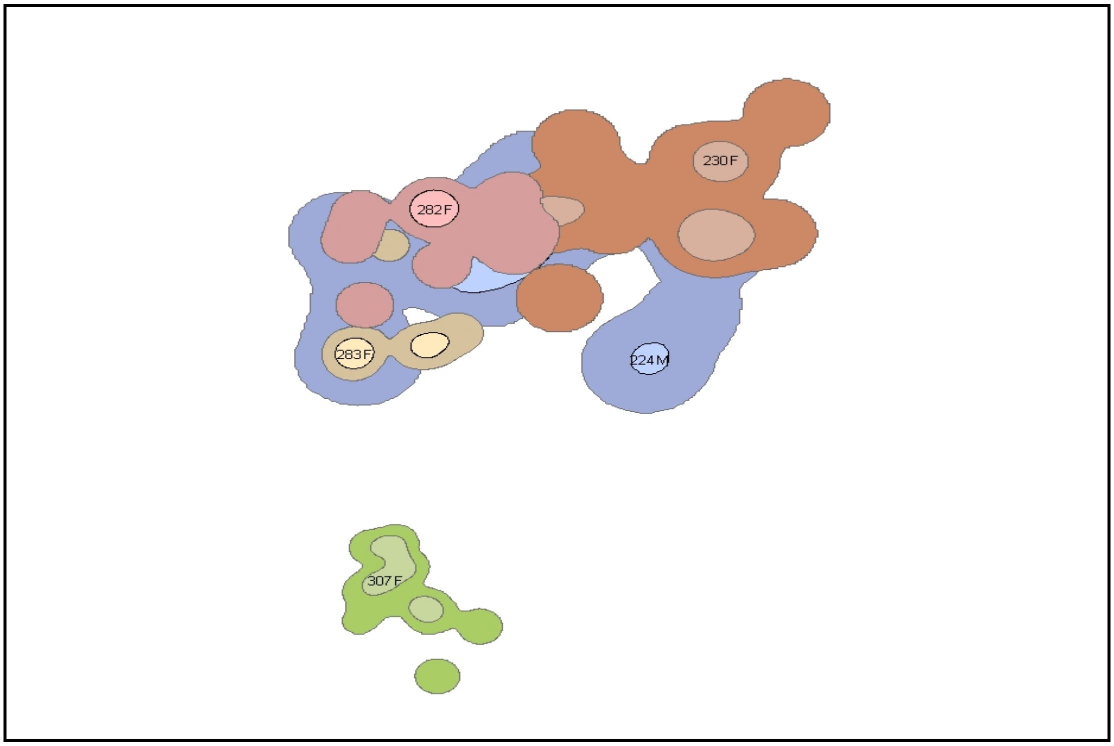



**Figure 16.** Fixed kernel home ranges and core areas for the OLS site in 2004.

In 2005, seasonal home ranges overlapped four times between males and three times between opposite sexes. Monthly home ranges overlapped six times between six pairs of squirrels. Core areas only overlapped once between opposite sexes (Figure 17). Home ranges were asymmetrically–shaped in both years, and, except for

224M and 045M, were comprised of multiple patches. Core areas were mostly elliptical, except for one 2004 female (04ols307F) and two 2005 males.

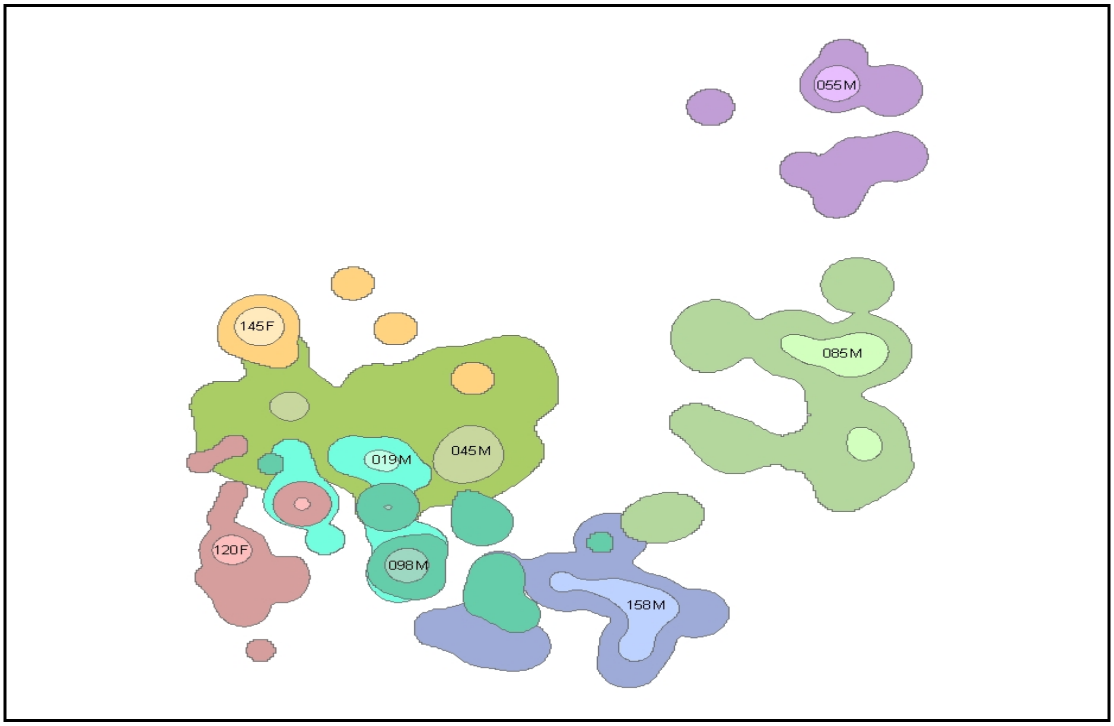



**Figure 17.** Fixed kernel home ranges and core areas for the OLS site in 2005.

**Large Stipa Site.** In 2004, seasonal home ranges overlapped once between females, once between males, and five times between the sexes (Figure 18). Likewise, there was overlap between females (1 time), males (6 times), and opposite sexes (13 times) in 2005 (Figure 19). There was no core area overlap at this site in either year, and core areas were circular or elliptical with the exception of three males. Monthly home ranges overlapped four times between four pairs in 2004 and 21 times between 15 pairs in 2005.

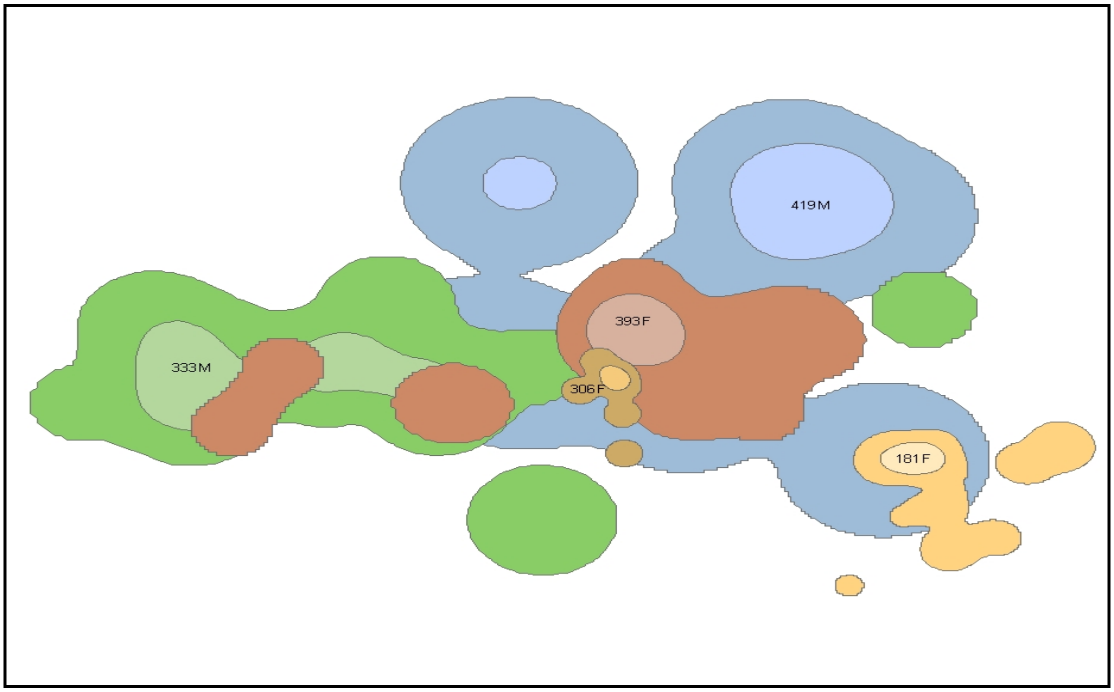



**Figure 18.** Fixed kernel home ranges and core areas for the Large Stipa site, 2004.

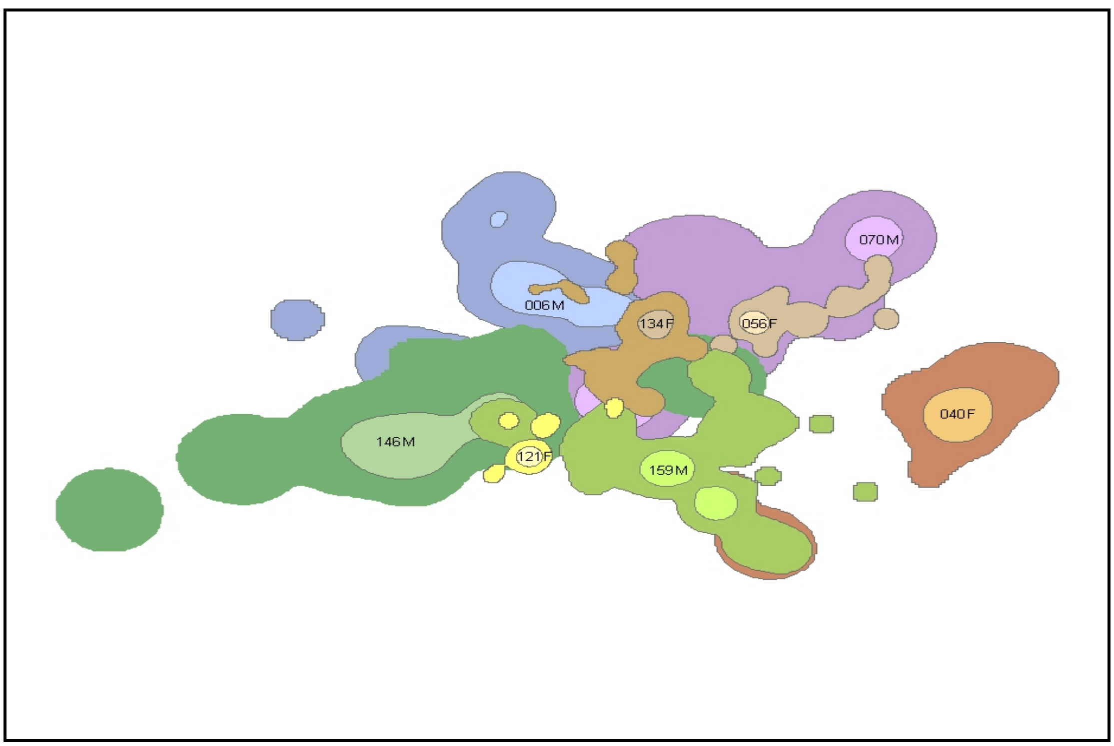



**Figure 19.** Fixed kernel home range and core area estimates at Large Stipa, 2005.

**Stipa 112 and Spigot 190 Sites.** There were no squirrels at Stipa 112 and Spigot 190 that had both site fidelity and at least 10 locations. The MCP95 home ranges for three squirrels with site fidelity are described to provide an absolute minimum home range size for these sites (Table 12). However, home range estimates from squirrels with adequate sample sizes at other sites would provide a more reasonable estimate of home range size for squirrels at Stipa 112 and Spigot 190.

**Table 12.** Minimum convex polygon estimates for squirrels with site fidelity at Spigot 190 and Stipa 112 sites. Three squirrels had site fidelity and 3–10 fixes.

| Collar | Sex | n | MCP95 ($m^2$) | Dates Tracked |
|---|---|---|---|---|
| 04_112_110 | F | 3 | 113 | Mar 3–Apr 22 |
| 04_112_381 | M | 6 | 2,993 | Mar 1–June 2 |
| 04spig297 | M | 8 | 7,247 | Mar 1–May 20 |

## Home Range and Core Area Estimates for Statistical Analysis

I calculated descriptive and inferential statistics for 33 squirrels with fidelity and at least 30 locations (Table 13 and 14). Their home range and core area estimates were based on 1,457 fixes, with an average of 44.2 fixes per squirrel (SE = 1.6, range 31–65).

**Table 13.** Distribution of squirrels used for the statistical analysis of home ranges and core areas. Thirty–three squirrels had site fidelity and n ≥ 30 locations. No squirrels at Stipa 112 and Spigot 190 were of adequate sample size for home range estimation.

| | Cemetery | Sage | Large Stipa | OLS | Total |
|---|---|---|---|---|---|
| 2004 Males | 1 | 1 | 1 | 1 | 4 |
| 2004 Females | 0 | 3 | 1 | 1 | 5 |
| 2005 Males | 0 | 5 | 4 | 5 | 14 |
| 2005 Females | 2 | 3 | 4 | 1 | 10 |
| **Total** | 3 | 12 | 10 | 8 | **33** |

Descriptive statistics for all three types of estimators are displayed in Table 14.

**Table 14.** Descriptive statistics (in $m^2$) for all squirrels with site fidelity and $n \geq 30$ locations.

| | n | $\overline{x}$ | Median | σ | Min | Max | 95% CI |
|---|---|---|---|---|---|---|---|
| FKE95 | 33 | 22,092 | 16,903 | 19,847 | 435 | 77,021 | 15,054–29,129 |
| MCP95 | 33 | 16,727 | 13,044 | 13,482 | 321 | 56,988 | 11,947–21,508 |
| JT95 | 33 | 45,854 | 39,056 | 52,392 | 1,006 | 285,433 | 27,276–64,431 |
| FKE50 | 33 | 2,620 | 1,754 | 2,336 | 46 | 8,181 | 1,792–3,448 |
| MCP50 | 33 | 4,086 | 2,178 | 4,883 | 29 | 17,022 | 2,355–5,817 |
| JT50 | 33 | 8,371 | 7,754 | 7,086 | 233 | 29,418 | 5,858–10,883 |

Statistical comparisons of home ranges and core areas show similar results for the three types of estimators (Tables 15 and 16). Home range sizes were significantly larger for males and for squirrels at medium (compared to large–sized) populations. Fixed kernel estimates showed home ranges were greater in 2005, but this relationship was not as strong when MCP95 and JT95 estimators were used. Home range and core area sizes were not significantly different by cover or vegetation type. Male core areas were significantly larger than those of females based on all core area estimators. Alternatively, sites with medium populations had significantly larger core areas than large populations based on FKE and JT, but not MCP, estimates. Core areas only differed by year using the JT estimator ($p = 0.05$), which was very different from FKE ($p = 0.13$) and MCP ($p = 0.32$) estimators.

**Table 15.** Statistics for all squirrels with site fidelity and at least 30 fixes were calculated. The p–values are based on t–tests of ln–transformed home ranges.

| FKE95 ($m^2$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *n* | $\bar{x}$ | *Median* | σ | *Min* | *Max* | *p* |
| Sex | M | 18 | 33,171 | 26,079 | 20,095 | 2,934 | 77,021 | .00 |
| | F | 15 | 8,796 | 6,269 | 7,927 | 435 | 29,988 | |
| Year | 2004 | 9 | 12,981 | 5,090 | 16,026 | 1,254 | 48,467 | .06 |
| | 2005 | 24 | 25,508 | 19,043 | 20,349 | 435 | 77,021 | |
| Cover | Yes | 20 | 23,286 | 16,602 | 21,421 | 1,254 | 77,021 | .43 |
| | No | 13 | 20,255 | 18,766 | 17,829 | 435 | 48,575 | |
| Vegetation | Native | 22 | 19,446 | 13,374 | 19,003 | 1,254 | 77,021 | .62 |
| | Non | 11 | 27,384 | 22,503 | 21,353 | 435 | 65,863 | |
| Population Size | Large | 15 | 15,414 | 11,401 | 18,912 | 435 | 77,021 | .04 |
| | Medium | 18 | 27,657 | 22,726 | 19,360 | 2,124 | 65,863 | |
| MCP95 ($m^2$) | | | | | | | | |
| | | *n* | $\bar{x}$ | *Median* | σ | *Min* | *Max* | *p* |
| Sex | M | 18 | 23,537 | 24,647 | 14,201 | 1,535 | 56,988 | .00 |
| | F | 15 | 8,556 | 7,303 | 6,276 | 321 | 22,532 | |
| Year | 2004 | 9 | 9,370 | 3,851 | 10,914 | 1,535 | 35,033 | .03 |
| | 2005 | 24 | 19,487 | 14,268 | 13,503 | 321 | 56,988 | |
| Cover | Yes | 20 | 17,134 | 11,533 | 14,585 | 3,233 | 56,988 | .49 |
| | No | 13 | 16,102 | 18,294 | 12,131 | 321 | 39,180 | |
| Vegetation | Native | 22 | 15,672 | 9,944 | 13,417 | 3,233 | 56,988 | .85 |
| | Non | 11 | 18,838 | 15,226 | 14,007 | 321 | 40,529 | |
| Population Size | Large | 15 | 12,282 | 9,198 | 14,154 | 321 | 56,988 | .02 |
| | Medium | 18 | 20,432 | 18,915 | 12,048 | 3,851 | 40,529 | |
| JT95 ($m^2$) | | | | | | | | |
| | | *n* | $\bar{x}$ | *Median* | σ | *Min* | *Max* | *p* |
| Sex | M | 18 | 53,386 | 47,423 | 30,889 | 4,722 | 127,144 | .01 |
| | F | 15 | 36,815 | 15,888 | 70,391 | 1,006 | 285,433 | |
| Year | 2004 | 9 | 51,947 | 12,928 | 90,894 | 4,336 | 285,433 | .25 |
| | 2005 | 24 | 43,569 | 41,915 | 30,419 | 1,006 | 127,144 | |
| Cover | Yes | 20 | 54,817 | 40,089 | 63,597 | 4,336 | 285,433 | .21 |
| | No | 13 | 32,064 | 39,056 | 23,997 | 1,006 | 73,425 | |
| Vegetation | Native | 22 | 33,071 | 21,161 | 28,638 | 4,336 | 127,144 | .29 |
| | Non | 11 | 71,420 | 52,042 | 5,080 | 1,006 | 285,433 | |
| Population Size | Large | 15 | 28,417 | 18,977 | 32,025 | 1,006 | 127,144 | .01 |
| | Medium | 18 | 60,384 | 44,562 | 61,890 | 8,697 | 285,433 | |

**Table 16.** Statistics for three core area estimators were calculated for all squirrels with site fidelity and n ≥ 30 locations. The p–values are based on t–tests of ln–transformed core areas.

| FKE50 ($m^2$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 4,036 | 4,036 | 2,272 | 327 | 8,181 | .00 |
| | F | 15 | 921 | 617 | 728 | 46 | 2,349 | |
| Year | 2004 | 9 | 1,952 | 502 | 2,553 | 200 | 7,013 | .13 |
| | 2005 | 24 | 2,871 | 2,130 | 2,254 | 46 | 8,181 | |
| Cover | Yes | 20 | 2,783 | 1,738 | 2,366 | 200 | 8,181 | .29 |
| | No | 13 | 2,370 | 2,127 | 2,360 | 46 | 7,011 | |
| Vegetation | Native | 22 | 2,382 | 1,738 | 2,294 | 200 | 8,181 | .68 |
| | Non | 11 | 3,096 | 2,127 | 2,456 | 46 | 7,013 | |
| Population Size | Large | 15 | 1,773 | 1,424 | 2,028 | 46 | 8,181 | .04 |
| | Medium | 18 | 3,326 | 2,758 | 2,392 | 323 | 7,013 | |
| **MCP50 ($m^2$)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 6,239 | 5,008 | 5,364 | 420 | 17,022 | .00 |
| | F | 15 | 1,502 | 770 | 2,538 | 29 | 10,271 | |
| Year | 2004 | 9 | 3,177 | 770 | 4,786 | 110 | 14,786 | .53 |
| | 2005 | 24 | 4,427 | 2,297 | 4,976 | 29 | 17,022 | |
| Cover | Yes | 20 | 4,103 | 2,105 | 4,977 | 40 | 17,022 | .65 |
| | No | 13 | 4,059 | 2,291 | 4,935 | 29 | 16,660 | |
| Vegetation | Native | 22 | 3,455 | 1,613 | 4,773 | 29 | 17,022 | .35 |
| | Non | 11 | 5,348 | 3,445 | 5,080 | 35 | 14,786 | |
| Population Size | Large | 15 | 2,979 | 1,177 | 4,727 | 35 | 17,022 | .08 |
| | Medium | 18 | 5,008 | 2,914 | 4,948 | 29 | 16,660 | |
| **JT50 ($m^2$)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 12,352 | 10,973 | 7,147 | 1,093 | 29,418 | .00 |
| | F | 15 | 3,592 | 2,609 | 2,812 | 233 | 9,037 | |
| Year | 2004 | 9 | 4,921 | 2,158 | 5,740 | 1,003 | 17,449 | .05 |
| | 2005 | 24 | 9,664 | 9,334 | 7,211 | 233 | 29,418 | |
| Cover | Yes | 20 | 9,489 | 8,337 | 7,859 | 1,003 | 29,418 | .22 |
| | No | 13 | 6,650 | 3,676 | 5,551 | 233 | 16,989 | |
| Vegetation | Native | 22 | 7,652 | 4,896 | 6,626 | 1,003 | 29,418 | .96 |
| | Non | 11 | 9,808 | 9,631 | 8,067 | 233 | 22,739 | |
| Population Size | Large | 15 | 5,908 | 3,928 | 7,332 | 233 | 29,418 | .01 |
| | Medium | 18 | 10,422 | 10,022 | 6,359 | 2,012 | 22,739 | |

ANOVA on ln–transformed data detected a significant difference in home range by site for each estimator (p values: FKE95 = 0.05, MCP95 = 0.01, and JT95 = 0.00; Figure 20). Core area sizes were also significantly different among sites based on FKE and JT estimators (p = 0.03 [FKE50]; 0.00 [JT50]). However, the apparent differences in sites may be partly due to the Cemetery site's small sample size (n = 3).

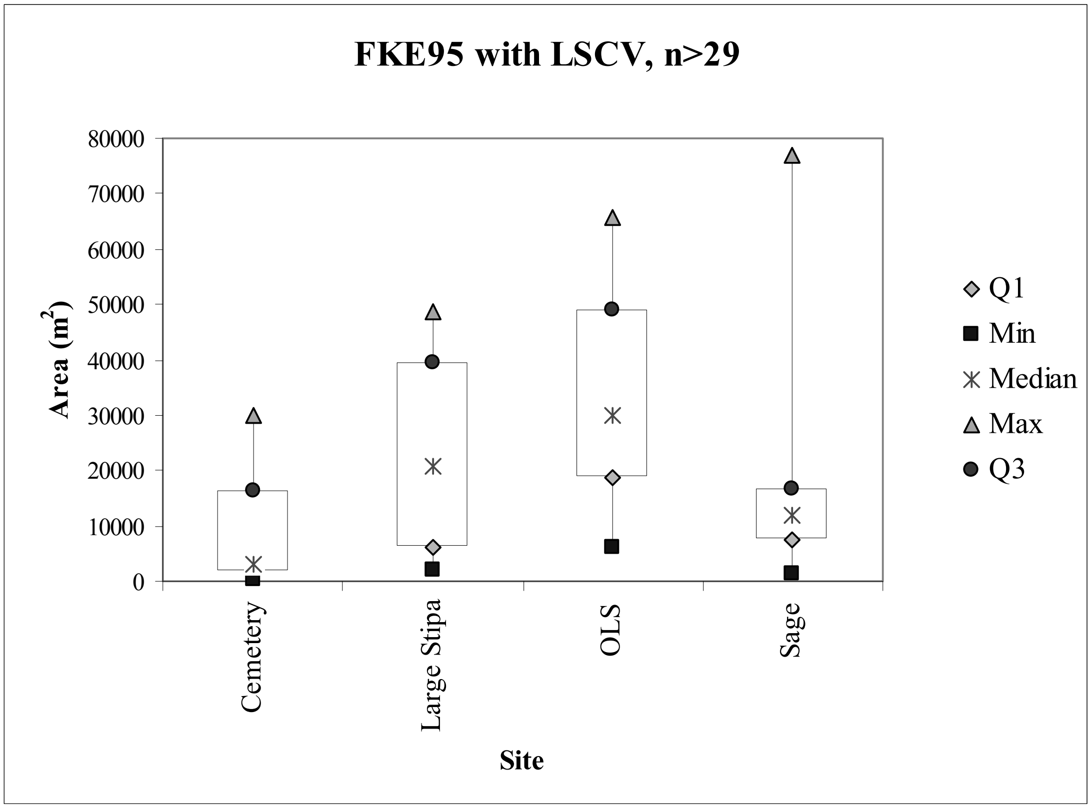



**Figure 20**. A comparison of fixed kernel home range estimates by site (Cemetery n = 3, Large Stipa n = 12, OLS n = 10, Sage n = 8). Q1 represents the 25th percentile and Q3 represents the 75th percentile.

Akaike's Information Criterion (AICc) modeling was used to evaluate interactions among sex, year, and site characteristics, and to determine whether results were similar to those obtained from t–tests (Table 15 and 16). AICc values for interactions among variables were calculated for all home range and core area estimators (Appendix D). Sex+Size and Sex+Year models ranked highest (i.e., where $\Delta AICc \leq 2$) for FKE and MCP home range estimators. Jennrich–Turner home range estimators only ranked the Sex+Size models in the highest category. All other models with sex as a variable fell within a potentially significant category ($2 < \Delta AICc \leq 10$) for all three estimators. Models with only year, size, or a combination of the two also fell within a potential significant category for MCP estimators. This was also the case for JT estimates, but these also considered cover and no interactions as potentially significant models too.

For core area analysis, Sex+Size and Sex models ranked highest for FKE and MCP estimates, but only Sex+Size ranked highest using JT estimates. Like home range, all models with sex fell within the "potentially significant" AICc category for all three estimators. Unlike home ranges, only models with 'sex' as a variable ranked highly significant. Overall, the AICc models had similar results as the t–tests; sex and variables combined with sex were the strongest models, but year and population size also generally ranked higher than other variables.

**Analysis of Rates (m/hr) and Distances (m) Moved by Individual**

835 distances and rates of movement were calculated between successive within–day locations. I reviewed all time intervals between within–day locations (15 minutes to 511 minutes ($\overline{x}$ = 76.9, median = 63.0)) and grouped information into several time interval categories (i.e., 15–44, 45–74, and 75–104–minute intervals, etc.). I only carried out statistical analysis of movements over a 45–74 minute (approximately one–hour) interval. Since squirrels have site fidelity to a fairly small area, I reasoned that movement over a 45–74 minute was more biologically meaningful than movements over longer intervals. As the interval length increases the opportunity for an individual to move away from and return to its first record location

increases. I did not statistically analyze movements over 15–44 minute intervals because sample sizes were very small. I pooled movement information by squirrel and compared minimum, mean, and maximum distances and rates of squirrels that had at least 5 samples (Table 17, 18, and 19).

**Table 17.** Descriptive statistics for movements of all squirrels with n ≥ 5 locations.

| 45–74 minute sample interval | n | $\bar{x}$ | Median | σ | Min | Max | 95% CI |
|---|---|---|---|---|---|---|---|
| Mean Movement (m) | 34 | 39.8 | 37.1 | 21.4 | 7.7 | 95.4 | 32.4–47.3 |
| Minimum Movement (m) | 34 | 4.4 | 1.8 | 8.0 | 0.0 | 40.9 | 1.7–7.2 |
| Maximum Movement (m) | 34 | 109.7 | 107.9 | 57.3 | 21.6 | 261.1 | 89.7–129.6 |
| Mean Rate (m/hr) | 34 | 40.8 | 38.6 | 21.6 | 7.8 | 94.6 | 33.2–48.3 |
| Minimum Rate (m/hr) | 34 | 4.7 | 1.9 | 8.6 | 0.0 | 43.1 | 1.7–7.7 |
| Maximum Rate (m/hr) | 34 | 110.6 | 106.6 | 60.0 | 22.2 | 265.5 | 89.7–131.6 |

**Table 18.** Statistics for minimum, mean, and maximum distances (m) moved over 45–74–min time intervals by squirrels with n ≥ 5 locations. The p–values are based on pooled variance t–tests of untransformed data (separate variance t–test result are provided in parenthesis if different).

| Minimum Movement (m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 6.3 | 2.2 | 10.4 | 0.0 | 40.9 | .16 |
| | F | 16 | 2.4 | 1.4 | 2.8 | 0.0 | 8.0 | |
| Year | 2004 | 10 | 1.7 | 0.0 | 2.9 | 0.0 | 6.9 | .21(.07) |
| | 2005 | 24 | 5.6 | 2.2 | 9.1 | 0.0 | 40.9 | |
| Cover | Yes | 20 | 3.9 | 2.2 | 5.2 | 0.0 | 20.6 | .64 |
| | No | 14 | 5.2 | 1.2 | 10.9 | 0.0 | 40.9 | |
| Vegetation | Native | 21 | 4.5 | 2.2 | 5.5 | 0.0 | 20.6 | .94 |
| | Non | 13 | 4.3 | 1.0 | 11.1 | 0.0 | 40.9 | |
| Population Size | Large | 15 | 7.4 | 3.1 | 10.8 | 0.0 | 40.9 | .05 |
| | Medium | 19 | 2.1 | 0.9 | 3.4 | 0.0 | 13.2 | |
| **Mean Movement (m)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 52.3 | 46.4 | 20.3 | 25.3 | 95.4 | .00 |
| | F | 16 | 25.7 | 25.9 | 11.8 | 7.7 | 45.4 | |
| Year | 2004 | 10 | 28.9 | 30.5 | 16.3 | 7.7 | 57.9 | .05 |
| | 2005 | 24 | 44.3 | 41.1 | 21.9 | 9.1 | 95.4 | |
| Cover | Yes | 20 | 36.5 | 32.9 | 16.7 | 10.6 | 70.5 | .28 |
| | No | 14 | 44.6 | 39.9 | 26.7 | 7.7 | 95.4 | |
| Vegetation | Native | 21 | 37.7 | 36.6 | 20.9 | 7.7 | 95.4 | .47 |
| | Non | 13 | 43.3 | 43.7 | 22.5 | 9.1 | 85.1 | |
| Population Size | Large | 15 | 33.6 | 29.2 | 18.8 | 9.1 | 85.1 | .14 |
| | Medium | 19 | 44.7 | 40.5 | 22.5 | 7.7 | 95.4 | |
| **Maximum Movement (m)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 138.9 | 120.4 | 56.4 | 60.0 | 261.1 | .00 |
| | F | 16 | 76.7 | 84.5 | 37.7 | 21.6 | 140.7 | |
| Year | 2004 | 10 | 76.6 | 72.2 | 44.1 | 21.6 | 149.4 | .03 |
| | 2005 | 24 | 123.4 | 115.3 | 57.2 | 32.7 | 261.1 | |
| Cover | Yes | 20 | 98.0 | 102.1 | 43.6 | 34.3 | 212.3 | .16 |
| | No | 14 | 126.3 | 115.6 | 71.0 | 21.6 | 261.1 | |
| Vegetation | Native | 21 | 108.8 | 101.6 | 61.4 | 21.6 | 261.1 | .92 |
| | Non | 13 | 111.0 | 117.9 | 52.2 | 32.7 | 212.3 | |
| Population Size | Large | 15 | 87.8 | 84.6 | 45.1 | 32.7 | 188.9 | .05 |
| | Medium | 19 | 126.9 | 118.1 | 61.0 | 21.6 | 261.1 | |

**Table 19**. Statistics for minimum, mean, and maximum rate (m/hr) moved over 45–74–min time intervals by squirrels with n ≥ 5 locations. The p–values are based on t–tests of untransformed data

| Minimum Rate (m/hr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 6.8 | 2.4 | 11.3 | 0.0 | 43.1 | .13 |
| | F | 16 | 2.3 | 1.7 | 2.7 | 0.0 | 8.5 | |
| Year | 2004 | 10 | 1.6 | 0.0 | 2.6 | 0.0 | 6.4 | .18(.06) |
| | 2005 | 24 | 6.0 | 2.2 | 9.9 | 0.0 | 43.1 | |
| Cover | Yes | 20 | 4.1 | 2.2 | 5.8 | 0.0 | 22.5 | .64 |
| | No | 14 | 5.6 | 1.4 | 11.7 | 0.0 | 43.1 | |
| Vegetation | Native | 21 | 4.9 | 2.9 | 6.3 | 0.0 | 22.5 | .90 |
| | Non | 13 | 4.5 | 0.9 | 11.7 | 0.0 | 43.1 | |
| Population Size | Large | 15 | 7.9 | 3.5 | 11.6 | 0.0 | 43.1 | .06 |
| | Medium | 19 | 2.2 | 0.9 | 4.0 | 0.0 | 16.8 | |
| **Mean Rate (m/hr)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 53.0 | 49.2 | 20.4 | 26.5 | 94.6 | .00 |
| | F | 16 | 27.1 | 25.2 | 13.2 | 7.8 | 47.7 | |
| Year | 2004 | 10 | 28.7 | 31.8 | 15.0 | 7.8 | 50.8 | .03 |
| | 2005 | 24 | 45.8 | 45.6 | 22.2 | 10.4 | 94.6 | |
| Cover | Yes | 20 | 36.7 | 36.0 | 16.9 | 9.5 | 76.1 | .19 |
| | No | 14 | 46.6 | 44.7 | 26.5 | 7.8 | 94.6 | |
| Vegetation | Native | 21 | 39.3 | 38.4 | 21.2 | 7.8 | 94.6 | .63 |
| | Non | 13 | 43.1 | 46.8 | 22.9 | 9.5 | 86.2 | |
| Population Size | Large | 15 | 34.8 | 30.0 | 19.2 | 10.4 | 86.2 | .16 |
| | Medium | 19 | 45.5 | 45.2 | 22.7 | 7.8 | 94.6 | |
| **Maximum Rate (m/hr)** | | | | | | | | |
| | | ***n*** | $\bar{x}$ | ***Median*** | **σ** | ***Min*** | ***Max*** | ***p*** |
| Sex | M | 18 | 138.4 | 118.6 | 59.9 | 56.8 | 265.5 | .00 |
| | F | 16 | 79.4 | 73.6 | 43.4 | 22.2 | 172.3 | |
| Year | 2004 | 10 | 74.7 | 66.2 | 41.6 | 22.2 | 146.9 | .02 |
| | 2005 | 24 | 125.6 | 111.9 | 60.8 | 41.7 | 265.5 | |
| Cover | Yes | 20 | 98.4 | 98.8 | 53.0 | 31.2 | 265.4 | .16 |
| | No | 14 | 128.1 | 125.3 | 66.9 | 22.2 | 265.5 | |
| Vegetation | Native | 21 | 112.0 | 95.4 | 61.6 | 22.2 | 265.5 | .87 |
| | Non | 13 | 108.4 | 109.0 | 59.6 | 31.2 | 265.4 | |
| Population Size | Large | 15 | 88.7 | 77.2 | 45.3 | 41.7 | 169.2 | .06 |
| | Medium | 19 | 127.9 | 111.3 | 65.5 | 22.2 | 265.5 | |

ANOVA of untransformed movement data showed that minimum ($p = 0.16$), mean ($p = 0.38$), and maximum ($p = 0.19$) movements and rates ($p = 0.18$, 0.38, and 0.20, respectively) were similar among sites.

AICc values were calculated to compare the significance of models for minimum, mean, and maximum distances and movement rates over one–hour intervals (Appendix E). For minimum distance moved and movement rate, Sex+Size and Sex*Size ranked highest (i.e., where $\Delta$AICc $\leq 2$). All other models with sex as a variable fell within the "potentially significant" category ($2 < \Delta$AICc $\leq 10$). The only exception was the Year*Native model which had an AICc value greater than 10 for minimum distance moved. For mean distance moved and movement rate, the only high ranking model was Sex+Year. Potentially significant models included all other models with sex as an interaction. For maximum distance moved and movement rate, Sex+Year, Sex+Size, Sex+Cover, and Sex (for distance but not rate) ranked as highly significant models. In conclusion, like the AICc models for home range and core area, movement models ranked sex highest, with mixed support for year and size.

**Relationship Between Movements, Home Ranges, and Core Areas**

Spearman correlation test, showed a high positive correlation ($p < 0.01$) between mean and maximum movement rates/distances moved with all home range and core area estimators (r [30] = 0.47 to 0.71). However, there was no correlation between minimum distances or rates moved and the home range or core area estimators (r [30] = – 0.01 to – 0.12). The same comparisons were made using Pearson correlation matrix on movements and ln–transformed home range, and core area estimates with similar results (Appendix A).

## Noteworthy Movements

**Distances Moved From Core Areas and Initial Capture Points.** For squirrels with only one core areas, the furthest distance traveled from its center ranged from 25.5 to 296.0 ($\bar{x}$ = 150.1) m. The distance between initial capture points and core area centers ranged from 2.7 m to 226.5 m ($\bar{x}$ = 75.5 m). The maximum distance traveled from an initial capture location was 761.7 m. Comparisons between initial capture points and final detections are illustrated in Appendix F.

**Potential Inter–Population[4] Dispersal.** One male (04sage431M) dispersed from the Sage site in 2004 to what appeared to be a smaller population between May 21 and May 27. It showed pre–dispersal movement to nearby, smaller site in late March but returned to the Sage site for about one month before returning to this location for dormancy. It dispersed 761 m from its initial point of capture. When accounting for topography, the actual distance traveled between two points was at least 851 m (Figure 21).

[4] The term "population" is used with a caveat – there appeared to be a separation of squirrel activity between the Sage site and the area where 04sage431M dispersed. While the only evidence of interaction between the two sites was the dispersal movement, I did not specifically test whether the two sites were the same population. However, the term population has been applied to at least one other squirrel site in the Seeps Lake, Washington area that is only 700m from the nearest population (Sherman and Shellman Sherman 2006). Depending on squirrel movement patterns and topography, among other factors, a population designation may be appropriate here.

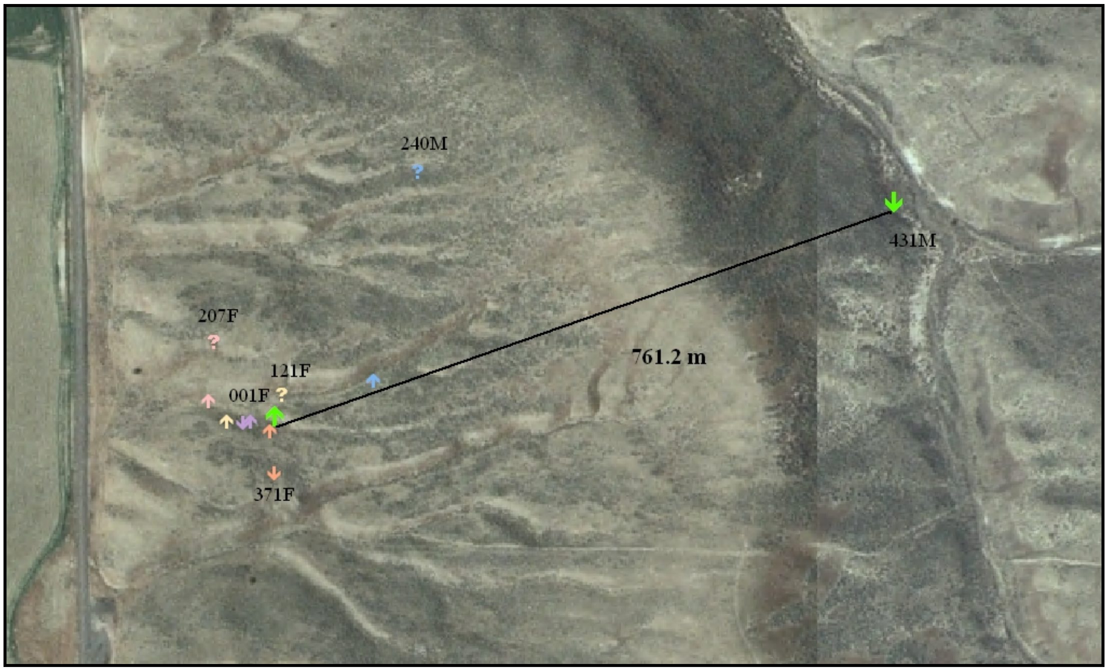



**Figure 21.** Inter–population dispersal. One incident of dispersal was documented by a male in 2004 at the Sage site. The distance from its initial point of capture (denoted by the green '↑') to its final location (green '↓') point was about three times greater than the other male tracked at this site (04sage240M). Distances from initial capture points (denoted by arrows pointing up) to final locations (denoted '↓' for dormancy or '?' for unknown fates) for females was much shorter.

**Early–Season Movements/Home Range Shifting.** Three female and three male home ranges shifted in February and March. Only one shift, a female at the Cemetery site, was completely unidirectional (Figure 22). Its initial point of capture was 149.3 m from its newly established core area, and was 132 m from the closest location in the new home range.

The other squirrels appeared to shift their home range, but they had some limited movement back toward the original capture point. However, they still had a noticeable gap between their initial capture location and remaining fixes, compared to the distance between other fixes taken throughout the season. The initial capture location for these five shifting home ranges were about 70 to 228.4 m from later–

established core areas, and 40–130 m from the next closest location in the rest of the home range, indicated that individuals' home ranges can shift between 70 and 228 m in the early season.

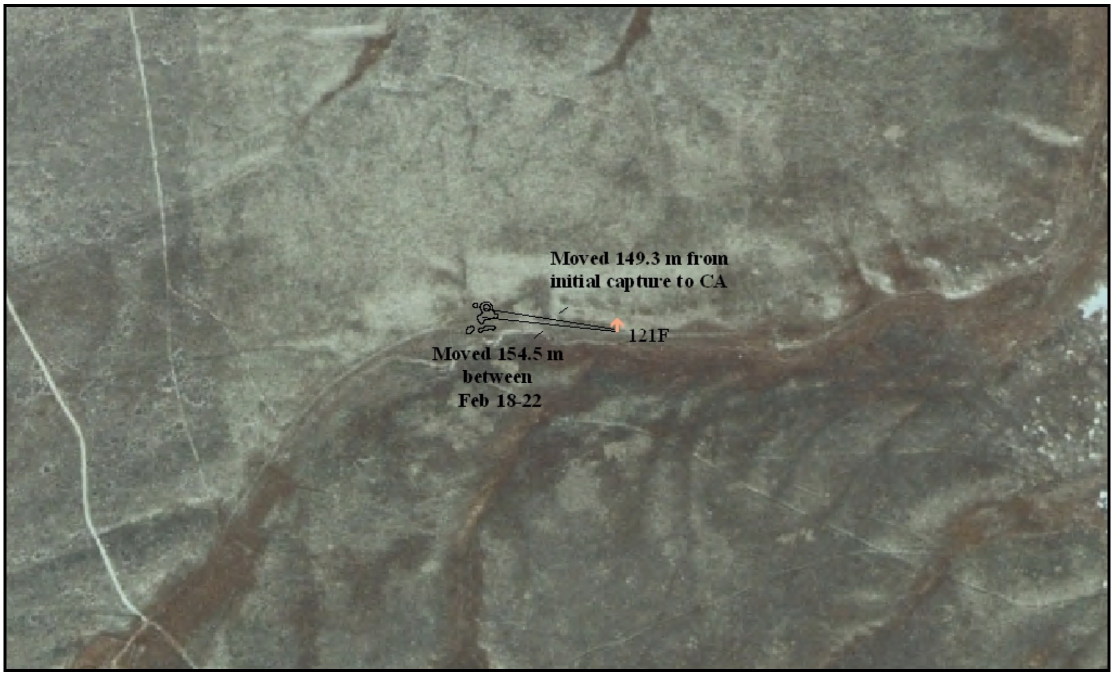



**Figure 22.** Early season movement of Cemetery female, 2005. Between February 18 and 22 one female (05cem121F) shifted its location to a new area that it occupied until it was taken by a predator in May. The distance between its initial capture location and established core area was 149.3 m.

**Late–Season Movements/Potential Intra–Population Dispersal.** Three squirrels had late season home range shifts that might have been dispersal attempts. A male, 04cem145M, moved into a new area, presumably its hibernaculum, between May 21 and June 2, about 71.5–90.5 m from its core areas, and 52.5 m from any other point within its home range. One female, 05cem072F, moved approximately 84.5 m from its core area in late May to an area not previously used and then disappeared. Thirdly, a female, 05sage083F, occupied two patches until it began moving northwest in mid–April (Figure 23). It was last detected about 148 m from its CA, or 197.4 m from its original capture point before disappearing after May 4.

**Figure 23.** Potential female dispersal attempt at the Sage site, 2005. 05sage083F moved 143.8 linear meters from April 14 to May 4. I was unable to locate its signal after May 4; however its movement pattern up until this date suggested some potential intra–population dispersal movement. The last fix on 05sage083F was 197.3 m from its initial capture point and 148 m from its core area. The last fixes for this individual suggest directional movement northwest of its initial capture location and west of its core area.

**Sallies and Potential Exploratory Movements.** Both sexes made potential exploratory movements between 80 to 305 m from their core areas outside their home range throughout the season. Some squirrels had frequent, but short, sallies (temporary excursions away from their home ranges) that the AMAE program did not necessarily include in its FKE95 home range estimate. For example, between February and April one female (05lstipa 121F) was located seven times outside of its FKE95 home range, between 50 and 91 m from its core area (Figure 24). Sallies suggest that these individuals may have located patches of habitat with higher food ability.


**Figure 24.** Multiple sallies documented outside of a female's home range at Large Stipa site, 2005. 05lstipa121F had several sallies outside its FKE–delineated home range throughout the season.

One male moved about 229.5 m from its core area, to an area not previously detected between April 25 and May 2. It returned to its core area on May 4 and remained there until it disappeared on May 11. Its sally could possibly be a pre–dispersal movement, but I cannot be certain without knowing its actual fate. Another male (05ols098M) moved about 197.5 m from its core area, or 109 m from its next closest fix on April 18 and then returned to its main home range for the rest of the season. Two males deviated from the rest of their home range in February. The first (05cem007M) moved *ca*. 84–99 m from its core areas, or 66 m from its next closest location, and then returned to its home range where it remained the rest of the season.

The second (05cem096M) moved about 266 m in late February, and then also returned to its main home range.

Two females also ventured from their main home range. One (05sage107F) moved *ca*. 169.7 m from its core area and 96 m from its next closest fix on March 8. Another (05ols307F) moved 267 to 305 m from its core areas on May 6, but returned the same day (Figure 25).

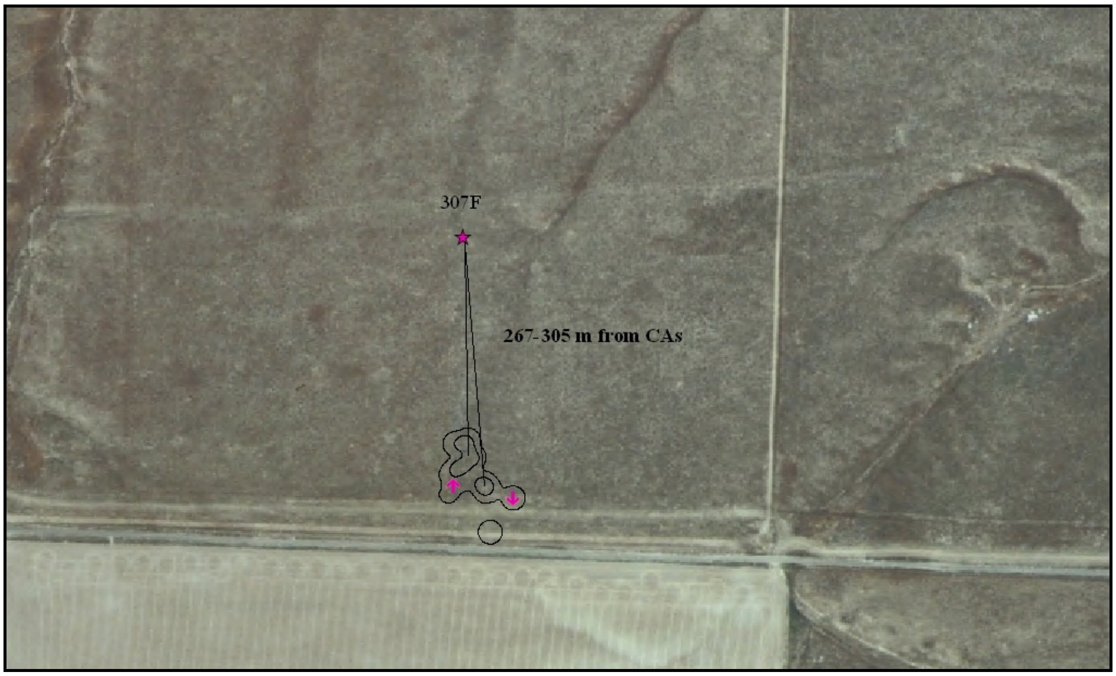



**Figure 25.** Late–season sally by an OLS female, 2005. 05ols307F sally away and back on May 6th.

# CHAPTER 6

# DISCUSSION

## Overview

My primary goal in this work was to describe the home range and core area sizes, and movements of adult and yearling Washington ground squirrels (*Spermophilus washingtoni*). My second goal was to compare their home ranges, core areas, and movements among sites, sexes, years, and site characteristics to determine which factors impact their space use. I also determined whether dispersal occurred in my study sample. I hypothesized that there would be no difference in home range and core areas sizes, hourly distances moved, movement rates, or dispersal distances among sites, sexes, years, or site characteristics.

The results of my study indicate that most adult and yearling Washington ground squirrels have high site fidelity and maintain relatively stable home ranges throughout the season. Most daily, monthly, and seasonal movements were short, and home range sizes were relatively small, consistent with those of other ground squirrel species (Drabek 1973, Jenkins and Eshelman 1984, Smith and Johnson 1985, Choromanski–Norris et al. 1989, Hubbs and Boonstra 1998, Harris and Leitner 2004). The maximum distance moved from an initial capture point was 761.7 m and the maximum distance moved from a core area center was 295.9 m. Inter–population dispersal was only documented once by a male in 2004 and, although rare, intra–population dispersal and home range shifting occurred in both sexes. Since dispersal was only documented once, I was unable to compare dispersal distances and rates among the sites, sexes, years, and site characteristics.

The size of home range and core area estimates varied depending on what estimator was used. However, the analysis of factors affecting range and movement sizes generally had similar results for all three estimators used in this study. Ratios of core area: home range sizes of females in this study were similar to Arctic ground squirrels under "control" conditions (i.e., no habitat manipulation; Hubbs and Boonstra 1998), with the average female core area comprising 11.5 percent of a home range (compared to 10.7 percent in Arctic ground squirrels). The average male core area comprised 12.9 percent of a home range, compared to 19.6 percent in one Arctic ground squirrel study (Hubbs and Boonstra 1998). The average male: female home range ratio was 3.8, which is within the range of those reported in tree squirrels (0.7–7.0), and is similar to values reported for Thirteen–lined ground squirrel (*S. tridecemlineatus*; 3.4) and Rock ground squirrel (*S. variegates*; 2.7) and was greater than those reported in Round–tailed (*S. tereticaudus*; 1.0) and Richardson's (*S. richardsonii*; 1.3) ground squirrels (Heaney 1984).

Home ranges were smaller than those reported for Rock ground squirrels, similar to Arctic grounds squirrels (*S. parryii*), and were much larger than estimates of Columbian and California (*S. beecheyi*) ground squirrels (Heaney 1984). The median MCP95 estimates for males (24,647 $m^2$) was nearly three times smaller than those reported in Mohave ground squirrels (67,300 $m^2$), but median MCP95 female home range estimates were nearly equal (7,303 $m^2$ for Washington ground squirrels in this study versus 7,400 $m^2$ for Mohave ground squirrels; Harris and Leitner 2004). One caveat to the foregoing is that the home range estimates for the different species of ground squirrels were made using different sampling strategies, using different estimators, or different computer programs to calculate home range estimates. Since these factors and the assumptions inherent in each of the distinct models can greatly impact home range sizes (Gallerani Lawson and Rodgers 1997), this makes comparing Washington ground squirrel home ranges to other ground squirrels problematic. However, this information shows that estimates for this study fall within the general range of what might be expected for members of the genus *Spermophilus*.

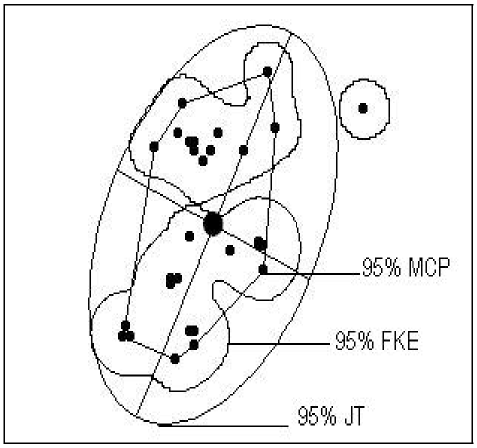
**Site Fidelity**

The AMAE extension of the Monte Carlo random walk test concluded that 54 of 80 squirrels examined in this study demonstrated site fidelity. Of the remaining 26 squirrels, 10 had fewer than three fixes, and so I could not test whether they had site fidelity. Sixteen squirrels did not demonstrate site fidelity, probably because I had small sample sizes for their home range estimates, ranging between 3 and 15 ($\bar{x} = 9$) fixes. These squirrels had so few fixes because their signals were lost (i.e., possibly due to battery failure or because a collar stopped moving in a location where there the signal was obstructed), or their collars stopped moving underground or were retrieved with evidence of predation early in the season.

**Home Range, Core Area, and Movements Estimation**

Home range and core area estimates were calculated using Jennrich–Turner (JT), Fixed Kernel Estimation (FKE), and Minimum Convex Polygon (MCP) techniques, and were usually representative of location fixes that were taken over the entire active season. Estimates varied among the three methods used. For home range, JT methods produced estimates nearly twice the size of FKE and three times the size of MCP methods. For core area, JT estimates were 4–5 times larger than FKE estimates and 3–4 times larger than MCP estimates. A variety of methods were used in part to make this study more readily comparable to other studies. I also used multiple methods since each estimator has its own strengths and weaknesses. Since I obtained similar results for all three estimators when considering which factors impact home range and core area sizes, this further increases the reliability of these findings.

The estimator that appeared to most accurately represent home ranges and core areas varied by individual (as determined by overlaying location fixes with each of the home range estimators' outputs). Fixes for some squirrels (Figure 26a) were represented almost equally with all three estimators, while other home ranges (Figure 26b) were most accurately represented by FKE estimates. Fixed kernel estimates with a smoothing parameter calculated by least squares cross–validation are considered one of the most robust techniques (Swihart and Slade 1997, Hooge et al. 1999). I also considered FKE estimates to be the most robust technique used in this study.

a) 

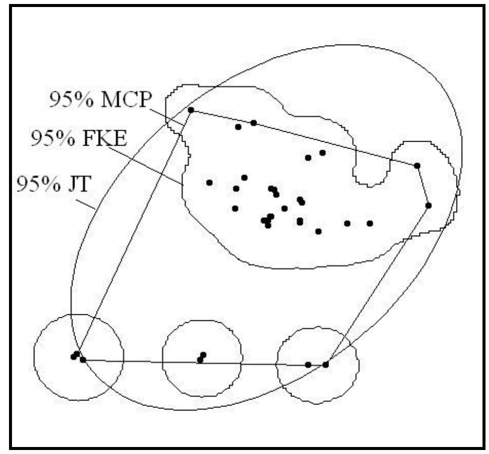

b) 


**Figure 26.** Comparisons of FKE, JT, and MCP estimators. The estimator that most accurately depicted a squirrel's home range varies by individual. In example a, all three estimators closely mimic the locations obtained. In example b, the FKE method appears to most accurately depict the home range size and area used.

**Possible Biases/Assumptions of Home Range and Core Area Estimates**

There are several areas of potential bias when estimating home range and core area sizes. While autocorrelation of data is an important consideration, data are more likely to be biased because of a small sample size than because of recording locations over a reasonably short time interval (Lair 1987, White and Garrott 1990). A reasonably short, and biologically independent, time independent time interval varies by species, but some researchers have used 30–minute intervals for owls (Ganey and Balda 1989) and 2–hour intervals for Mohave ground squirrels (Harris and Leitner 2004). I assumed that locality fixes that were about one–hour apart were based on statistically independent locations of one individual. I also assumed that 30 fixes was an acceptable minimum sample size for all three methods of home range estimation. However, there were three MCP–based home ranges that stabilized after 50 locations were obtained.  Consequently, estimates that appeared stable at lower sample sizes may not actually be stable.  This is illustrated by a sudden, sharp increase in a MCP–based home range size (Figure 27).

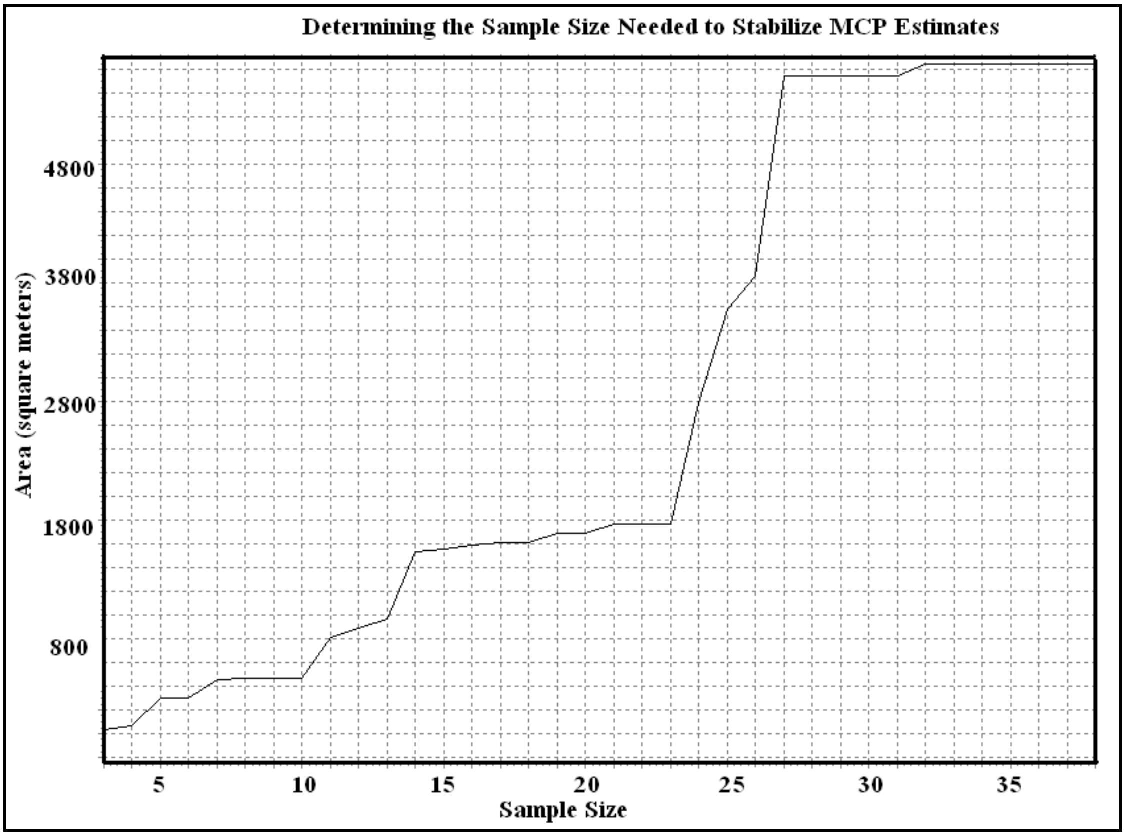



**Figure 27.**  Using Biotas 1.03.1 to determine the sample sizes needed for 95% Minimum Convex Polygon home ranges to reach their asymptote.  Biotas was used to determine the point at which home range size (MCP95) did not increase with increasing sample size.  This analysis was performed for all squirrels with a minimum on 20 locations.  For collar 181 at the Large Stipa site, home range did not change after 32 locations were recorded.  Alternatively, the final home range size did not increase by more than 5 percent after 27 locations were recorded.

The results described herein could also be biased if capture, tagging, or tracking altered survival or behavior (White and Garrott 1990, Millspaugh and Marzluff 2001).  I assumed that tracking did not significantly modify squirrel movement or behavior or, if it did, that it affected all individuals equally.

Biased results may also occur from tracking errors, which I minimized by testing equipment and recording locations with the smallest degree of GPS–error possible. Transmitter signals were usually strong, but detection was more difficult on windy days and at the two most northern sites (Stipa 112 and Spigot 190) on the Naval Weapons System Training Facility–Boardman. It was sometimes necessary to be within 40 meters of the collar before detection was made under these conditions. Interference at these sites resulted in missing data that could have impacted the overall home range and core area size estimates by reducing them due to decreased data points. Battery failure in the transmitter of some individuals also may have resulted in underestimated home ranges, or ranges that were not representative of the complete season. The battery life of most transmitters was 4.5 to 5 months, enabling tracking throughout the season from emergence to immergence or death. However, there were at least two instances of known battery failure toward the end of the season, so it is possible that some of my unknown fates were individuals that remained within 1– to 1.5–km of my sites.

**Movement Differences Between Sites, Sex, Year, and Site Characteristics**

There was large variation in home range and core area sizes, and in movements, but patterns nevertheless emerged. First, males moved longer distances and had larger home ranges and core areas than females. This was true using all three methods of home range estimation, as well as mean and maximum movement distances and rates. However, there were no significant differences between the sexes in minimum distances moved. Greater movement and range size of males was expected since this species is polygamous, with males encompassing the territories of several females within their own. There were instances when male home ranges were smaller than female home ranges at the same site. This may be explained by differences in resource availability within the male and female home ranges at the same site or differences in their reproductive status (e.g., non–breeding males may have smaller home ranges than breeding females), but neither of these hypotheses were tested.

Movements, home ranges and core areas were generally larger in 2005, which may potentially be explained by the lower level of precipitation during this year, and in the fall and winter preceding this year. Lower precipitation may have reduced the quality and/or quantity of forage, requiring larger areas to obtain adequate fat and protein for reproduction and survival. Since core area estimates were more similar than home range estimates between years (for MCP and FKE, but not JT methods), this implies that core area sizes were close to what might be considered the minimum required core area size for Washington ground squirrels at the study sites.

Movements, home ranges, and core areas were also larger at sites with medium–sized populations (i.e., Large Stipa, OLS sites) than sites with large populations (i.e., Cemetery, Sage sites). This may be because the larger, denser sites have more strongly defended territories in response to greater competition for resources. Alternatively, larger movements at medium–sized sites may be due to the increased need to traverse larger areas to acquire mates (for males) or engage in cooperative breeding behaviors within social coalitions (for females). The latter hypothesis could be tested by comparing monthly home range movements between sexes. Monthly MCP–based home ranges were based on very small sample sizes, so I could not confirm whether male movements were significantly larger earlier in the season.

There were no significant differences in home range and core area sizes or movements between sites with predominately native versus non–native vegetation, or between sites with and without shrub cover. However, because cover and vegetation type were characterized at a larger (site) scale, and not at a home range or core area scale, it is possible that I was not able to identify a relationship that could exist at a smaller–scale.

The Cemetery site appeared to have smaller home ranges and core areas than other sites. It also had the smallest range of home range and core area sizes, while the other larger site, the Sage site, had the largest range of home range and core area sizes. One caveat is that the Cemetery site only had three individuals with estimates that could be used in statistical analyses. The median, range, and variability of home range and core area sizes were nearly equal at the OLS and Large Stipa sites. Distances moved between consecutive fixes, on the other hand, appeared similar between Cemetery, OLS, and Large Stipa sites, but smaller at the Sage site. However, this relationship was not significant (p values for mean movement = .39, minimum = .16, maximum = .19).

**Home Range and Core Area Overlap**

There was extensive home range overlap at all sites throughout the study. Since the entire colony was not collared and tracked, the extent of overlap is undoubtedly greater than what I documented. Given the amount of home range, and to a lesser extent core area, overlap, territory sizes (or areas occupied and defended by a single squirrel or coalition) are likely smaller than both home range and core area estimates. This is generally consistent with Sherman's (2000) observation of male territories being from 370 to 930 $m^2$ because all but one male home range and two core areas were larger than his observation of male territory size. Both of these exceptions occurred in the atypically dense, Cemetery site, where it is very likely that territories are smaller than those observed by Sherman (2000) in Washington.

**Seasonal and Monthly Home Range Overlap.** There was intra– and inter–sexual seasonal and monthly overlap, though seasonal overlap was more frequent. The number of occurrences of monthly overlap between females appeared stable throughout the season, but overlap between males and between the sexes was greatest in February and decreased throughout the remainder of the season. This is consistent with the thought that males have larger home ranges and make large movements early in the season to acquire mates.

Most overlap occurred between the sexes, and the Sage and Large Stipa sites had more occurrences of monthly overlap than OLS and Cemetery sites. It is not surprising to have less overlap at sites of perceived lower quality vegetation, but the difference is also partly due to the fact that more collars were successfully tracked throughout the season at the Sage and Large Stipa sites.

**Core Area overlap.** Core areas rarely overlapped, only occurring six times between the sexes, four times between males and twice between females. The extent of overlap ranged from 106.3–1311.9 $m^2$ between males, 25.5–55.5 $m^2$ between females, and 68.2–1907.5 $m^2$ between the sexes. I would have expected more female overlap between core areas since females can form coalitions and exhibit cooperative breeding behaviors, such as burrow and territory sharing (Sherman and Shellman Sherman 2006). It is possible that the amount and degree of female core area overlap changed throughout the active season and was not adequately measured by comparing seasonal core area overlap. Alternatively, it is also possible that cooperative breeding behaviors did not occur in my study area, or by the individuals studied (i.e., female territories are more highly defended), or that cooperative behaviors (e.g., cooperative anti–predator behavior) occurred outside of the core areas in the remainder of their home ranges. Finally, it is possible that collared females overlapped core areas with other females that were not radio–collared, making it less likely that radio–collared females would have overlapping core areas.

**Limitations.** Since the same squirrels were not trapped during consecutive years I could not determine whether their yearly home ranges overlapped, or—if it occurred—the degree of overlap. Home range overlap between consecutive years has been documented in female Mohave ground squirrels (Harris and Leitner 2004). I also could not determine if home range shifting occurred in a unidirectional manner over several years or if home ranges shifted back and forth over a series of years. Also, this is only representative of the individual, rather than the population scale.

**Burrow Sharing.** I tracked radio–collared males and females to the same burrow on several occasions. This occurred three times in 2004 in females (April 6) and both sexes (April 2 and May 6). In one case, a male and female were located within the same burrow at 18:30h on 2 April. In 2005, burrow sharing was documented between males (March 2) and opposite sexes (April 4 and 11, May 3, 17, and 19).

### Home Range Shifting and Dispersal

Home ranges were generally stable, but squirrels used different portions of their range in a given day and month. Adult and yearling dispersal appears rare since inter–population dispersal occurred only once by a male among 80 individuals. There was, however, some intra–population movement/dispersal in both sexes. Juvenile female dispersal has not yet been analyzed in this species using radio–telemetry.

### Factors Affecting Movements, Home Range, and Core Area Sizes

**Vegetation.** Vegetation quality and quantity affects ground squirrel survival because, at a minimum, it provides essential fat and protein, water, cover from predators, and nesting materials. There is a limited understanding of the relative importance of different vegetation types and amounts. For example, while vegetation may provide cover from predators, less cover may also provide increased ability to detect predators. Cover is provided not only by sagebrush and rabbitbrush, but also some of the larger bunchgrasses (e.g., western needle–and–threadgrass, bluebunch wheatgrass), and to some degree by tumblemustard. One might expect a home range or core area to be smaller in areas with higher quality and quantity of vegetation.

The results of the vegetation survey generally supported my original site classifications, where I visually estimated that Cemetery, OLS, and Spigot sites contained mostly non–native vegetation and that the Sage, Large Stipa, and Stipa 112 sites were more representative of native vegetation conditions. The only caveat is that the Stipa 112 site contained greater than anticipated levels of non–native ground cover. However the vegetation survey did not pick up the variety of native forbs (e.g., *Phlox* sp., plantain; *Plantago patagonica*; *Penstemon* sp.) present at Stipa 112. Also, while non–native species were more prevalent than expected in the ground–level vegetation, Stipa 112 contained a large "canopy" of native western needle–and–threadgrass cover. Sage and OLS sites had the most shrub cover, consistent with my original characterization of that site, but shrub cover was only 9.1–17.0 percent of all cover. Spigot 190, Cemetery, and Stipa 112 had minimal amounts of shrub cover, and Large Stipa had no shrub cover. Although they lacked large amounts of shrub cover, western needle–and–threadgrass provided cover at Spigot 190, Stipa 112, and Large Stipa sites, and Tumblemustard and other invasive species (e.g., cheatgrass, fiddleneck; *Amsinckia* sp.) provided some cover at Cemetery sites. The height, density, and distribution of cover were not noted in my survey.

The amount of litter vs. bare ground and/or crust also varied greatly by site. Large Stipa had the largest amount of bare ground and crust compared to litter. In contrast, OLS and Cemetery had much greater amounts of litter in their ground cover. Bare ground–to–litter ratios were subequal at Sage, Spigot 190, and Stipa 112.

**Climate.** Weather can affect the amount of activity (i.e., distances moved and movement rates) and, consequently, likelihood of capture of a variety of species (e.g., Shaw 1945, Perry et al. 1977). Mark–recapture sessions were less successful during periods with high precipitation, wind, or excessive heat.

As previously noted, increased precipitation that potentially increases food availability could account for possible differences in movement by year. Precipitation in 2004 was higher, and in 2005 was lower than the historic mean. Also, 2004 received more precipitation (73.7 mm) than 2005 (40.6 mm) in the fall and winter preceding the squirrels' January–July active season. The presumed increased food availability in 2004 may have affected the home range and core area sizes in this study. I would hypothesize larger home range sizes in drought years because squirrels may have to range farther in order to acquire sufficient food for reproduction and to achieve enough weight for overwinter survival. Increased food availability may also have affected the timing of dormancy in 2004. Dormancy (anecdotally) occurred earlier in 2005, possibly because forage dried out sooner, which in turn may have altered inter–annual survival; however inter–annual survival was not measured.

**Population Structure.** Mark–recapture data provide an approximate indication of population size, density, and population structure (i.e., age, sex) of the trapped sites. Data were consistent with my original classification of population size, and enabled me to quantify what I had characterized as large, medium, and small sizes (based on a comparison of known, active colonies within the study area). Differences in population size and/or density provide one possible explanation for differences in home range and core area sizes by site. Generally, I would anticipate higher population densities, and potentially smaller home ranges and core areas, in areas with higher resources (e.g., food, shelter, appropriate soil structure). I would also hypothesize that home ranges and core areas would overlap less often in large populations (i.e., Cemetery and Sage sites) due to increased competition for resources.

The number of trapping hours varied by site due to differences in the timing and weather conditions when the grid was open, and number of individuals in a population. Large Stipa had to be trapped in 2005, during a low precipitation year, which could have influenced its overall population size. However, I assumed that its population size would be similar to 2004, or close enough that it would not warrant a change in its size classification.

### Other Indicators of Site Quality

**Fates.** The high incidence of predation among squirrels in my study populations is consistent with previous observations (Betts 1990; 1999, Sherman 2000, Klein 2005). Predators included raptors and badgers, but I only directly observed predation of a radio–collared squirrel on one occasion by a Northern Harrier (*Circus cyaneus*). The amount of predation was similar between years, sexes, and sites that varied in amount of shrub cover. However, sites with predominantly non–native vegetation had higher percentages of predation and lower survival. I hypothesize this may be caused by a need to forage longer in non–native sites to obtain sufficient fat and protein resources, which may increase their exposure to predators. Predation was also higher in large populations compared to medium–sized sites, possibly because Washington ground squirrels' predators might focus their hunting efforts on larger sites that have more food availability.

Predation and survival rates documented herein are not certain, as the actual outcomes for individuals with unknown fates could skew predation: dormancy ratios in either direction. I assumed that squirrels with unknown fates had an equal chance of survival as predation.

Timing for initiation of dormancy ranged from 11 May to 10 June, with males (anecdotally) appearing to enter dormancy before earlier than females. This is consistent with prior descriptions of the timing of dormancy, where males are thought to enter dormancy before females, and dormancy begins in mid–May to June (Carlson et al. 1980, Verts and Carraway 1998). Dormancy began earliest at the Sage site (11 May) in 2005 and again in 2004 (19 May). This could imply that resources were exhausted earlier in the season at that site, or that emergence occurred earlier so squirrels had a quicker opportunity to acquire weight needed for dispersal

**Mark–Recapture Weights.** As expected, adults/yearlings weighed more than juveniles, and adult/yearling males weighed more than adult/yearling females. However, there was no difference in body mass between juvenile males and females, and both age classes had greater weights at sites with non–native vegetation. Juvenile weights were also greater at sites with large populations and sites with shrub cover. My finding that individuals weighed less at the native sites is the opposite of what I would expect since Greene (1999) documented the highest body masses for this species when found in bunchgrass communities.

Comparisons among recapture mass should be made with caution. This is because mass increased in the same order that sites were trapped, where smaller weights occurred at sites trapped earlier in the season. Also, one site (Large Stipa) was trapped in 2005, when precipitation was lower and food may have been scarcer.

**Initial Capture Weights.** The masses of individuals when radio–collared only differed by population size, but not sex, site, year, or other site characteristics. The difference in initial capture weights by population size appears driven by smaller male mass at Spigot 190 and Stipa 112 sites. I would have expected initial capture mass might be greatest at Large Stipa and Stipa 112, since these sites had a large amount of bunchgrasses (Greene 1999). However, because individuals were weighed early in the season, they had little time to accumulate much body fat after emergence, suggesting that the initial capture weights I recorded were close to the absolute minimum weight necessary to survive dormancy.

# CHAPTER 7

# CONCLUSIONS AND RECOMMENDATIONS

This study provided the first home range and core area estimates for Washington ground squirrels (*Spermophilus washingtoni*). Consistent with many other ground squirrel species, males of this species move greater distances than females, and adults and yearlings are much less dispersive than juvenile males (Klein 2005). Most individuals showed a high degree of site fidelity, with little shifting of home area throughout the season. The only inter–population dispersal that I documented occurred by a male in 2004, but there was some potential home range shifting or intra–population dispersal (up to 148 m from a core area) by both sexes in both years.

There was a large amount of inter– and intra–sexual seasonal and monthly home range overlap, but little core area overlap, indicating that territory sizes (i.e., areas defended and occupied by a single individual or coalition without overlapping other territories) are likely smaller than, but similar to core area sizes. Contrary, to my original null hypotheses, home ranges and movements were larger during the drier year (i.e., 2005), in the smaller (i.e., medium as opposed to large) populations, and for males. Sex was clearly the most significant of these three variables. I detected no differences in home range and core area size or movements by vegetation type, or sites with and without shrub cover, supporting my original null hypotheses for vegetation, cover, and site variables. However, a relationship between cover and vegetation type may be masked by the strong differences between sexes and population sizes and, to a less extent, year.  Alternatively, a relationship between cover and vegetation type may occur when vegetation is characterized at the home range– or core area–scale, as opposed to a larger, site scale.

Home range sizes varied between 321 and 56,988 $m^2$ for Minimum Convex Polygon estimates, 435 and 77,021 $m^2$ for Fixed Kernel Estimates, and 1,006 and 285,433 $m^2$ using Jennrich–Turner estimates.  The widest distance between two points of a home range estimate was 494.3 m.  This combined, suggests that the maximum area needed for an individual home range is 56,988–285,433 $m^2$, with at least 494.3 m across its home range.  This area is an overestimate, since it is based on the maximum home ranges observed in this study.  Alternatively, considering a 95 percent confidence interval, suggests that the area needed for an individual's home range is between 27,276–64,431 $m^2$, using Jennrich–Turner methods, or 15,054–29,129 $m^2$, based on FKE methods.  Although FKE methods are more robust, applying the most conservative estimate may appropriate when there is sparse knowledge of the distribution of resources across a landscape.

One male (out of 80 individuals monitored) displayed inter–population dispersal, of 761.1 m (or 850.8 m if topography is considered), and the home ranges of some individuals shifted 70 to 228 m.  This would suggest that an individual (adult or yearling) or colony can potentially shift up to this distance annually given adequate (or shifting) resources.  Of course, individuals' home ranges may shift back and forth over a series of years instead of moving unidirectionally.  Also, individual home range shift may not be significant when examined at the colony–scale.

One approach when revisiting sites that have not been recently surveyed would be to include a search radius of at least 228 m times the number of years since they colony was last surveyed, in order to account for potential individual or colony shift. The most cautious approach would incorporate maximum dispersal distances for all age classes and sexes (up to 3521 m [Klein 2005] times the number of years since the colony was last surveyed), into a search radius. However, this large of a search radius may not be practical, depending on the number of years that has lapsed since the last time a site was surveyed or if there are dispersal barriers that would eliminate the need for this large of a search radius. Alternatively, since long–range (>700m) dispersal is considered rare (Sherman and Shellman Sherman 2006), a smaller search radius of 400 to 700 or 880 m multiplied by the number of years since the last survey would be more reasonable approach. This would account for the majority of dispersers in Washington and would account for the median dispersal distance and for shifters" in Oregon, based on information obtained in this and previous dispersal studies and observations (Klein 2005, Sherman and Shellman Sherman 2006).

In Oregon, wind farm developments near occupied colonies often apply a 1000–m buffer between new developments and known colonies. In Washington, a 400–m buffer is applied for similar developmental uses. While both distances are shorter than the dispersal capability of this species, both distances exceed amount of home range shift that I documented for adults and yearlings within a single year. However, 400–m is smaller than the widest distance across a home range that I measured in this study (i.e., 494.3 m), meaning a buffer of 400–m can potentially encroach on some individuals' home ranges. Whether or not these distances provide adequate buffers over a period of time was not addressed in this study, but should be addressed in future studies. Multiple–year studies of individuals and colonies would more accurately determine whether these buffers sufficiently account for larger–scale shifting (if it occurs) and whether these buffers still allow for sufficient dispersal opportunities.

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APPENDICES

**APPENDIX A.** Spearman Rank and Pearson Correlation Tables.

**Table 1.** Spearman rank correlation: home range and core area estimators (if n ≥ 30 fixes) vs. distances/rates moved, based on 32 observations, df = 30, $R_{sig}$ = 0.30, α =0.10; $R_{sig}$ = 0.35, α =0.05, $R_{sig}$ = 0.45, α =0.01;..

| | MCP 95 | FKE 95 | JT 95 | MCP 50 | FKE 50 | JT 50 | Min Rate | Mean Rate | Max Rate | Min Move | Mean Move | Max Move |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MCP95** | 1.00 | | | | | | | | | | | |
| **FKE95** | 0.94 | 1.00 | | | | | | | | | | |
| **JT95** | 0.79 | 0.85 | 1.00 | | | | | | | | | |
| **MCP50** | 0.82 | 0.90 | 0.74 | 1.00 | | | | | | | | |
| **FKE50** | 0.86 | 0.93 | 0.81 | 0.83 | 1.00 | | | | | | | |
| **JT50** | 0.87 | 0.88 | 0.80 | 0.73 | 0.86 | 1.00 | | | | | | |
| **Min Rate** | – 0.04 | –0.12 | 0.05 | –0.10 | –0.08 | –0.02 | 1.00 | | | | | |
| **Mean Rate** | **0.60** | **0.61** | **0.57** | **0.65** | **0.56** | **0.58** | 0.25 | 1.00 | | | | |
| **Max Rate** | **0.56** | **0.52** | **0.47** | **0.51** | **0.47** | **0.56** | 0.28 | 0.81 | 1.00 | | | |
| **Min Move** | – 0.04 | –0.12 | 0.06 | –0.09 | –0.08 | –0.01 | 1.00 | 0.25 | 0.26 | 1.00 | | |
| **Mean Move** | **0.63** | **0.66** | **0.60** | **0.71** | **0.61** | **0.62** | 0.24 | 0.99 | 0.81 | 0.23 | 1.00 | |
| **Max Move** | **0.62** | **0.61** | **0.58** | **0.62** | **0.54** | **0.66** | 0.20 | 0.80 | 0.91 | 0.18 | 0.84 | 1.00 |

**Table 2.** Spearman Rank Correlation: initial capture weight (pre–March 17) vs. distances and rates moved, based on n = 29 observations, df = 27, $R_{sig} = 0.31$, $\alpha = 0.10$; $R_{sig} = 0.37$, $\alpha = 0.05$.

| | Initial Capture Weight | Min Move | Mean Move | Max Move | Min Rate | Mean Rate | Max Rate |
|---|---|---|---|---|---|---|---|
| **Initial Capture Weight** | 1.00 | | | | | | |
| **Min Move** | − 0.24 | 1.00 | | | | | |
| **Mean Move** | − 0.14 | 0.29 | 1.00 | | | | |
| **Max Move** | − 0.23 | 0.21 | 0.83 | 1.00 | | | |
| **Min Rate** | − 0.29 | 1.00 | 0.30 | 0.22 | 1.00 | | |
| **Mean Rate** | − 0.16 | 0.30 | 0.99 | 0.81 | 0.30 | 1.00 | |
| **Max Rate** | **− 0.33** | 0.27 | 0.80 | 0.91 | 0.29 | 0.81 | 1.00 |



**Table 3.** Pearson Correlation: initial capture weight (captured before March 17) vs. ln–transformed home range and core area sizes (if n ≥30 fixes), based on 27 observations, df = 25, $R_{sig} = 0.32$, $\alpha = 0.10$; $R_{sig} = 0.38$, $\alpha = 0.05$.

| | Initial Capture Weight | Ln MCP95 | Ln FKE95 | Ln JT95 | Ln MCP50 | Ln FKE50 | Ln JT50 |
|---|---|---|---|---|---|---|---|
| **Initial Capture Weight** | 1.00 | | | | | | |
| **LNMP95** | 0.03 | 1.00 | | | | | |
| **LNFK95** | 0.06 | 0.93 | 1.00 | | | | |
| **LNJT95** | 0.01 | 0.96 | 0.97 | 1.00 | | | |
| **Ln MCP50** | 0.17 | 0.77 | 0.92 | 0.83 | 1.00 | | |
| **Ln FKE50** | 0.08 | 0.91 | 0.97 | 0.93 | 0.87 | 1.00 | |
| **Ln JT50** | 0.13 | 0.91 | 0.92 | 0.95 | 0.76 | 0.91 | 1.00 |

**Table 4.** Pearson Rank Correlation: ln–transformed home range estimators (if n ≥ 30 fixes)vs. distances/rates moved, based on 32 observations, df = 30, $R_{sig}$ = 0.30, α =0.10; $R_{sig}$ = 0.35, α =0.05.

| | Min Move | Mean Move | Max Move | Min Rate | Mean Rate | Max Rate | Ln MCP95 | Ln FKE95 | Ln JT95 |
|---|---|---|---|---|---|---|---|---|---|
| **Min Move** | 1.00 | | | | | | | | |
| **Mean Move** | 0.30 | 1.00 | | | | | | | |
| **Max Move** | 0.14 | 0.89 | 1.00 | | | | | | |
| **Min Rate** | 0.99 | 0.34 | 0.17 | 1.00 | | | | | |
| **Mean Rate** | 0.31 | 0.99 | 0.90 | 0.35 | 1.00 | | | | |
| **Max Rate** | 0.12 | 0.83 | 0.95 | 0.14 | 0.86 | 1.00 | | | |
| **Ln MCP95** | –0.03 | 0.59 | 0.62 | 0.01 | 0.58 | 0.58 | 1.00 | | |
| **Ln FKE95** | –0.01 | 0.61 | 0.61 | 0.05 | 0.58 | 0.53 | 0.87 | 1.00 | |
| **Ln JT95** | 0.01 | 0.50 | 0.51 | 0.06 | 0.47 | 0.44 | 0.75 | 0.78 | 1.00 |



**Table 5.** Pearson Rank Correlation: ln–transformed core area estimators (if n ≥ 30 fixes) vs. distances/rates moved, based on 32 observations, df = 30, $R_{sig}$ = 0.30, α =0.10; $R_{sig}$ = 0.35, α =0.05.

| | Min Move | Mean Move | Max Move | Min Rate | Mean Rate | Max Rate | Ln MCP50 | Ln FKE50 | Ln JT50 |
|---|---|---|---|---|---|---|---|---|---|
| **Min Move** | 1.00 | | | | | | | | |
| **Mean Move** | 0.30 | 1.00 | | | | | | | |
| **Max Move** | 0.14 | 0.89 | 1.00 | | | | | | |
| **Min Rate** | 0.99 | 0.34 | 0.17 | 1.00 | | | | | |
| **Mean Rate** | 0.31 | 0.99 | 0.90 | 0.35 | 1.00 | | | | |
| **Max Rate** | 0.12 | 0.83 | 0.95 | 0.14 | 0.86 | 1.00 | | | |
| **Ln MCP50** | –0.03 | 0.56 | 0.50 | 0.02 | 0.52 | 0.42 | 1.00 | | |
| **Ln FKE50** | 0.02 | 0.57 | 0.55 | 0.06 | 0.54 | 0.49 | 0.77 | 1.00 | |
| **Ln JT50** | 0.02 | 0.56 | 0.60 | 0.07 | 0.53 | 0.54 | 0.58 | 0.86 | 1.00 |

**APPENDIX B.** Home range and core area analysis for 54 squirrels with site fidelity and at least three fixes.

**Table 1.** Home ranges and core areas were calculated for all squirrels showing site fidelity that had at least three fixes (n = 54 ). Estimates should be applied judiciously, with consideration of how lower sample sizes (n) and increased autocorrelation may (i.e., lower t2/r2 values) impact the accuracy of each estimator.).

| Fate | ID | Year | Sex | n | LSCV h | t2/ r2 | FKE 95 | FKE 50 | MCP 95 | MCP 50 | JT 95 | JT 50 | Track Period (Days) | No. Days w/ Fixes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | cem145 | 2004 | M | 37 | 6.8 | 2.0 | 2934 | 327 | 1535 | 420 | 4722 | 1092 | 24 | 9 |
| P | cem083 | 2005 | F | 13 | 10.2 | – | 3189 | 414 | 1408 | 72 | 5419 | 1254 | 13 | 5 |
| P | cem020 | 2005 | F | 15 | 4.3 | – | 765 | 136 | 621 | 89 | 1713 | 396 | 24 | 9 |
| P | cem082 | 2005 | F | 22 | 3.1 | – | 330 | 40 | 496 | 11 | 956 | 221 | 34 | 11 |
| U | cem031 | 2005 | F | 26 | 6.5 | – | 2094 | 239 | 1140 | 219 | 2892 | 669 | 43 | 13 |
| P | cem121 | 2005 | F | 29 | 3.2 | – | 487 | 42 | 585 | 76 | 1066 | 247 | 83 | 11 |
| P | cem107 | 2005 | F | 31 | 2.9 | 1.6 | 435 | 46 | 321 | 35 | 1006 | 233 | 53 | 17 |
| S | cem072 | 2005 | F | 40 | 23.5 | 1.0 | 29988 | 2127 | 22532 | 10271 | 52042 | 2041 | 86 | 31 |
| P | cem159 | 2005 | M | 3 | NA | – | NA | NA | NA | NA | NA | NA | 17 | 4 |
| P | cem096 | 2005 | M | 16 | 28.6 | – | 35882 | 6826 | 9304 | 2744 | 69691 | 16125 | 24 | 9 |
| U | cem007 | 2005 | M | 20 | 11.0 | – | 7568 | 829 | 4190 | 557 | 12572 | 2909 | 49 | 13 |
| P | lstip393 | 2004 | F | 26 | 20.0 | 0.9 | 16985 | 1714 | 12910 | 474 | 25861 | 5984 | 60 | 10 |
| S | lstip181 | 2004 | F | 39 | 10.0 | 1.0 | 5090 | 502 | 3851 | 640 | 12928 | 2991 | 72 | 17 |
| S | lstip333 | 2004 | M | 36 | 23.2 | 1.7 | 29209 | 5592 | 18294 | 4769 | 49505 | 11454 | 74 | 15 |
| U | lstip121 | 2005 | F | 44 | 9.2 | 1.6 | 2124 | 323 | 9432 | 29 | 11277 | 2609 | 84 | 23 |
| S | lstip056 | 2005 | F | 55 | 10.0 | 1.2 | 5573 | 422 | 5413 | 1250 | 8697 | 2012 | 93 | 28 |
| S | lstip134 | 2005 | F | 57 | 10.6 | 1.9 | 8080 | 617 | 8725 | 1004 | 15888 | 3676 | 95 | 30 |
| S | lstip040 | 2005 | F | 65 | 23.0 | 0.6 | 18766 | 2349 | 19537 | 2291 | 39056 | 9037 | 101 | 35 |

| Fate | ID | Year | Sex | n | LSCV h | t2/ r2 | FKE 95 | FKE 50 | MCP 95 | MCP 50 | JT 95 | JT 50 | Track Period (Days) | No. Days w/ Fixes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | lstip146 | 2005 | M | 47 | 29.5 | 0.9 | 48575 | 7011 | 28703 | 5345 | 43438 | 10050 | 79 | 23 |
| S | lstip070 | 2005 | M | 55 | 27.4 | 0.8 | 42801 | 4593 | 26040 | 16560 | 61655 | 14266 | 91 | 28 |
| S | lstip006 | 2005 | M | 62 | 22.0 | 1.6 | 46797 | 4764 | 39180 | 7854 | 73425 | 16989 | 115 | 36 |
| S | lstip159 | 2005 | M | 64 | 17.3 | 1.6 | 22949 | 2134 | 25772 | 2303 | 43195 | 9994 | 92 | 30 |
| P | ols282 | 2004 | F | 14 | 14.6 | – | 11085 | 793 | 4201 | 206 | 17722 | 4101 | 27 | 7 |
| U | ols230 | 2004 | F | 18 | 20.7 | – | 25737 | 3481 | 13036 | 3940 | 285606 | 8854 | 27 | 8 |
| U | ols283 | 2004 | F | 20 | 11.8 | – | 4952 | 934 | 3472 | 355 | 14372 | 3325 | 12 | 6 |
| S | ols307 | 2004 | F | 45 | 9.4 | 0.9 | 6269 | 1493 | 5282 | 770 | 285433 | 2158 | 43 | 14 |
| P | ols224 | 2004 | M | 40 | 25.9 | 1.0 | 48467 | 7013 | 35033 | 14786 | 75415 | 17449 | 62 | 14 |
| U | ols120 | 2005 | F | 37 | 17.6 | 1.2 | 16903 | 1413 | 13310 | 2178 | 33510 | 7754 | 80 | 26 |
| U | ols055 | 2005 | M | 21 | 20.9 | | 20111 | 1702 | 10956 | 393 | 43688 | 10108 | 36 | 13 |
| U | ols045 | 2005 | M | 32 | 29.6 | 0.8 | 65863 | 5339 | 40529 | 12078 | 89881 | 20797 | 71 | 21 |
| S | ols158 | 2005 | M | 39 | 22.3 | 1.2 | 37601 | 5838 | 25011 | 3445 | 58017 | 13424 | 81 | 24 |
| U | ols019 | 2005 | M | 39 | 18.5 | 1.8 | 22503 | 3167 | 15226 | 7219 | 41625 | 9631 | 73 | 24 |
| S | ols085 | 2005 | M | 43 | 27.0 | 1.1 | 50939 | 5710 | 35402 | 5247 | 98277 | 22739 | 81 | 30 |
| S | ols098 | 2005 | M | 43 | 19.3 | 1.4 | 19320 | 1582 | 13044 | 2383 | 45687 | 10571 | 100 | 28 |
| U | sage207 | 2004 | F | 10 | NA | – | NA | NA | 4172 | 190 | NA | NA | 19 | 5 |
| S | sage371 | 2004 | F | 43 | 8.5 | 1.6 | 4412 | 440 | 3505 | 1177 | 7771 | 1798 | 77 | 20 |
| S | sage001 | 2004 | F | 47 | 5.8 | 1.6 | 1254 | 200 | 3233 | 110 | 4336 | 1003 | 90 | 20 |
| U | sage121 | 2004 | F | 48 | 6.7 | 1.5 | 2892 | 245 | 3573 | 453 | 5773 | 1336 | 60 | 17 |
| S | sage431 | 2004 | M | 47 | 15.1 | 1.8 | 16301 | 1754 | 10022 | 5473 | 21640 | 5007 | 85 | 23 |
| P | sage072 | 2005 | F | 16 | 7.0 | – | 1915 | 201 | 922 | 169 | 3792 | 877 | 20 | 10 |
| U | sage073 | 2005 | F | 22 | 19.7 | – | 17695 | 1659 | 12856 | 595 | 30001 | 6942 | 64 | 13 |

| Fate | ID | Year | Sex | n | LSCV h | t2/ r2 | FKE 95 | FKE 50 | MCP 95 | MCP 50 | JT 95 | JT 50 | Track Period (Days) | No. Days w/ Fixes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U | sage018 | 2005 | F | 36 | 14.5 | 0.9 | 11401 | 1419 | 7303 | 1773 | 18977 | 4391 | 75 | 23 |
| U | sage083 | 2005 | F | 36 | 19.3 | 0.8 | 10287 | 1424 | 13133 | 40 | 38552 | 8920 | 83 | 24 |
| S | sage107 | 2005 | F | 48 | 13.1 | 1.5 | 8474 | 799 | 9198 | 519 | 16975 | 3928 | 106 | 32 |
| P | sage133 | 2005 | M | 27 | 15.8 | – | 16496 | 4155 | 9280 | 1885 | 24549 | 5680 | 48 | 16 |
| P | sage000 | 2005 | M | 31 | 14.9 | 1.7 | 14372 | 1721 | 8717 | 2891 | 20682 | 4785 | 75 | 19 |
| P | sage057 | 2005 | M | 34 | 19.1 | 1.7 | 21155 | 1881 | 24284 | 1022 | 42205 | 9765 | 63 | 22 |
| P | sage033 | 2005 | M | 35 | 31.8 | 1.2 | 77021 | 8181 | 56988 | 17022 | 127144 | 29418 | 85 | 24 |
| S | sage045 | 2005 | M | 47 | 20.6 | 0.9 | 17903 | 2556 | 9890 | 1454 | 49159 | 11374 | 92 | 28 |
| S | sage097 | 2005 | M | 55 | 10.9 | 1.3 | 12376 | 3480 | 9998 | 2031 | 15275 | 3534 | 93 | 28 |
| S | spig297 | 2004 | M | 8 | NA | – | NA | NA | NA | NA | NA | NA | 81 | 7 |
| P | 112_110 | 2004 | F | 3 | NA | – | NA | NA | NA | NA | NA | NA | 52 | 3 |
| S | 112_381 | 2004 | M | 6 | NA | – | NA | NA | NA | NA | NA | NA | 81 | 6 |

**APPENDIX C.** Stabilization of home ranges using 95% Minimum Convex Polygon analysis.

**Table 1.** MCP95 home range estimates for 33 squirrels were graphed to determine the point where home range stabilized with increasing sample size. For those with a question mark (?), the home range reached its plateau close to the final recorded location. It is possible that given more locations this home range would continue to increase in size. Two home ranges were still increasing at the end of the season, but were included in the statistical analysis since their estimates were based on movements throughout the season.

| ID | n | MCP95 Stabilized At: | | Dates Tracked | Status at Last Fix | Increase between n=30 and end for MCP95 ($m^2$) | Percentage of Total MCP95 at n = 30 ($m^2$) |
|---|---|---|---|---|---|---|---|
| | | n | Date | | | | |
| 05cem072f | 40 | NA | NA | Feb 16–May 12 | Increasing | 6782 | 70 |
| 05cem107f | 31 | 23 | Mar 24 | Feb 18– Apr 11 | Stable/Unknown | NA | 100 |
| 04cem145m | 37 | 30 | May 18 | May 10– June 2 | Stable | 0 | 100 |
| 04lstipa181f | 39 | 27 | May 7 | Mar 16– May 26 | Stable | 0 | 100 |
| 05lstipa121f | 44 | 35 | Apr 13 | Feb 15– May 10 | Stable | 2057 | 78 |
| 05lstipa056f | 55 | 51 | May 17 | Feb 23–May 23 | Stable | 3113 | 43 |
| 05lstipa134f | 57 | 41 | Apr 27 | Feb 19– May 23 | Stable | 3725 | 57 |
| 05lstipa040f | 65 | 56 | May 17 | Feb 17– May 27 | Stable | 9287 | 53 |
| 04lstipa333m | 36 | 25 | May 7 | Mar 30– June 1 | Stable | 0 | 100 |
| 05lstipa146m | 47 | 42 | Apr 27 | Feb 17– May 5 | Stable | 12603 | 56 |
| 05lstipa070m | 55 | 43 | May 3 | Feb 19– May 19 | Stable | 7790 | 70 |
| 05lstipa006m | 62 | 50 | May 17 | Feb 17– June 10 | Stable | 16680 | 57 |
| 05lstipa159m | 64 | 51 | May 2 | Feb 17–May 18 | Stable | 7772 | 70 |
| 05ols120f | 37 | 28 | Apr 11 | Feb 14–May 3 | Stable | 0 | 100 |
| 04ols307f | 45 | 43 | May 24 | Apr 19–June 1 | Stable | 1332 | 75 |
| 05ols045m | 32 | 27 | Apr 13 | Feb 15–Apr 25 | Stable? | 0 | 100 |
| 05ols158m | 39 | 20 | Mar 31 | Mar 4– May 23 | Stable | 0 | 100 |
| 05ols19m | 39 | 37 | May 2 | Feb 21– May 3 | Stable | 0 | 100 |
| 04ols224m | 40 | 28 | May 5 | Mar 1– May 7 | Stable | 3033 | 91 |

| ID | n | MCP95 Stabilized At: | | Dates Tracked | Status at Last Fix | Increase between n=30 and end for MCP95 ($m^2$) | Percentage of Total MCP95 at n = 30 ($m^2$) |
|---|---|---|---|---|---|---|---|
| | | n | Date | | | | |
| 05ols085m | 43 | 36 | May 10 | Mar 4–May 23 | Stable | 0 | 100 |
| 05ols098m | 43 | 36 | Apr 18 | Feb 14–May 23 | Stable | 0 | 100 |
| 05sage018f | 36 | 30 | Apr 4 | Feb 10–Apr 25 | Stable/Unknown | 0 | 100 |
| 05sage083f | 36 | NA | NA | Feb 11–May 4 | Increasing | 4508 | 66 |
| 04sage371f | 43 | 39 | Apr 14 | Mar 4– May 3 | Stable | 280 | 92 |
| 04sage001f | 47 | 37 | Apr 26 | Mar 4– June 1 | Stable | 0 | 100 |
| 04sage121f | 48 | 44 | Apr 9 | Mar 5–May 3 | Stable | 2123 | 41 |
| 05sage107f | 48 | 41 | May 11 | Feb 8–May 24 | Stable | 0 | 100 |
| 05sage000m | 31 | 17 | Mar 9 | Feb 10/ Apr 12 | Stable/Unknown | 8717 | 100 |
| 05sage057m | 34 | 30 | Apr 4 | Feb 9– Apr 12 | Stable/Unknown | 0 | 100 |
| 05sage033m | 35 | 28 | Apr 4 | Feb 1– May 2 | Stable | 0 | 100 |
| 04sage431m | 47 | 34 | Apr 14 | Mar 4– May 21 | Stable | 0 | 100 |
| 05sage045m | 47 | 44 | May 2 | Feb 9– May 11 | Stable | 1890 | 82 |
| 05sage097m | 55 | 39 | Mar 23 | Feb 8– May 11 | Stable | 748 | 93 |

**Appendix D.** AICc models for home ranges and core areas.

**Table 1.** AICc modeling of ln–transformed FKE95 home ranges.

| Model | Ln FKE95 AICc | ΔAICc | Akaike Weight | #Parameters (K) |
|---|---|---|---|---|
| Sex+Size | –4.179 | 0.000 | 0.340 | 3 |
| Sex+Year | –3.615 | 0.563 | 0.256 | 3 |
| Sex | –2.104 | 2.075 | 0.120 | 2 |
| Sex*Size | –2.046 | 2.133 | 0.117 | 4 |
| Sex*Year | –1.034 | 3.145 | 0.070 | 4 |
| Sex+Cover | 0.146 | 4.324 | 0.039 | 3 |
| Sex+Native | 0.321 | 4.500 | 0.036 | 3 |
| Sex*Cover | 2.744 | 6.923 | 0.011 | 4 |
| Sex*Native | 2.881 | 7.060 | 0.010 | 4 |
| Year+Size | 10.162 | 14.341 | 0.000 | 3 |
| Size | 11.130 | 15.308 | 0.000 | 2 |
| Year*Size | 11.842 | 16.021 | 0.000 | 4 |
| Year | 11.882 | 16.061 | 0.000 | 2 |
| Year+Cover | 13.229 | 17.407 | 0.000 | 3 |
| No Interactions | 13.511 | 17.690 | 0.000 | 1 |
| Year+Native | 14.009 | 18.188 | 0.000 | 3 |
| Cover | 15.105 | 19.284 | 0.000 | 2 |
| Year*Cover | 15.132 | 19.311 | 0.000 | 4 |
| Native | 15.524 | 19.702 | 0.000 | 2 |
| Year*Native | 16.440 | 20.619 | 0.000 | 4 |

**Table 2.** AICc modeling of ln–transformed MCP95 home ranges.

| Model | Ln MCP95 AICc | ΔAICc | Akaike Weight | #Parameters (K) |
|---|---|---|---|---|
| Sex+Size | –5.723 | 0.000 | 0.361 | 2 |
| Sex+Year | –5.029 | 0.695 | 0.255 | 3 |
| Sex*Size | –3.431 | 2.292 | 0.115 | 4 |
| Sex | –2.691 | 3.032 | 0.079 | 2 |
| Sex*year | –2.447 | 3.276 | 0.070 | 4 |
| Sex+Native | –0.739 | 4.984 | 0.030 | 3 |
| Sex+Cover | –0.393 | 5.331 | 0.025 | 3 |
| Year+Size | –0.132 | 5.591 | 0.022 | 3 |
| Sex*Native | 1.782 | 7.506 | 0.008 | 4 |
| Size | 1.964 | 7.688 | 0.008 | 2 |
| Year*Size | 2.099 | 7.822 | 0.007 | 4 |
| Sex*Cover | 2.190 | 7.913 | 0.007 | 4 |
| Year | 2.869 | 8.592 | 0.005 | 2 |
| Year+Cover | 4.389 | 10.112 | 0.002 | 3 |
| Year+Native | 5.254 | 10.977 | 0.001 | 3 |
| No Interactions | 5.611 | 11.334 | 0.001 | 1 |
| Year*Cover | 6.987 | 12.711 | 0.001 | 4 |
| Cover | 7.361 | 13.084 | 0.001 | 2 |
| Year*Native | 7.677 | 13.400 | 0.000 | 4 |
| Native | 7.834 | 13.557 | 0.000 | 2 |

**Table 3.** AICc modeling of ln–transformed JT95 home ranges.

| Model | Ln JT95 AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Size | 0.907 | 0.000 | 0.486 | 3 |
| Sex*Size | 3.481 | 2.575 | 0.134 | 4 |
| Year*Size | 4.554 | 3.647 | 0.078 | 4 |
| Sex | 4.923 | 4.016 | 0.065 | 2 |
| Size | 5.164 | 4.257 | 0.058 | 2 |
| Sex+Cover | 6.218 | 5.311 | 0.034 | 3 |
| Sex+Year | 6.367 | 5.461 | 0.032 | 3 |
| Year+Size | 6.606 | 5.699 | 0.028 | 3 |
| Sex+Native | 6.612 | 5.705 | 0.028 | 3 |
| Sex*Year | 8.349 | 7.442 | 0.012 | 4 |
| Sex*Native | 8.447 | 7.540 | 0.011 | 4 |
| Sex*Cover | 8.752 | 7.845 | 0.010 | 4 |
| No Interactions | 9.898 | 8.991 | 0.005 | 1 |
| Cover | 10.488 | 9.581 | 0.004 | 2 |
| Year | 10.725 | 9.818 | 0.004 | 2 |
| Native | 10.969 | 10.063 | 0.003 | 2 |
| Year+Cover | 11.108 | 10.201 | 0.003 | 3 |
| Year+Native | 11.891 | 10.984 | 0.002 | 3 |
| Year*Native | 12.418 | 11.511 | 0.002 | 4 |
| Year*Cover | 13.640 | 12.733 | 0.001 | 4 |

**Table 4.** AICc modeling of ln–transformed FKE50 core areas.

| Model | Ln FKE50 AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Size | –4.857 | 0.000 | 0.410 | 3 |
| Sex | –2.890 | 1.967 | 0.154 | 2 |
| Sex+Year | –2.637 | 2.220 | 0.135 | 3 |
| Sex*Size | –2.495 | 2.362 | 0.126 | 4 |
| Sex+Cover | –1.058 | 3.799 | 0.061 | 3 |
| Sex+Native | –0.474 | 4.383 | 0.046 | 3 |
| Sex*Year | –0.036 | 4.821 | 0.037 | 4 |
| Sex*Cover | 1.471 | 6.328 | 0.017 | 4 |
| Sex*Native | 1.978 | 6.836 | 0.014 | 4 |
| Size | 12.988 | 17.845 | 0.000 | 2 |
| Year+Size | 13.427 | 18.284 | 0.000 | 3 |
| Year*Size | 13.803 | 18.660 | 0.000 | 4 |
| Year | 14.958 | 19.815 | 0.000 | 2 |
| No Interactions | 15.147 | 20.004 | 0.000 | 1 |
| Year+Cover | 15.771 | 20.628 | 0.000 | 3 |
| Cover | 16.219 | 21.076 | 0.000 | 2 |
| Year+Native | 17.190 | 22.047 | 0.000 | 3 |
| Native | 17.244 | 22.101 | 0.000 | 2 |
| Year*Cover | 17.489 | 22.346 | 0.000 | 4 |
| Year*Native | 19.078 | 23.936 | 0.000 | 4 |

**Table 5.** AICc modeling of ln–transformed MCP50 core areas.

| Model | Ln MCP50 AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Size | 23.040 | 0.000 | 0.317 | 3 |
| Sex | 23.436 | 0.396 | 0.260 | 2 |
| Sex*Size | 25.422 | 2.382 | 0.096 | 4 |
| Sex+Native | 25.517 | 2.477 | 0.092 | 3 |
| Sex+Year | 25.783 | 2.743 | 0.080 | 3 |
| Sex+Cover | 25.864 | 2.824 | 0.077 | 3 |
| Sex*Native | 27.657 | 4.617 | 0.032 | 4 |
| Sex*Year | 28.375 | 5.335 | 0.022 | 4 |
| Sex*Cover | 28.393 | 5.353 | 0.022 | 4 |
| Size | 35.463 | 12.423 | 0.001 | 2 |
| No Interactions | 36.589 | 13.548 | 0.000 | 1 |
| Year+Size | 36.848 | 13.807 | 0.000 | 3 |
| Native | 38.009 | 14.969 | 0.000 | 2 |
| Year | 38.418 | 15.378 | 0.000 | 2 |
| Cover | 38.629 | 15.588 | 0.000 | 2 |
| Year*Size | 39.987 | 16.947 | 0.000 | 4 |
| Year+Native | 40.193 | 17.153 | 0.000 | 3 |
| Year+Cover | 40.562 | 17.522 | 0.000 | 3 |
| Year*Native | 42.586 | 19.546 | 0.000 | 4 |
| Year*Cover | 43.131 | 20.090 | 0.000 | 4 |

**Table 6.** AICc modeling of ln–transformed JT50 core areas.

| Model | Ln JT50 AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Size | –12.825 | 0.000 | 0.550 | 3 |
| Sex*Size | –10.322 | 2.503 | 0.157 | 4 |
| Sex+Year | –10.030 | 2.795 | 0.136 | 3 |
| Sex | –8.171 | 4.653 | 0.054 | 2 |
| Sex*Year | –7.459 | 5.366 | 0.038 | 4 |
| Sex+Cover | –6.768 | 6.057 | 0.027 | 3 |
| Sex+Native | –6.202 | 6.623 | 0.020 | 3 |
| Sex*Native | –4.683 | 8.142 | 0.009 | 4 |
| Sex*Cover | –4.167 | 8.658 | 0.007 | 4 |
| Year+Size | 0.568 | 13.392 | 0.001 | 3 |
| Size | 1.889 | 14.714 | 0.000 | 2 |
| Year*Size | 2.451 | 15.276 | 0.000 | 4 |
| Year | 4.348 | 17.173 | 0.000 | 2 |
| Year+Cover | 4.403 | 17.227 | 0.000 | 3 |
| Year*Cover | 5.434 | 18.259 | 0.000 | 4 |
| No Interactions | 6.323 | 19.148 | 0.000 | 1 |
| Year+Native | 6.773 | 19.597 | 0.000 | 3 |
| Cover | 6.945 | 19.770 | 0.000 | 2 |
| Native | 8.580 | 21.405 | 0.000 | 2 |
| Year*Native | 9.195 | 22.020 | 0.000 | 4 |

**Appendix E.** AICc models for distances moved and movement rates.

**Table 1.** AICc modeling of untransformed minimum distances moved over 45–74 min intervals.

| Model | Min 45–74 Move AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex*Size | 137.442 | 0.000 | 0.398 | 4 |
| Sex+Size | 139.388 | 1.946 | 0.150 | 3 |
| Year+Size | 140.264 | 2.822 | 0.097 | 3 |
| Size | 140.312 | 2.870 | 0.095 | 2 |
| Year*Size | 141.769 | 4.327 | 0.046 | 4 |
| No interactions | 142.13 | 4.688 | 0.038 | 1 |
| Sex | 142.223 | 4.781 | 0.036 | 2 |
| Year | 142.667 | 5.225 | 0.029 | 2 |
| Sex+Year | 143.395 | 5.953 | 0.020 | 3 |
| Cover | 144.149 | 6.707 | 0.014 | 2 |
| Sex+Cover | 144.295 | 6.853 | 0.013 | 3 |
| Native | 144.385 | 6.943 | 0.012 | 2 |
| Sex+Native | 144.551 | 7.109 | 0.011 | 3 |
| Year+Cover | 144.982 | 7.540 | 0.009 | 3 |
| Year+Native | 145.077 | 7.635 | 0.009 | 3 |
| Sex*Year | 145.103 | 7.661 | 0.009 | 4 |
| Sex*Cover | 146.469 | 9.027 | 0.004 | 4 |
| Year*Cover | 147.021 | 9.579 | 0.003 | 4 |
| Sex*Native | 147.118 | 9.676 | 0.003 | 4 |
| Year*Native | 147.605 | 10.163 | 0.002 | 4 |

**Table 2.** AICc modeling of untransformed mean distances moved over 45–74 min intervals.

| Model | Mean 45–74 Move AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Year | 193.642 | 0.000 | 0.222 | 3 |
| Sex+Cover | 193.891 | 0.249 | 0.196 | 3 |
| Sex | 194.381 | 0.739 | 0.154 | 2 |
| Sex+Size | 194.640 | 0.998 | 0.135 | 3 |
| Sex*Year | 195.126 | 2.338 | 0.069 | 4 |
| Sex*Cover | 195.980 | 1.484 | 0.106 | 4 |
| Sex*Size | 196.499 | 2.857 | 0.053 | 4 |
| Sex+Native | 196.685 | 3.043 | 0.049 | 3 |
| Sex*Native | 199.117 | 5.475 | 0.014 | 4 |
| Year | 207.592 | 13.950 | 0.000 | 2 |
| Year+Size | 207.791 | 14.149 | 0.000 | 3 |
| Size | 209.186 | 15.718 | 0.000 | 2 |
| Year+Cover | 209.209 | 15.567 | 0.000 | 3 |
| Year+Native | 209.281 | 15.639 | 0.000 | 3 |
| No interactions | 209.333 | 15.544 | 0.000 | 1 |
| Year*Size | 209.360 | 15.691 | 0.000 | 4 |
| Cover | 210.334 | 16.963 | 0.000 | 2 |
| Year*Cover | 210.605 | 16.692 | 0.000 | 4 |
| Native | 211.186 | 17.544 | 0.000 | 2 |
| Year*Native | 211.860 | 18.218 | 0.000 | 4 |

**Table 3.** AICc modeling of untransformed maximum distances moved over 45–74 min intervals.

| Model | Max 45–74 Move AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Year | 264.363 | 0.000 | 0.240 | 3 |
| Sex+Size | 264.546 | 0.183 | 0.219 | 3 |
| Sex+Cover | 264.871 | 0.508 | 0.186 | 3 |
| Sex | 266.324 | 1.961 | 0.090 | 2 |
| Sex*Size | 266.676 | 2.313 | 0.075 | 4 |
| Sex*Year | 266.937 | 2.574 | 0.066 | 4 |
| Sex*Cover | 266.996 | 2.633 | 0.064 | 4 |
| Sex+Native | 268.580 | 4.217 | 0.029 | 3 |
| Sex*Native | 270.973 | 6.610 | 0.009 | 4 |
| Year+Size | 271.570 | 7.207 | 0.007 | 3 |
| Year*Size | 271.914 | 7.551 | 0.005 | 4 |
| Year | 273.369 | 9.006 | 0.003 | 2 |
| Year+Cover | 274.274 | 9.911 | 0.002 | 3 |
| Size | 274.332 | 9.969 | 0.002 | 2 |
| Year*Cover | 275.396 | 11.033 | 0.001 | 4 |
| Year+Native | 275.752 | 11.389 | 0.001 | 3 |
| No interactions | 276.352 | 11.989 | 0.001 | 1 |
| Cover | 276.489 | 12.126 | 0.001 | 2 |
| Year*Native | 278.267 | 13.904 | 0.000 | 4 |
| Native | 278.603 | 14.240 | 0.000 | 2 |

**Table 4.** AICc modeling of untransformed minimum movement rates (m/hr) over 45–74 min intervals.

| Model | Min 45–74 Rate AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex*Size | 143.069 | 0.000 | 0.336 | 4 |
| Sex+Size | 144.436 | 1.367 | 0.169 | 3 |
| Year+Size | 145.37 | 2.301 | 0.106 | 3 |
| Size | 145.731 | 2.662 | 0.089 | 2 |
| Year*Size | 146.711 | 3.642 | 0.054 | 4 |
| Sex | 147.185 | 4.116 | 0.043 | 2 |
| No interactions | 147.392 | 4.323 | 0.039 | 1 |
| Year | 147.668 | 4.599 | 0.034 | 2 |
| Sex+Year | 148.153 | 5.084 | 0.026 | 3 |
| Sex+Cover | 149.248 | 6.179 | 0.015 | 3 |
| Cover | 149.411 | 6.342 | 0.014 | 2 |
| Sex+Native | 149.466 | 6.397 | 0.014 | 3 |
| Native | 149.635 | 6.566 | 0.013 | 2 |
| Sex*Year | 149.717 | 6.648 | 0.012 | 4 |
| Year+Cover | 149.99 | 6.921 | 0.011 | 3 |
| Year+Native | 150.069 | 7.000 | 0.010 | 3 |
| Sex*Cover | 151.272 | 8.203 | 0.006 | 4 |
| Sex*Native | 152.046 | 8.977 | 0.004 | 4 |
| Year*Cover | 152.148 | 9.079 | 0.004 | 4 |
| Year*Native | 152.631 | 9.562 | 0.003 | 4 |

**Table 5.** AICc modeling of untransformed mean movement rates (m/hr) over 45–74 min intervals.

| Model | Mean 45–74 Rate AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Year | 194.901 | 0.000 | 0.287 | 3 |
| Sex+Cover | 195.149 | 0.248 | 0.254 | 3 |
| Sex | 196.602 | 1.701 | 0.123 | 2 |
| Sex+Size | 197.177 | 2.276 | 0.092 | 3 |
| Sex*Year | 197.285 | 2.384 | 0.087 | 4 |
| Sex*Cover | 197.492 | 2.591 | 0.079 | 4 |
| Sex+Native | 199.015 | 4.114 | 0.037 | 3 |
| Sex*Size | 199.485 | 4.584 | 0.029 | 4 |
| Sex*Native | 201.517 | 6.616 | 0.011 | 4 |
| Year | 207.415 | 12.514 | 0.001 | 2 |
| Year+Size | 207.844 | 12.943 | 0.000 | 3 |
| Year+Cover | 208.558 | 13.657 | 0.000 | 3 |
| Year*Size | 209.157 | 14.256 | 0.000 | 4 |
| Year+Native | 209.480 | 14.579 | 0.000 | 3 |
| Year*Cover | 209.827 | 14.926 | 0.000 | 4 |
| No interactions | 210.043 | 15.142 | 0.000 | 1 |
| Size | 210.131 | 15.230 | 0.000 | 2 |
| Cover | 210.458 | 15.557 | 0.000 | 2 |
| Native | 212.056 | 17.155 | 0.000 | 2 |
| Year*Native | 212.058 | 17.157 | 0.000 | 4 |

**Table 6.** AICc modeling of untransformed maximum movement rates (m/hr) over 45–74 min intervals.

| Model | Max 45–74 Rate AICc | ΔAICc | Akaike Weight | # Parameters (K) |
|---|---|---|---|---|
| Sex+Year | 269.762 | 0.000 | 0.289 | 3 |
| Sex+Size | 270.897 | 1.135 | 0.164 | 3 |
| Sex+Cover | 270.997 | 1.235 | 0.156 | 3 |
| Sex | 272.098 | 2.336 | 0.090 | 2 |
| Sex*Year | 272.327 | 2.565 | 0.080 | 4 |
| Sex*Cover | 273.422 | 3.660 | 0.046 | 4 |
| Sex*Size | 273.472 | 3.710 | 0.045 | 4 |
| Sex+Native | 274.070 | 4.308 | 0.034 | 3 |
| Year+Size | 274.680 | 4.918 | 0.025 | 3 |
| Year*Size | 274.765 | 5.003 | 0.024 | 4 |
| Year | 276.096 | 6.334 | 0.012 | 2 |
| Sex*Native | 276.607 | 6.845 | 0.009 | 4 |
| Year+Cover | 277.001 | 7.239 | 0.008 | 3 |
| Size | 277.867 | 8.105 | 0.005 | 2 |
| Year*Cover | 278.467 | 8.705 | 0.004 | 4 |
| Year+Native | 278.491 | 8.729 | 0.004 | 3 |
| No interactions | 279.508 | 9.746 | 0.002 | 1 |
| Cover | 279.630 | 9.868 | 0.002 | 2 |
| Year*Native | 280.944 | 11.182 | 0.001 | 4 |
| Native | 281.739 | 11.977 | 0.001 | 2 |

**APPENDIX F.** Comparison between initial capture and final locations by site and year.

A comparison between initial capture locations and last fixes is displayed by site and year. Initial capture points are denoted by an '↑' and final fixes are denoted by an '↓' for dormancy, 'X' for predation, and '?' for unknown fates. Each squirrel is represented with a different color in each figure, and collar identification (number and sex) are displayed by each squirrel's final location.

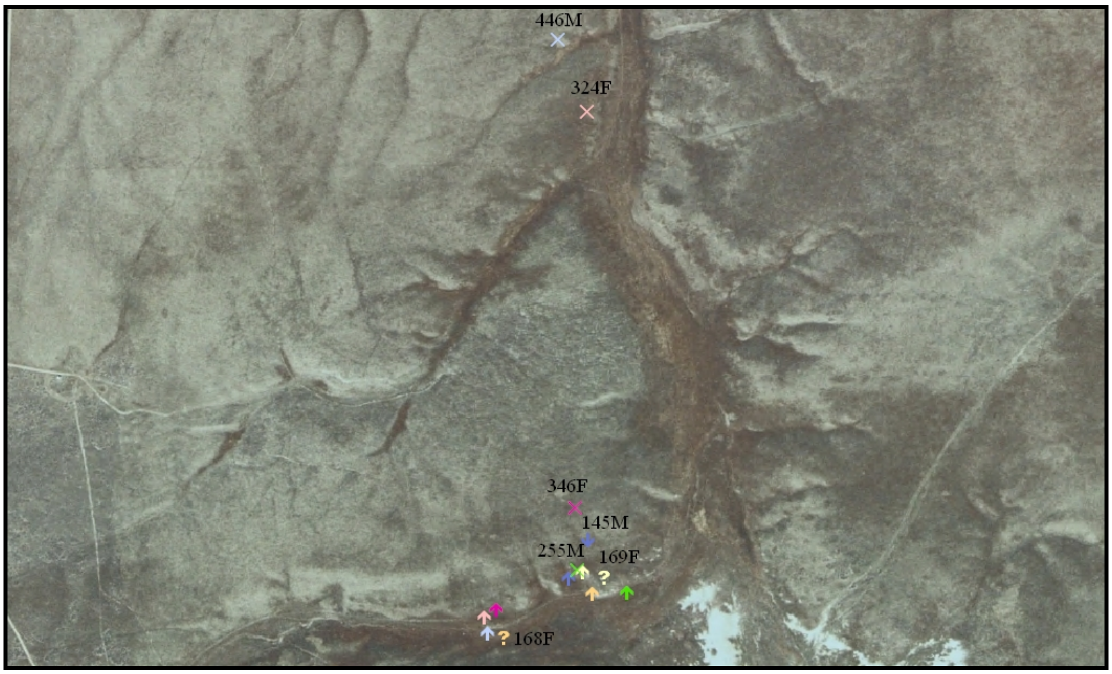


**Figure 1.** Cemetery site, 2004: One male survived to enter dormancy and two were killed by predators within the colony. Two other squirrels taken by predators either moved from the colony before predation or were killed and carried approximately 914 and 1057 m away from their initial capture locations. Two signals were lost during radio–tracking. Since this site contained a lot of debris that could block signals, and because I searched a large area for these collars, it is likely they stopped moving within the colony.

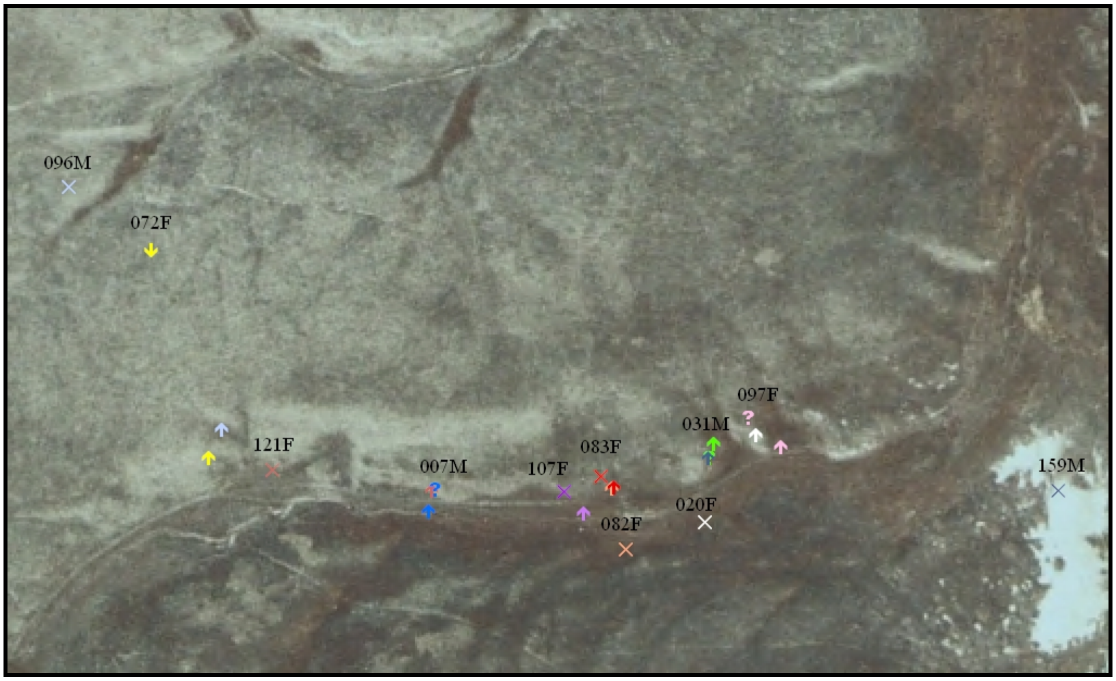


**Figure 2.** Cemetery site, 2005: One female survived, four were killed, and two males had undetermined fates. Most home ranges were located in the lower elevations.

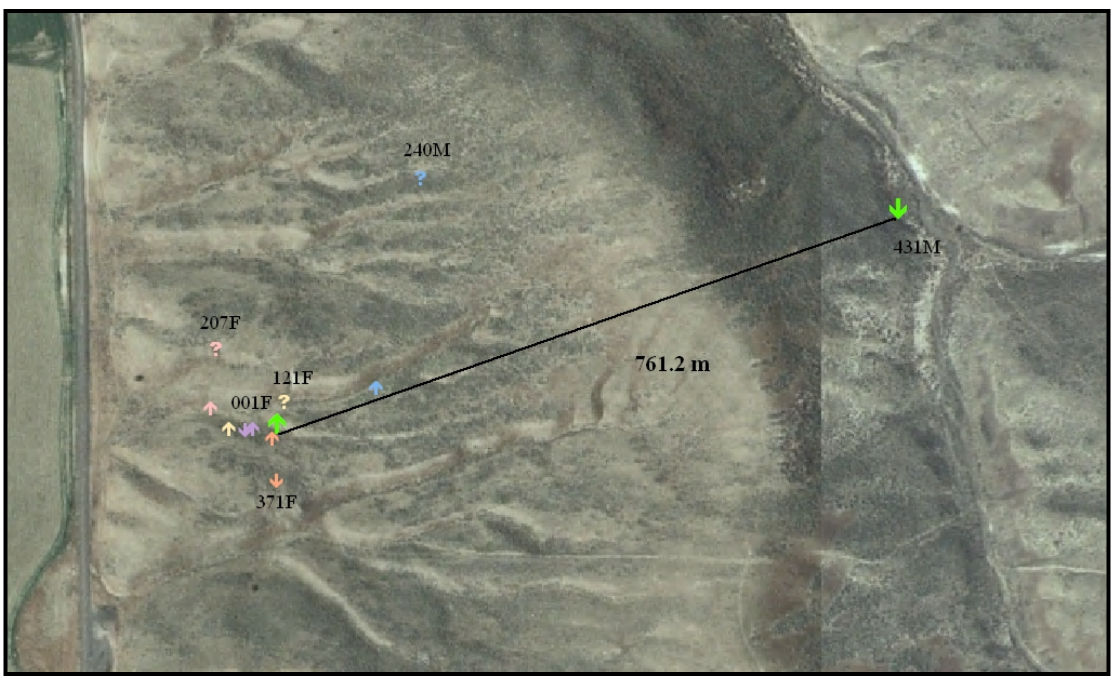


**Figure 3.** Sage site, 2004: Three females and one male survived and two squirrels had unknown fates. Predation was not documented at the Sage site in 2004. Most squirrels remained close to initial capture points, but one dispersed at least 762.1 m.


**Figure 4.** Sage site, 2005: One female and four males were killed. Four entered dormancy and the female had the largest distance between its initial capture and final location.

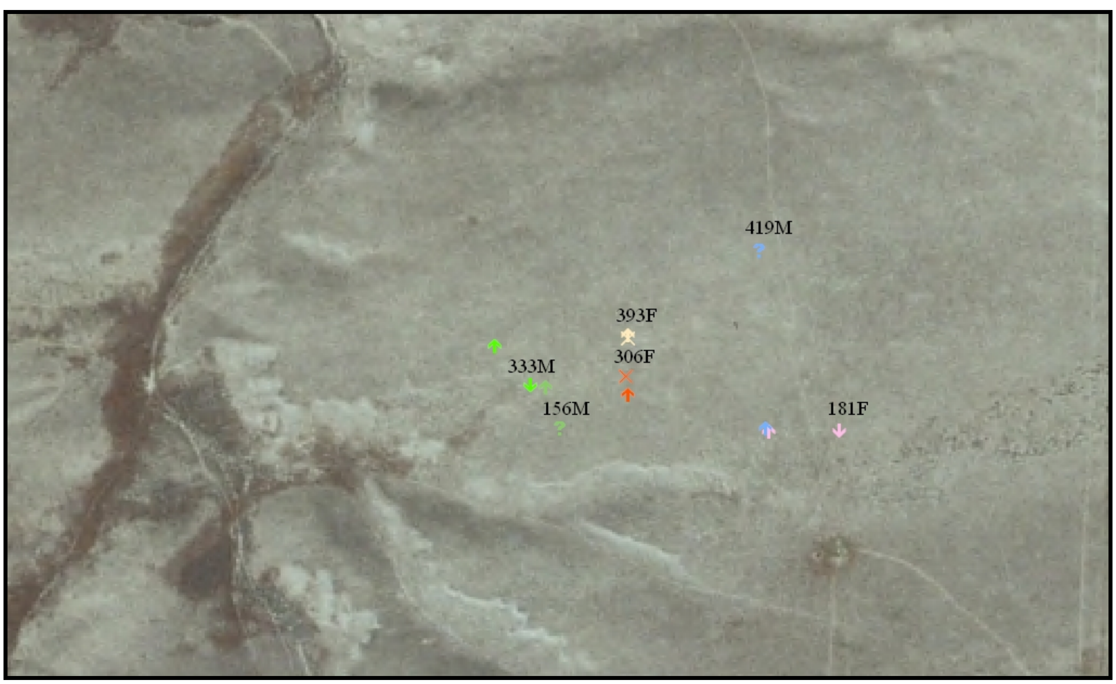


**Figure 5.** Large Stipa site, 2004: Two females were killed by predators, two males had unknown fates, and one male and female survived to dormancy.

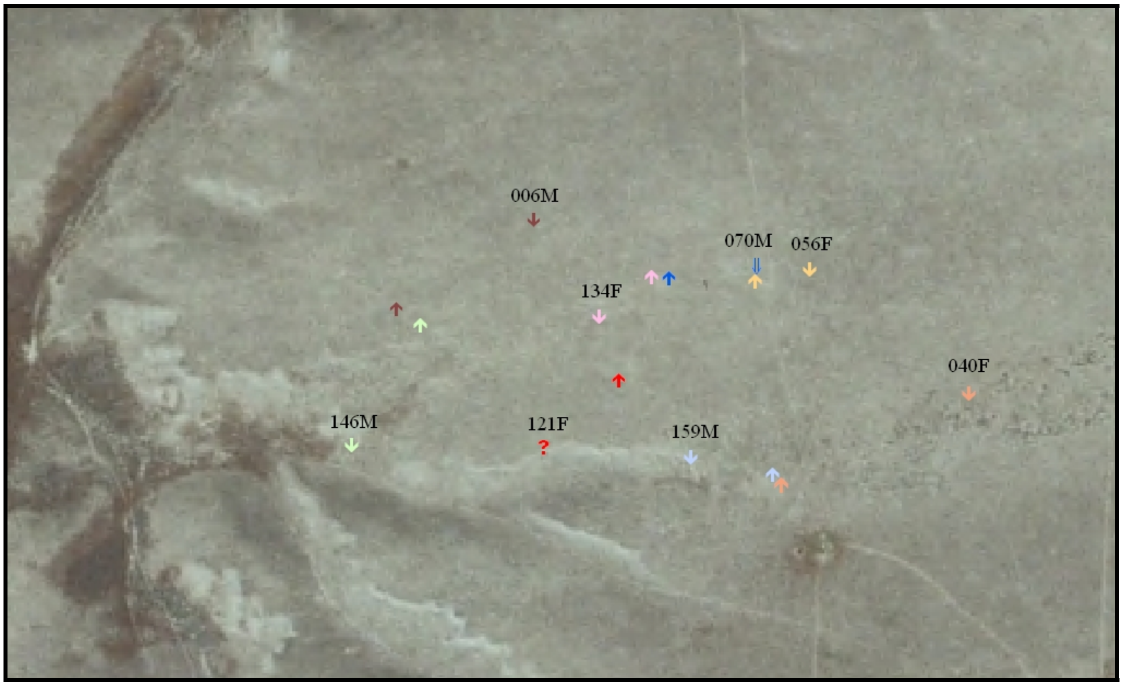


**Figure 6.** Large Stipa site, 2005: Predation was not documented in 2005, but one female had an undetermined fate. Seven survived to dormancy.

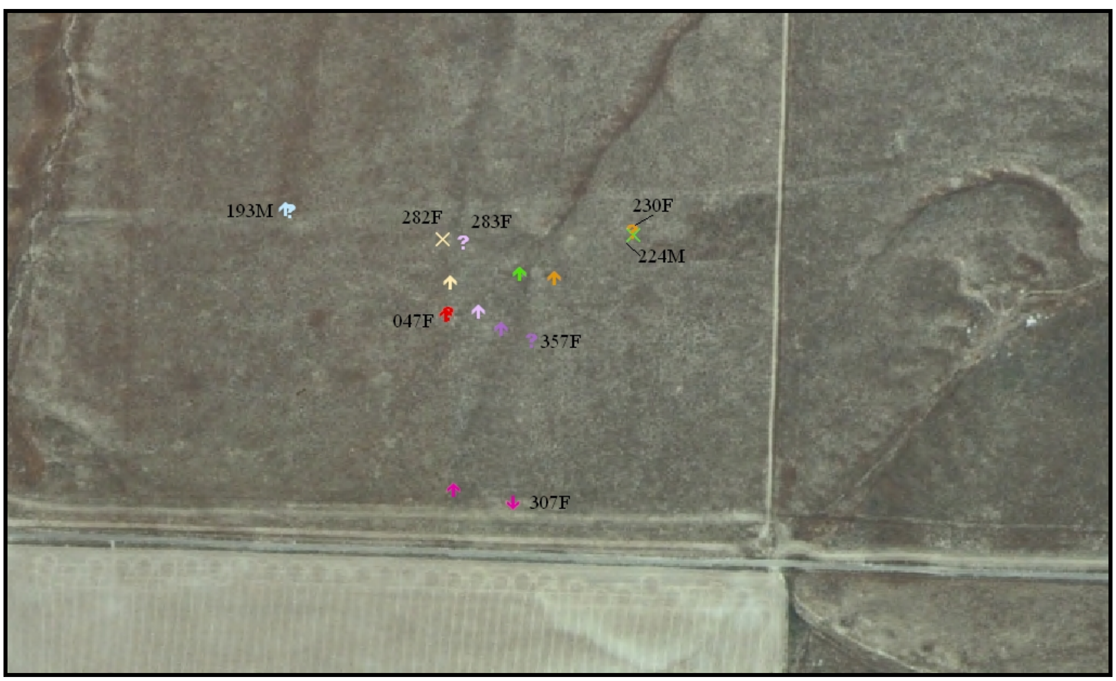


**Figure 7.** OLS site, 2004: Most squirrels had undetermined fates. Two were killed by predators, and one female survived to dormancy.

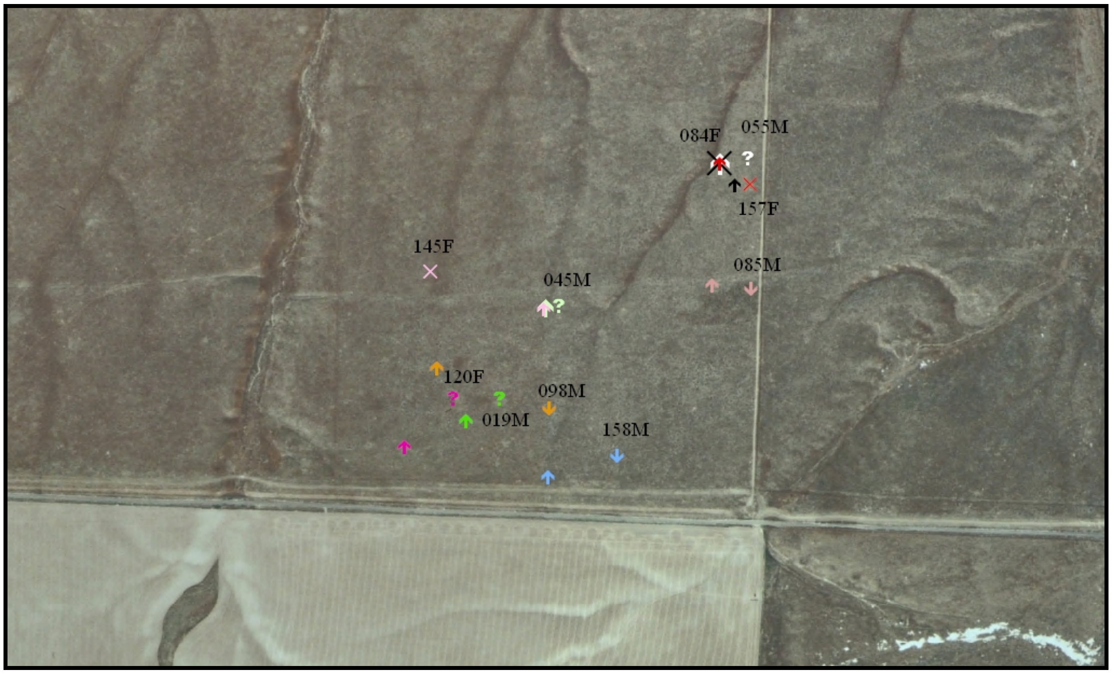


**Figure 8.** OLS site, 2005: Three squirrels died, three survived to dormancy, and four had unknown fates. Distances between initial capture and final locations were small.

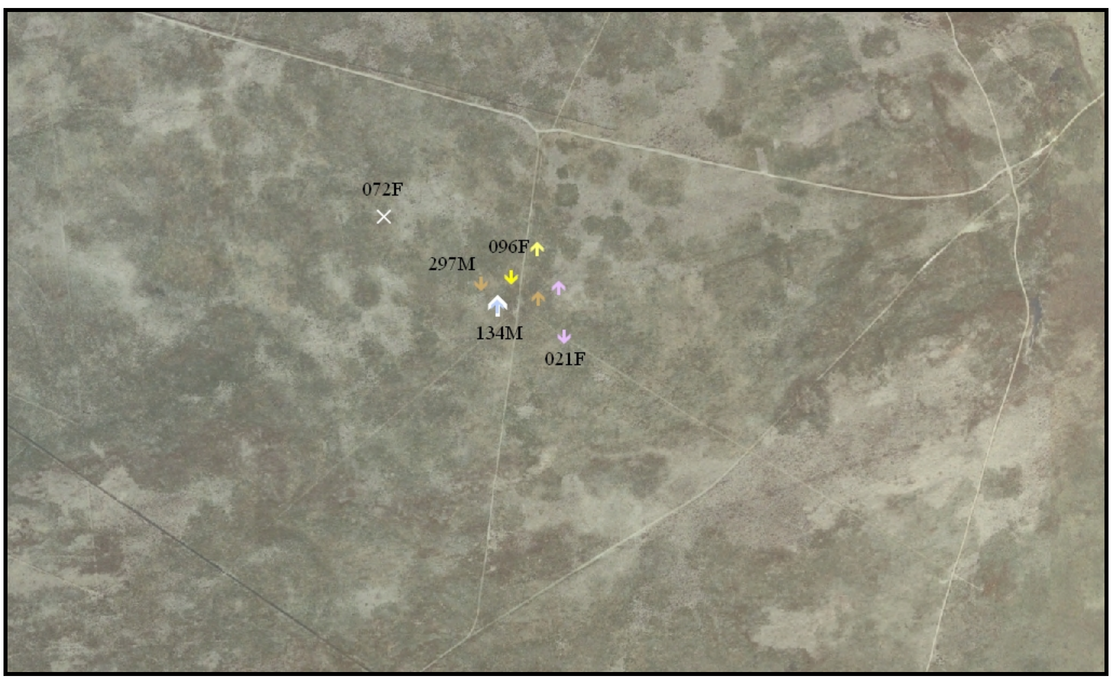


**Figure 9.** Spigot 190 site, 2004: Four survived to dormancy, but distances traveled from initial capture points were very small. One squirrel was eaten by a predator.

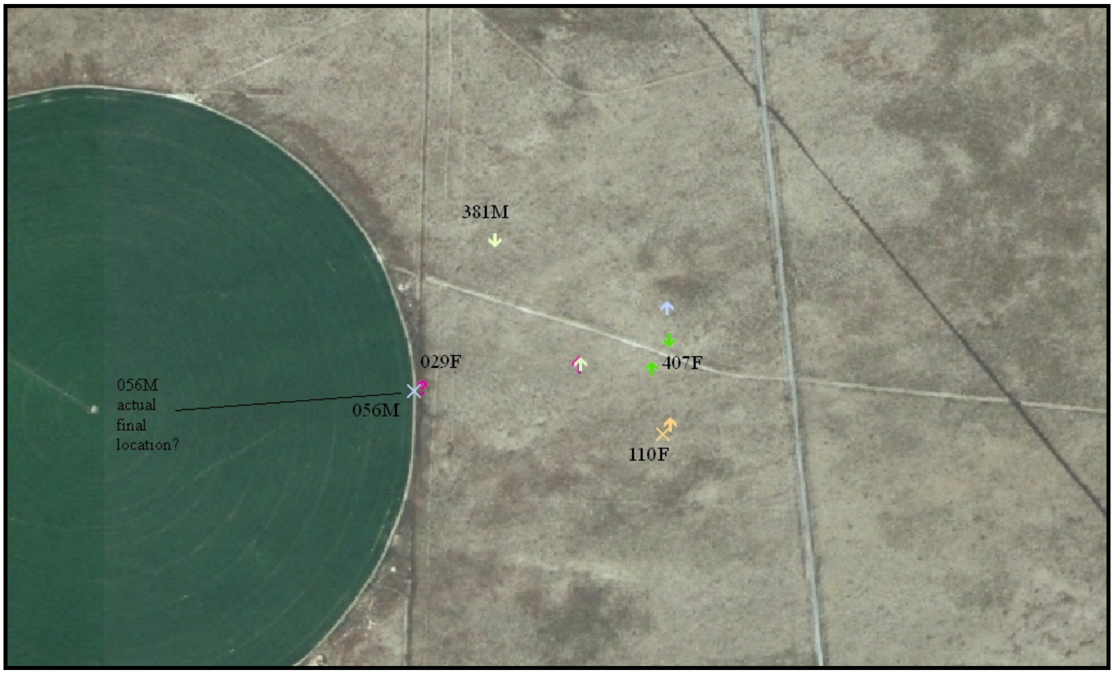


**Figure 10.** Stipa 112 site, 2004: Two squirrels survived, one had an undetermined fate, and two died. Collar 056M was located in the crop circle west of the Stipa 112 site on private property. I estimated its final location by triangulation from the edge of the Naval Weapons System Training Facility–Boardman. I presumed this squirrel died by predation because the collar moved to the crop circle early in the season and remained there until I finished tracking in June. The signal was very strong, which I would expect if this individual was carried off by a raptor that perhaps perched on the irrigation system while it consumed its prey. It is unlikely that the squirrel moved its home range into this area because it did not move the rest of the season.

AN ABSTRACT OF THE THESIS OF

Kimberly J. Klein for the degree of
Master of Science in Wildlife Science presented on March 24, 2005.
Title: Dispersal Patterns of Washington Ground Squirrels in Oregon

Abstract approved:

Signature redacted for privacy.

Gail S. Olson

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Robert G. Anthony

The Washington ground squirrel (*Spermophilus washingtoni*) is a state listed endangered species in Oregon and a candidate for federal listing under the Endangered Species Act. It occupies sagebrush steppe and grasslands in the Columbia River Basin. Much of its historic habitat has been lost due to agricultural development. Remaining habitat patches are at risk for further fragmentation. I studied dispersal and demography of Washington ground squirrels in north-central Oregon using capture/recapture and telemetry techniques from March through June in 2002 and 2003. A total of 125 juvenile male squirrels from 4 study sites were collared and tracked; dispersal status was determined for 102 animals. The average dispersal probability was 0.72 (95% CI = 0.63 to 0.80) and did not vary significantly between years or among sites. Median dispersal distance was 880 m, ranged from 40-3521 m, and did not vary substantially between years or among sites. Timing of dispersal in 2003 occurred significantly earlier than in 2002 and may have been due to differences in weather patterns. Mean density varied

among sites and was higher in 2003 than in 2002 ($\hat{N}/ha_{2003} = 66$, $\hat{N}/ha_{2002} = 45$). Probability of survival to immergence for collared squirrels ranged from 0.20 (95% CI = 0.09 to 0.39) to 0.56 (95% CI = 0.38 to 0.72) among sites and years. Raptors and badgers were the primary and secondary causes of mortality. Survival rates of dispersers were higher than non-dispersers, presumably due to badger predation on natal sites. These results provided support for the emigrant fitness hypothesis as an adaptive explanation for dispersal behavior in this species.

I also studied habitat selection for settlement sites by dispersing squirrels. Environmental resources, including soil and vegetation type, distance to the nearest road and historic colony, location relative to a 1998 fire, slope, and aspect were hypothesized to influence dispersal patterns via resource selection. Roads and agricultural lands were examined as potential barriers to dispersal. Directionality of dispersal did not differ from random on two sites, but was non-random on a third. Evidence of selection against low-shrub and perennial grass-dominated sites was detected. Dispersers did not select settlement sites based on soil series, but animals on one site did select for soils with a silt-loam texture. Settlement locations were closer to primitive roads and historically-occupied sites than expected. No selection for or avoidance of slope, aspect, or areas that had been burned was detected. Primitive roads did not act as barriers to dispersal, but land in agricultural production likely altered dispersal patterns.

# Dispersal Patterns of Washington Ground Squirrels in Oregon

by
Kimberly J. Klein

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented March 24, 2005
Commencement June 2005

Master of Science thesis of Kimberly J. Klein
presented on March 24, 2005.

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Kimberly J. Klein, Author

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Verne Marr deserves special thanks and recognition for his scientific contributions, his hard work in the field, and his mentorship as well. Verne not only made data collection possible with his expertise on Washington ground squirrels and sagesteppe ecology, but he also helped to shape this thesis by unselfishly sharing his ideas, his energy, and his great outlook on life. I would also like to thank Russ Morgan of ODFW, who was a crucial asset to all aspects of this project and a pleasure to work with. I appreciate the efforts of John Phillips of the Navy, for his ongoing attention to natural resource issues on Boardman. I thank Leslie Nelson of the Nature Conservancy for logistic support and for providing housing in the field.

Many people contributed their time and efforts to this project. Nathan Woodard and Robin Severe were great field technicians in 2003. I especially appreciate those who volunteered for field work, particularly Darci Stumbaugh, Betsy Glenn, Spencer Rearden, and Chuck Bartlett. I would also like to thank Kara Yetishefske and Josh Halofsky for help with data analysis. I would also like to thank numerous friends and family for their support and encouragement, especially my partner John Seigle, my parents Thomas and Katherine Klein, and my siblings, Amanda Johnson and Jeffery Klein. Many others deserve thanks as well. To all those who have made my experience at OSU enjoyable, interesting, challenging, and fruitful, I thank you.

## CONTIBUTION OF AUTHORS

Dr. Robert Anthony and Dr. Gail Olson contributed to all aspects of this thesis, including project design, data collection, analysis, and writing of both manuscript chapters (Chapter 2 and Chapter 3). As co-authors, both made substantial contributions and deserve equal recognition for their efforts.

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## Dispersal Patterns of Washington Ground Squirrels in Oregon

# CHAPTER 1

# INTRODUCTION

The Washington ground squirrel (*Spermophilus washingtoni*) has been important to the ecology of the Columbia Basin for thousands of years. Fossilized sciurid skulls dating from 13,000 years ago have been found (Spencer 1989) and identified as *S. washingtoni* (V. Marr, pers. commun.). Ground squirrels are ecologically important as a semifossorial species. Burrowing aerates soil and increases water infiltration (Laundré 1993, 1998) and underground defecation adds nutrients that increase plant productivity (Yensen et al. 1991). Washington ground squirrels are also an important prey species. Known predators include golden eagles *(Aquila chrysaetos)*, red-tailed hawks (*Buteo jamaicensis)*, ferruginous hawks (*Buteo regalis)*, Swainson's hawks (*Buteo swainsoni)*, prairie falcons (*Falco mexicanus)*, short-eared owls (*Asio flammeus)*, northern harriers (*Circus cyaneus)*, rough-legged hawks (*Buteo lagopus),* gopher snakes (*Pituophis melanoleucus)*, and rattle snakes (*Crotalus viridis)* (Carlson et al. 1980). Badgers (*Taxidea taxus)* were found to be the major predator of Washington ground squirrels (Bailey 1936, Scheffer 1941). The Washington ground squirrel may be vital to the survival of many species.

## STATUS AND RANGE

The Washington ground squirrel was a recent addition to the Oregon endangered species list and was federally listed as a candidate species, priority level 2 (U. S. Fish and

Wildlife Service 2004). Its historic range was south and east of the Columbia River from the mouth of the John Day River, east to Walla Walla, Washington, and north to Spokane (Baily 1936) (Figure 1.1). An unsuccessful search for Washington ground squirrels was conducted in the northern parts of Umatilla and Morrow Counties by L. W. Turner in 1971 (Olterman 1972). No further records of this species in Oregon were known until its rediscovery on the Boardman U.S. Naval Weapons Systems Training Facility (Boardman) in 1978 (Rohweder et al. 1979). Betts (1990) reinventoried historically-occupied sites in 1989 and found that 38% had been vacated. Subsequent visits conducted in 1998 revealed that 69% of the colonies monitored in 1989 were no longer occupied (Betts 1999). Overall, 69% of historic habitat for Washington ground squirrels is no longer inhabited (Wisdom et al. 2000).

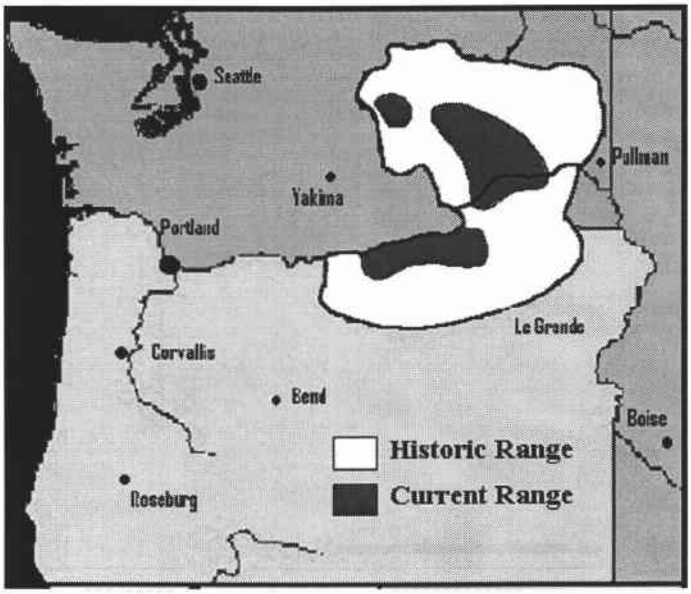


Figure 1.1. Current and historic range of the Washington Ground Squirrel (after Betts 1990).

Washington ground squirrels occupy uncultivated low-elevation sagebrush steppe habitat. They have been found in areas dominated by various vegetation types, including big sagebrush (*Artemisia tridentata*), low shrubs, and annual and perennial grasses (Carlson et al. 1980, Quade 1994, Greene 1999). Transect surveys on Boardman detected the highest density of squirrels in sagebrush habitats, followed by bunchgrass and annual grass dominated areas (Greene 1999). Sites occupied by Washington ground squirrels had higher vegetative cover and soils with higher silt content (Warden soils) than unoccupied sites (Greene 1999).

Currently this species is found in 3 populations; 2 lie along the Columbia River Basin in southeastern Washington, and 1 occurs in a small area of Gilliam, Morrow, and Umatilla Counties, Oregon. The Oregon population occurs south of the Columbia River, east of the John Day River and west of the city of Milton-Freewater (Morgan and Nugent 1999). The contraction in range and decline in abundance of Washington ground squirrels is primarily due to habitat loss from conversion of sagebrush steppe and semi-arid grassland to agricultural production (Carlson et al. 1980, Betts 1990, Quade 1994).

An estimated 54% of historic habitat in the Columbia River Basin has been converted to agriculture (Oregon Department of Fish and Wildlife 1999). The negative population trends that have occurred throughout the range of this species are not likely to be reversed under current and proposed management (Raphael et al. 2001). Boardman is part of the largest contiguous tract of sagebrush steppe habitat in the current range of this species. Other areas with extant populations include the adjacent 23,000-acre Boardman Conservation Area, a tract of public land administered by the Bureau of Land

Management (BLM) known as Horne Butte, and the Lindsay Prairie Preserve, which is owned by the Nature Conservancy (Morgan and Nugent 1999).

**CURRENT THREATS**

Major threats to the Washington ground squirrel currently include recreational target shooting and habitat loss and degradation. The potential impact of each of these threats on squirrel populations varies among locations based on ownership and land management practices. Sherman (2000) documented recreational shooting of Washington ground squirrels in the Seep Lakes Wildlife Management Area, Washington. Some private landowners have expressed disdain for this species while others are interested in maintaining suitable habitat for them.

Degradation of the quality and diversity of sagebrush steppe habitat has occurred throughout the Western U.S. due to non-native plant invasion, fire, and overgrazing. Invasion of annual grasses and non-native weeds in arid and semi-arid environments reduces native biodiversity and habitat heterogeneity (Young et al. 1976, Eissenstat and Caldwell 1988, Melgoza and Nowak 1991). Loss of plant species that provide key nutrients may reduce the ability of ground squirrels to gain necessary pre-hibernatory body mass (Rickart 1982). A population decline among Idaho ground squirrels (*S. brunneus*) was associated with vegetative changes (Sherman and Runge 2002). Those squirrels readily fed on non-native vegetation including *Poa bulbosa, Bromus commutatus* and *Medicago sativa*, which may not have provided adequate long-term nutrition. Survival and reproduction rates were adversely affected (Sherman and Runge

2002). Washington ground squirrels use a variety of microhabitats and plant species (Greene 1999) and may likewise be adversely affected by loss of vegetative heterogeneity.

Fire within semi-arid sagebrush and grassland habitat results in fragmentation, loss of the sagebrush component, and the replacement of much of the tall perennial bunchgrasses and native forbs with invasive annual grasses (Young et al. 1976, Melgoza and Nowak 1991, Fischer et al. 1996). The impact of fire on Boardman was observed after more than 20,000 acres burned in 1998. The response of Washington ground squirrels to this fire depended on soil type. Burned sites in Warden soil had a lower rate of abandonment than unburned sites, whereas burned sites in several other soil types had higher rates of abandonment (Marr 2001).

The impacts of cattle grazing on the Washington ground squirrel are not well understood. On Boardman, more squirrels were detected along transects in ungrazed than grazed perennial grassland and more in grazed than ungrazed sagebrush (Greene 1999). Grazed sagebrush and perennial grass sites were found to have higher amounts of bare ground than ungrazed sites, and more squirrels were located on areas with less bare ground (Greene 1999). Grazing may influence squirrel populations, but most squirrel colonies are found in areas that have been grazed. Several areas in Oregon are currently managed to maintain habitat for sagebrush-steppe species. The BLM manages Horne Butte for maintenance of Washington ground squirrel populations. Additionally, The Boardman Conservation Area and Lindsay Prairie Preserve are protected areas with excellent long-term prospects for the Washington ground squirrel.

**NATURAL HISTORY**

The Washington ground squirrel is a semi-social, semifossorial member of the subgenus *Spermophilus*. Adult body length measures 185-245 mm. Pelage is characterized by pale gray coloring, white dorsal spots, a distinct lateral line, and a black tip on the tail (Rickart and Yensen 1992, Verts and Carraway 1998). The closest taxonomic relatives are thought to be Idaho and Townsend's (*S. townsendii*) ground squirrels (Nadler 1966, Yensen and Sherman 1997). The nearest geographic neighbors are Belding's *(S. beldingi*), Townsend's, and Columbian ground squirrels (*S. columbianus*) (Hill 1978).

The Washington ground squirrel is only active 4-5 months per year. Adults emerge from hibernation first, generally in late January or early February. Males emerge before females and polygamous breeding occurs soon after females emerge. Young are born in February or early March. All female Washington ground squirrels, including yearlings, captured by Scheffer (1941) had evidently reproduced, but reproductive rates of yearling males are not known. Gestation lasts approximately 25 days (Scheffer 1941). Mean litter sizes of 5 (Carlson et al. 1980) to 8 young (Scheffer 1941) have been reported. The young emerge from the natal burrow in mid-March and disperse from the natal area in mid-April. Adult males are the first to begin hibernation and immerge in mid- to late-May. Adult females follow in late May or early June, and juveniles of both sexes begin to hibernate in late June or early July (Quade 1994, Carlson et al. 1980). Timing of immergence was thought to occur earlier in areas with poor forage (Carlson et al. 1980). Body mass and composition are the primary determinants of over-winter survival (Murie and Boag 1984, Smith and Johnson 1985).

Dispersal rates, timing, distances, and directions influence population demography, rates of gene flow, recolonization of available habitat, and colonization of new habitat. Dispersal patterns of Washington ground squirrels are particularly important because this species has a limited geographic range and small population numbers (Oregon Department of Fish and Wildlife 1999). Small populations tend to be more susceptible to loss of genetic diversity, detrimental stochastic events, and inbreeding depression. The combined effects of these risks may increase the likelihood of extinction (Primack 1993, Meffe and Carroll 1994). Dispersal is the primary mode of gene exchange between subpopulations (Templeton 1987) and is therefore crucial for maintaining genetic diversity and avoiding inbreeding. Dispersal has also been shown to lower extinction rates in a fragmented metapopulation (Levins 1969). There have been no previous dispersal studies on the Washington ground squirrel.

**OBJECTIVES**

This study was conducted in order to fill gaps in current knowledge of the natural history and behavior of the Washington ground squirrel, and to better understand the potential responses of this species to spatial habitat change. Given the abrupt habitat changes that occur on many of the fragmented landscapes occupied by *S. washingtoni*, it was important to understand how dispersers respond to landscape heterogeneity. This study investigated patterns of dispersal and the habitat features that affected those patterns.

The objectives were to:

- Estimate dispersal rates and variability among sites and years
- Determine distances and timing of dispersal events
- Describe population density and structure among several sites
- Compare survival rates and causes of mortality of dispersers with non-dispersers
- Discern patterns in dispersal directions, selection of post-dispersal settlement habitats, and avoidance of dispersal barriers

Chapter 2, "Dispersal and Demography of Washington Ground Squirrels in North-Central Oregon," describes dispersal rates, timing, and distances, as well as demography of natal sites and survival rates of radio-collared ground squirrels. Chapter 3, "Dispersal by Washington Ground Squirrels: the Influence of Resource Selection and Barriers," examines the habitat characteristics of settlement locations selected by dispersing ground squirrels.

# CHAPTER 2

# DISPERSAL AND DEMOGRAPHY OF WASHINGTON GROUND SQUIRRELS IN NORTH-CENTRAL OREGON

## ABSTRACT

The Washington ground squirrel (*Spermophilus washingtoni*) is a state listed endangered species in Oregon and a candidate for federal listing under the Endangered Species Act. I studied the demography and dispersal patterns of Washington ground squirrels in north-central Oregon using capture/recapture and telemetry techniques from March through June in 2002 and 2003. A total of 125 juvenile male squirrels from 4 study sites were collared and tracked; dispersal status could be determined for 102 animals. The average dispersal probability was 0.72 (95% CI = 0.63 to 0.80) and did not vary significantly between years or among sites. Median dispersal distance was 880 m, ranged from 40-3521 m, and did not vary substantially between years or among sites. Timing of dispersal in 2003 occurred significantly earlier than in 2002 and may have been due to differences in weather patterns. Mean density varied among sites and was higher in 2003 than in 2002 ($\hat{N}/ha_{2003} = 66$, $\hat{N}/ha_{2002} = 45$). Probability of survival to immergence for collared squirrels ranged from 0.20 (95% CI = 0.09 to 0.39) to 0.56 (95% CI = 0.38 to 0.72) among sites and years. Raptors and badgers were the primary and secondary causes of mortality. Survival rates of dispersers were higher than non-dispersers, presumably due to badger predation on natal sites. These results provided support for the emigrant fitness hypothesis as an adaptive explanation for dispersal behavior.

**INTRODUCTION**

Dispersal is a key determinant of spatial arrangement, demography, and evolutionary potential for many species. Dispersal has been shown to lower extinction rates in fragmented metapopulations (Levins 1969) and facilitate recolonization of previously-occupied habitat patches (Hanski 1998). Dispersal is crucial for maintaining gene flow among isolated populations (Templeton 1987). Small, isolated populations tend to be more susceptible to loss of genetic diversity, detrimental environmental events, inbreeding depression, and demographic deterioration. The combined effects of these risks may increase the likelihood of extinction (Primack 1993, Caughley 1994, Meffe and Carroll 1994).

Natal dispersal is the movement of juveniles away from their place of birth prior to reproductive maturity (Greenwood 1980) and is a key event in the life history of most species within subgenus *Spermophilus* (Holekamp 1984*a*). Comparative research on dispersal among sciurids has provided insight into the influence of competition (Dobson 1982), sociality (Gaines and McClenaghan 1980, Devillard et al. 2004), and life history (Holekamp 1984*a*) on dispersal.

Male ground squirrels within *Spermophilus* generally disperse at higher rates than females (Holekamp 1984*a*, Smale et al. 1997, Devillard et al. 2004). Female dispersal rates were more variable and more responsive to changes in density and resource availability than those of males (Dobson 1979, Nunes et al. 1997, Wiggett and Boag 1992*b*). Among several species, dispersal rates of males were relatively unaffected by environmental and demographic factors (Slade and Balph 1974, Dobson 1979, Holekamp

1983). Several authors have concluded that these patterns arise because females disperse in response to limited resources, whereas males disperse to avoid inbreeding (Dobson 1979, Holekamp 1986, Nunes et al. 1997). However, dispersal rates of male Richardson's ground squirrels (*S. richardsonii*) were influenced by the severity of winter and spring weather, reproductive success, density, and dispersion within the population (Michener 1979, Michener and Michener 1977). The degree of variability in dispersal rates within each species may be constrained by genetic, physical, or behavioral limitations.

Dispersal distances are probably influenced by topographic features, resource availability, population density, and population composition (Holekamp 1984*b*). Dispersal distances have been documented for many *Spermophilus* species and can range from 50-10,000 m (Michener and Michener 1977, Wiggett and Boag 1989). The distribution of dispersal distances tends to be highly skewed by a few long-distance dispersers (e.g., Olson and Van Horne 1998, Wiggett and Boag 1989, Byrom and Krebs 1999). It may be particularly important to document long distance dispersal events because they can be motivated by different evolutionary pressures than local dispersal (Muller-Landau et al. 2003) and have different effects on population demography and distribution (Caswell et al. 2003).

Timing of dispersal for many sciurids depends on age at sexual maturity and growth rate (Blumstein and Armitage 1999). Species with delayed maturation generally disperse as yearlings whereas those that reproduce as yearlings disperse as juveniles (reviewed in Holekamp 1984*a*). Timing of dispersal for yearling Columbian ground squirrels (*S. columbianus)* has been associated with emergence of juveniles and likely acts to reduce levels of competition on the natal site (Wiggett and Boag 1989, 1992*a*). The within-season timing of dispersal has been associated with attainment of sufficient body mass or composition (Holekamp 1983, 1984*a, b*, 1986; Nunes et al. 1998).

Survival rates of dispersers depend on environmental conditions at the natal and settlement sites (Gaines and McClenaghan 1980) and the risks involved in dispersing (Waser et al. 1994, Byrom and Krebs 1999). Various authors have concluded that dispersal is inherently risky (Errington 1946, Gaines and McClenaghan 1980, Waser et al. 1994). Lower survival rates for dispersers than non-dispersers have been reported for arctic ground squirrels (*S. parryii)* (Byrom and Krebs 1999), yellow-bellied marmots (*Marmota flaviventris)* (Van Vuren and Armitage 1994), and black-tailed prairie dogs (*Cynomys ludovicianus)* (Garrett and Franklin1988). Dispersers may be exposed to greater predation rates than philopatric individuals (Slade and Balph 1974). Sex-biased predation on *S. richardsonii* has been attributed to lack of familiarity with local refugia during exploration and dispersal (Schmutz et al. 1979). However, survival rates were not found to differ between dispersing and non-dispersing Piute ground squirrels (*S. mollis)* (Olson and Van Horne 1998) or *S. columbianus* (Hackett 1987).

Assessment of the effects of environmental or demographic factors on dispersal patterns and survival rates can lend insight into the adaptive significance of dispersal and its ultimate cause. Lidicker (1975) proposed that dispersal decreases the probability of inbreeding. Conversely, philopatry may serve to maintain an adaptive level of inbreeding or avoid a maladaptive level of outbreeding (Fisher 1958, Shields 1982). Dispersal may reduce the amount of competition for mating opportunities (Dobson 1982, 1983), food resources (Dobson 1979, Dobson and Kjelgaard 1985), or space (Hamilton and May 1977). Two central hypotheses have been presented to explain how dispersal evolved; they include the resident and emigrant fitness hypotheses. The "resident fitness hypothesis" suggests dispersal is adaptive for residents, but not necessarily for dispersers (Anderson 1989, Wiggett and Boag 1992*b*). The underlying assumption is that dispersal is not voluntary, but is socially facilitated, and serves to reduce competition on the natal site (Christian 1970). Dispersal rates are predicted to increase with increased adult densities or levels of agonism, and decrease when resources are unlimited. Survival or reproduction of residents is expected to exceed that of dispersers. Supportive evidence for this hypothesis has been found among juvenile male *S. columbianus* (Wiggett and Boag 1993*b*). Dispersal was socially induced and a high degree of male bias in the adult sex ratio was associated with increased dispersal rates.

The "emigrant fitness hypothesis" suggests that dispersal is beneficial to the disperser (Anderson 1989). Dispersers could gain fitness advantages over non-dispersers in the form of increased survival or reproduction if dispersal reduces inbreeding, lessens competition for resources, or improves access to mates (Fisher 1958, Lidicker 1975, Hamilton and May 1977, Shields 1982, Dobson 1982 and 1983). Dispersal is predicted to occur under conditions of limited resources, a high degree of relatedness, or scarcity of mating opportunities. Among the aforementioned population of male *S. columbianus,* decreased density and removal of the adult population did not alter dispersal rates (Wiggett and Boag 1993*b*), which supported these predictions. Analysis of survival and reproduction revealed that reproductive success of immigrants was greater than that of natal residents, supporting the emigrant fitness hypothesis for males (Wiggett and Boag 1993*a*).

Dispersal patterns and survival rates determine the adaptive value of dispersal and have important consequences for demography and genetics of local populations. Additionally, information on dispersal is crucial for making management decisions regarding species that occupy fragmented landscapes. The Washington ground squirrel has a limited geographic range and small population numbers (Oregon Department of Fish and Wildlife 1999). This species occupies fragmented patches of habitat in the Columbia River Basin of Washington and Oregon. Washington ground squirrels hibernate 7-8 months each year. Adults breed shortly after emergence from hibernation in January or February and juveniles emerge from the natal burrow in March. Juvenile males disperse before they immerge for hibernation in June or July, yet there has been no prior research on dispersal rates, distances, and timing among *S. washingtoni*.

I studied dispersal patterns and population demography of *S. washingtoni* in the Columbia River Basin of north-central Oregon in 2002 and 2003. The objectives of my research were: 1) to estimate variability in dispersal rates, dispersal distances, and timing of dispersal among 3 sites and between 2 years, 2) describe dispersal behaviors as they relate to demography, and 3) determine whether survival rates of Washington ground squirrels supported the predictions of the resident fitness hypothesis or the emigrant fitness hypothesis. Because dispersal is thought to be costly (Errington 1946, Slade and Balph 1974, Waser et al. 1994), I aligned my predictions with the resident fitness hypothesis. I predicted that dispersal rates would increase with increasing density, decrease with increasing female sex ratios, and increase with increasing proportions of adults. I also predicted that dispersers would have lower within-season survival rates than non-dispersers.

## STUDY AREA

The Boardman Naval Weapons Systems Training Facility (Boardman) was a 46,127-acre target range managed by the Department of Defense. It was located directly south of the Columbia River, 72 km west of Pendleton, Oregon (Figure 2.1). Previous research on Washington ground squirrels has been conducted there by Carlson et al. (1980), Quade (1994), Greene (1999), and Morgan and Nugent (1999). Boardman, along with the adjacent property (Boardman Conservation Area) constituted the largest unfragmented tract of sagebrush steppe habitat remaining in the Washington ground squirrel's range (Kagan 1987).

Elevation on Boardman ranged from 162 to 308 m. Mean annual precipitation was 22 cm. Most of the yearly precipitation fell in the autumn and winter; summer months were hot and dry. Winds often exceeded 45 km/hr. Boardman contained several vegetative types. Morgan and Nugent (1999) categorized 4 classes of vegetation relative to native conditions, and Greene (1999) added a bitterbrush group (Table 2.1). Bitterbrush (*Persia tridentata*) shrub-lands occurred on sandy soils at the north end and perennial bunchgrasses and sagebrush (*Artemesia tridentata*) occurred on loamy soils at the south end. Washington ground squirrels were found in areas dominated by all vegetation types (pers. observ.), but were less common in bitterbrush habitats (Greene 1999). The presence of ground squirrel colonies has been significantly associated with Warden and Sagehill soils on the southern end of Boardman, which had high silt content and deep profiles (Greene 1999).

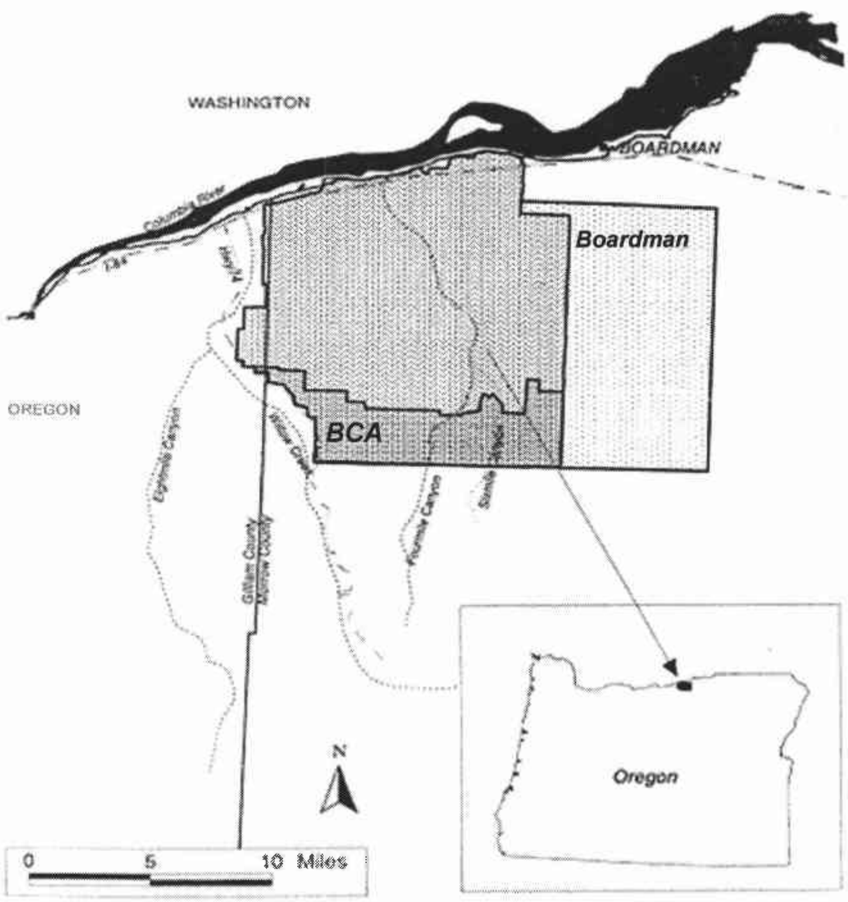


Figure 2.1. The Boardman Naval Weapons Training Facility (Boardman) and adjacent Boardman Conservation Area (BCA) in north-central Oregon (after Morgan and Nugent 1999).

Table 2.1. Major vegetative types on Boardman Naval Weapons Systems Training Facility in north-central Oregon (Greene 1999, Morgan and Nugent 1999).

| **Vegetative Community Type** | **Dominant Vegetation** | **Current Condition Relative to Native Condition** |
|---|---|---|
| Big sagebrush | Variable amounts of sagebrush (*Artemesia tridentata*) with cryptogrammic crust, bunchgrasses and forbs in the understory | Most representative of native, undisturbed conditions. |
| Bunchgrass | Bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and thread grass *(Stipa comata),* Sandberg's bluegrass (*Poa secunda*), bottlebrush squirrel tail (*Sitanion hystrix* ) | Most species in this habitat type are native. |
| Low shrub | Rabbitbrush (*Chrysothamnus sp.*) and matchweed (*Gutierrezia sarothrae*) with a cheatgrass (*Bromus tectorum*) understory | Represents habitat that has been grazed or burned in the past. |
| Annual grass | Cheatgrass and weed species with few shrubs | Habitat type shows the impacts of heavy grazing and/or recent fire |
| Bitterbrush | Variable amounts of bitterbrush (*Purshia tridentata)* with cryptogrammic crust, bunchgrasses, and forbs in the understory | Represents native conditions |

## METHODS

### Field Methods

Research was conducted on 3 sites within Boardman in 2002 and 4 in 2003 (Figure 2.2). High density sites were selected to ensure a sufficient sample of juvenile squirrels for the dispersal study. In 2003, Tub Spring, Mystery Road, and Cemetery were selected, and the Spigot was added in 2004. At all sites, rectangular trapping grids were centered on the location of greatest squirrel activity. At Tub Spring, a 9 x 11 trap grid with 99 Tomahawk® single-door squirrel traps (model 202, 48.3 x 15.3 x 15.3 cm) was

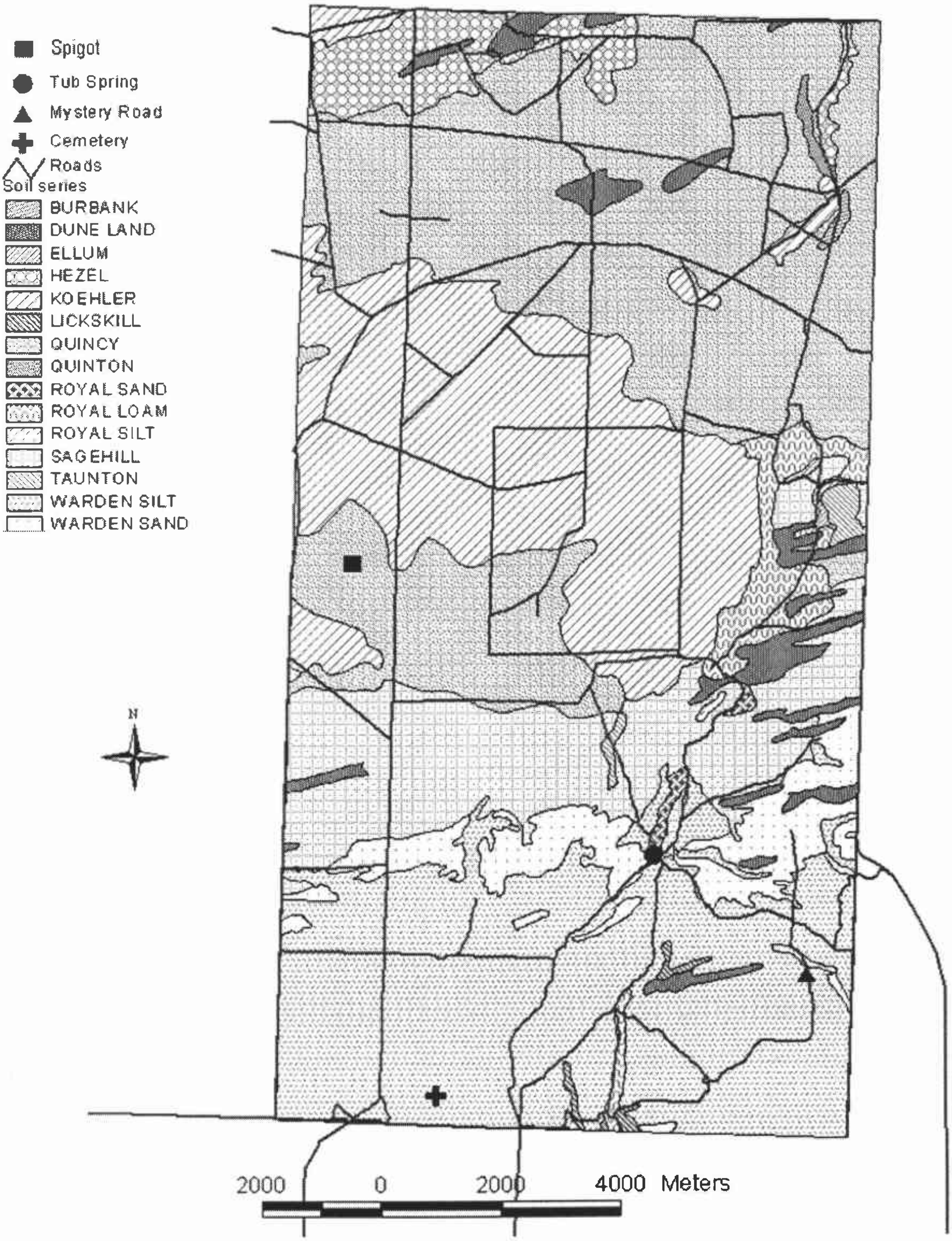


Figure 2.2. Trapping sites and soil types on Boardman Naval Weapons Systems Training Facility in north-central Oregon.

established over an 18,000-$m^2$ area. Traps at Mystery Road were arranged to reflect the elongated spread of activity along a bluff; a 6 x 17 grid with 102 traps covered 18,000 $m^2$. At Cemetery, an 8 x 13 grid had 104 traps in an 18,900-$m^2$ area. The Spigot had 99 traps on an 11 x 9 grid covering 18,000 $m^2$. All traps were placed at 15 m intervals and covered with plywood, cardboard, or natural debris to protect captured animals from heat.

Trapping was conducted from the time juveniles emerged from natal burrows in March through the juvenile dispersal period in April (Appendix A). Traps were set during daylight hours when ground temperature did not exceed 32°C. Each trapping session consisted of baiting all traps with apples (Greene 1999) and leaving them open 1 to 2 hrs. Upon capture, animals were sexed, aged as juveniles or adults, and marked with a Passive Integrated Transponder (PIT) tag. Juvenile males >78 g were fitted with a 3.8 g radio transmitter (Advanced Telemetry Systems®, model M1610, 40 pulses/min). Squirrels were trapped periodically to adjust collars. Oregon State University's Institutional Animal Care and Use Committee approved all animal handling procedures (permit no. 2691).

I followed signals using Telonix® receivers and hand-held or vehicle-mounted H antennas. Locations were determined by tracking each animal to its burrow or hideout. Garmin® geographic positioning system (GPS) units with wide angle augmentation capabilities were used to record locations in Universal Transverse Mercator coordinates using NAD27 CONUS projection data. The mean of 68 points taken from a daily reference location was identical to that location on a 7.5-minute topographic map. The daily GPS location differed from the actual location by an average of 5.0 m (95%

confidence interval [CI] = 3.4 to 6.7 m). The procedure for recording the locations of squirrels was the same as that for taking reference locations; therefore, I assumed a similar margin of error for squirrel locations.

I determined the status of collared squirrels by: observing a living animal, detecting movement from a previous location, or recovering the collar. If no movement was detected prior to immergence for hibernation, I attempted to recover the collar and determine the fate of the animal. Collars from animals killed by badgers were often found in burrows that were much larger than those generally occupied by squirrels. Collars from animals killed by raptors were usually found on prominent ridge tops or under trees or large bushes, and were often accompanied by mute or castings. Animals killed by unidentified predators were characterized by partially eaten carcasses or damaged collars left in locations not typical of raptors or badgers. Carcasses of squirrels that died from unidentified causes were generally found intact below ground. Animals that were assumed to have survived to hibernation were those that were tracked through May, became more sedentary thereafter, and were tracked to the same location repeatedly in June with no evidence of predation.

I defined a dispersal event as a unidirectional non-overlapping shift in home range (Lidicker 1975) and identified such movements from the daily telemetry locations. Philopatric squirrels were those that exhibited no unidirectional movement from the natal area or returned to the natal range after such a movement. The post-dispersal settlement location was defined as the first location after a dispersal movement that was followed by movement in multiple directions that overlapped the settlement location. When a squirrel engaged in >1 dispersal event, the final location that met this criterion was designated the post-dispersal settlement location.

**Data Analysis**

*Dispersal Patterns.*-- All juvenile males with known fates that were collared prior to the mean dispersal date were included in analyses of dispersal rates, timing, and distances. Proportions of dispersers versus non-dispersers were estimated for each site and year. Differences among sites and between years were analyzed with comparisons of CIs and with a $X^2$ comparison of equality of proportions (SPLUS 2002). Dispersal distance was measured between GPS tracking locations using the Animal Movement Extension in Arcview 3.2 (2002). Distance was measured between the last location prior to dispersal and the post-dispersal settlement location. Differences among sites and between years were tested for with a comparison of 95% CIs and a 2-way factorial analysis of variance (ANOVA). Dispersal distances were log transformed to meet the assumption of normality. The average dispersal date was compared among sites and between years. Comparisons of CIs and a 2-way factorial ANOVA were used to test for differences in mean dispersal dates between years and among sites. An $\alpha = 0.05$ significance level was used throughout.

*Abundance and Density Estimation.*-- Individual capture histories of Washington ground squirrels from each trapping grid were used to estimate abundance, density, and capture probabilities of all animals using closed-population estimation methods (Otis et al 1978) in program CAPTURE (White et al. 1982). Only data from capture events in April were included to meet the assumption of population closure. The model used for abundance estimation was selected following a 2-step procedure. First, a suite of top models and closely competing models were identified using $X^2$ goodness of fit testing and the selection criteria of program CAPTURE (Otis et al. 1978). Second, the robustness of the best models was evaluated using the simulation capabilities of program CAPTURE (Rexstad and Burnham 1992) (Appendix B). Selection of the best overall model was based on robustness under varying levels of heterogeneity, time, and behavioral influences. The M(th) Chao estimator (Chao et al. 1992) was selected as the best model and was used to estimate capture probability and abundance. Density was estimated on each site in each year by dividing abundance by area sampled. Area was calculated by adding one-half the mean maximum distance moved between recaptures to grid dimensions (Wilson and Anderson 1985).

*Sex and Age.*-- Capture probabilities of males, females, juveniles, and adults were estimated using open-population estimators (Cormack 1964, Jolly 1965, Seber 1965) to determine if observed capture rates ($p$) were different among these groups. A set of hypothesis-based *a priori* models were designed and tested using program MARK (Version 3.1; White and Burnham 1999). Selection of the most parsimonious model was performed using the second-order quasi-Akaike information criterion ($QAIC_c$) (Akaike 1985, Burnham and Anderson 1998, Anderson et al. 2001). The best model had the lowest $QAIC_c$ value and the greatest ability to explain variation seen in the data. Models with $\Delta$ $QAIC_c < 2$ were considered competing models (Burnham and Anderson 1998). Ratios of $QAIC_c$ weights were examined to assess the ability of a model to better explain variability than a lower ranked model in the same set (Anderson et al. 2000).

Overdispersion within the data set was corrected with $\hat{c} = 1.39$ (Burnham et al. 1987). Capture probabilities were not found to differ among sex and age groups, so proportions of males, females, adults, and juveniles could be determined directly from captures. Comparisons of CIs were used to test for differences in proportions among sites and between years.

*Survival.*-- Within-year survival rates (S) were estimated in two analyses, one for all collared males, and a second for animals identified as dispersers and non-dispersers. Animals included in the second analysis were collared prior to the mean dispersal date, lived beyond this date, and were tracked until they dispersed. In both analyses animals that were lost, shed their collars, or died as a result of trapping were included, but were censored after the last time they were seen alive. Animals were also censored when they immerged for hibernation. Survival rates were calculated weekly from 7 April to 2 June in each year. Survival rates were estimated using the staggered entry Kaplan-Meier procedure (Pollock et al. 1989) with known fate models in Program MARK (Version 3.1; White and Burnham 1999).

A set of candidate models was developed to determine survival rates (S) of all collared males. Models were developed based on *a-priori* hypotheses. Survival was hypothesized to vary among each year and site (*site*year*) (e.g., Tub Spring 2002 or Tub Spring 2003), among sites but not years (*site*), or between years but not sites (*year*). Temporal variation in S was hypothesized to be constant (.), varying by week (*t*), linear through time (*T*), or quadratic through time (*TT*). A second set of candidate models was developed to explore hypotheses regarding S of dispersers and non-dispersers. Survival rates were hypothesized to vary between groups (*disp*), with S of non-dispersers exceeding that of dispersers. Alternately, S was hypothesized to be the same for all animals (.). Models in both analyses included 1or 2 variables. Models with 2 variables explored additive (+) or interactive (*) effects between a grouping variable and a time variable. I followed the convention of Lebreton et al. (1992) and White and Burnham (1999) in building and naming *a priori* models. Model selection for survival of animals with known fates was performed using the second-order Akaike information criterion ($AIC_c$) in the same manner as for estimation of capture probabilities (Akaike 1985, Burnham and Anderson 1998, Anderson et al. 2001).

*Correlation of dispersal with sex, age, density, and survival.*-- Correlations between the dispersal rate and the proportion of females, and the dispersal rate and the proportion of adults were examined with Pearson's product-moment correlation ($r$). Confidence intervals for $r$ were calculated using Fisher's $z$-transformation (Snedecor and Cochran 1980, Sokal and Rohlf 1995). Correlations between dispersal rate and estimated density, and dispersal rate and estimated survival were examined in the same manner. Estimates from each site in each year were assumed to be independent to allow adequate sample sizes for correlation. This assumption was supported by the high degree of yearly demographic fluctuation observed among many *Spermophilus* populations (Michener and Michener 1977, Olson and Van Horne 1998, Sherman and Runge 2002).

**RESULTS**

*Dispersal patterns.*-- A total of 54 juvenile males were fitted with radio telemetry transmitter collars in 2002; 26 at Tub Spring, 11 at Mystery Road, and 20 at Cemetery. Seventy-one juvenile males were collared in 2003; 30 at Tub Spring, 14 at Mystery Road, 17 at Cemetery, and 10 at Spigot. Of all collared squirrels, 95 could be identified as dispersers or non-dispersers. All squirrels at Spigot were collared after the mean dispersal date and were therefore excluded from analyses of dispersal distances, rates, timing, and survival. The proportion of dispersers at each site was: Cemetery = 0.67, 95% CI = 0.036 to 1.0, n = 27; Mystery Road = 0.81, 95% CI = 0.695 to 0.923, n = 21; and Tub Spring = 0.68, 95% CI = 0.32 to 1.0, n = 47. The average proportion of dispersers did not differ significantly among the 3 sites ($X^2 = 1.43$, degrees of freedom [df] = 2, $P = 0.49$). There were also no significant differences between years ($X^2 = 0.27$, df = 1, $P = 0.61$). In 2002, the proportion of animals that dispersed was 0.74 (95% CI = 0.61 to 0.87, n = 48); in 2003, the proportion was 0.70 (95% CI from 0.43 to 0.96, n = 47). The overall average proportion was 0.72 (95% CI from 0.63 to 0.80).

The median dispersal distance was 880.0 m (n = 67) for all sites and years combined. The median is a more appropriate measure than the mean distance dispersed due to the high degree of skewness in the data (Figure 2.3). The mean was 991.0 m, with min = 40.3 m, max = 3520.7 m, and Bonferroni corrected 95% CI for the mean from 694.9 to 1287.1 m. No differences were detected in dispersal distances among sites ($F = 0.73$, df = 2, 63, $P = 0.49$) or between years ($F = 0.03$, df = 1, 63, $P = 0.87$).

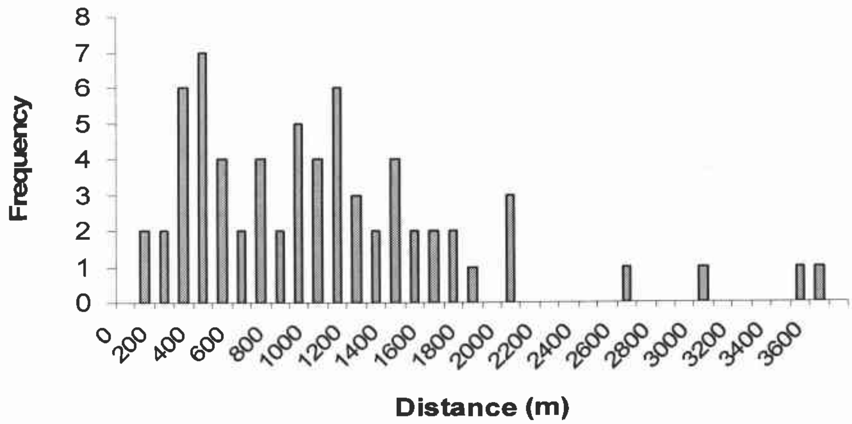


Figure 2.3. Frequency histogram of 67 dispersal distances traveled by Washington ground squirrels on Boardman Naval Weapons Systems Training Facility.

Dispersal events generally occurred during a discrete period of several hours to several days. Animals dispersed 9 days earlier in 2003 than in 2002 (95% CI = 6 to 12 days). The mean date for dispersal in 2002 was 27 April (95% CI = 24 to 30 April, n = 35). In 2003, the mean was 19 April (95% CI = 16 to 21 April, n = 32). The difference in timing of dispersal between 2002 and 2003 was significant ($F = 44.1$, df = 1, 63, $P < 0.0001$). No differences among sites could be detected in the timing of dispersal events ($F = 0.21$, df = 2, 63, $P = 0.82$). The mean dispersal date on each site was: Cemetery = 24 April (95% CI = 19 to 28 April, n = 18); Mystery Road = 24 April (95% CI = 18 to 30 April, n = 17); Tub Spring = 22 April (95% CI = 19 to 25 April, n = 32).

*Abundance and Density Estimation.*-- A total of 621 individuals were trapped on all sites in April of 2002 and 2003 (Appendix A). The M(th) Chao estimator (Chao et al. 1992) was selected as the best model for estimation of abundance and capture probability on each site in each year. This estimator was among the best models for each site according to CAPTURE's model selection criteria (Otis et al. 1978). Squirrels did not exhibit a consistent behavioral response to trapping, but time effects and individual heterogeneity were detected. Simulations showed M(th) Chao to be robust to the influence of heterogeneity, time effects, and behavioral effects on capture probabilities (Appendix B).

Estimates of abundance and density were consistently higher in 2003 than in 2002 (Table 2.2). Mean density among sites (excluding Spigot) was estimated to be 45/ha in 2002 and 66/ha in 2003. A significant difference in density between years was found at Cemetery ($\hat{N}/ha_{2002} = 40$, 95% CI = 34 to 53, $\hat{N}/ha_{2003} = 90$, 95% CI = 70 to 126). Density estimates ranged from 11/ha (95% CI = 10 to 17) at Mystery Road in 2002 to 90/ha at Cemetery in 2003. Estimates were consistently higher at Cemetery and Tub Spring than at other sites. Abundance was estimated with relatively good precision; the coefficient of variation ranged from 5.1 to 9.8%.

Estimated capture probabilities ($\hat{p}$) from M(th) Chao differed among individuals and trapping occasions. Estimated capture probabilities were generally lower in 2003 than 2002 (Figure 2.4). All sites had similar overall average $\hat{p}$ ($\hat{\bar{p}} = 0.140$, 0.142, 0.137 at Tub Spring, Mystery Road, and Cemetery) with the exception of Spigot ($\hat{\bar{p}} = 0.28$). Time-specific $\hat{p}$'s in 2002 ranged from 0.09 to 0.23, 0.03 to 0.39, and 0.05 to 0.29 at Tub Spring, Mystery Road, and Cemetery, respectively. In 2003 the time-specific $\hat{p}$'s ranged from 0.09 to 0.18 at Tub Spring, 0.01 to 0.22 at Mystery Road, 0.01 to 0.16 at Cemetery, and 0.13 to 0.54 at Spigot.

Table 2.2. Abundance and density estimates of Washington ground squirrels on Boardman Naval Weapons Systems Training Facility. Individual capture histories were used to estimate abundance with model M(th) Chao. Non-overlapping CIs indicate a significant difference between years at the Cemetery site.

| | **Abundance** | | | 95% CI | | **Density** | | 95% CI | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site/ yr | $\hat{N}$ [a] | SE | CV[b] | Lower[c] | Upper[d] | $\hat{N}$/ha | SE | Lower | Upper | MMDM[e] | Ha [f] |
| TUB '02 | 233 | 26.4 | 8.83 | 196 | 302 | 82.47 | 9.34 | 69.38 | 106.90 | 2.5 | 2.83 |
| TUB '03 | 266 | 27.27 | 9.75 | 226 | 335 | 88.44 | 9.07 | 75.14 | 111.38 | 3.21 | 3.01 |
| MY '02 | 38 | 5.82 | 6.53 | 33 | 58 | 11.16 | 1.71 | 9.69 | 17.03 | 3.95 | 3.40 |
| MY '03 | 69 | 13.48 | 5.12 | 54 | 111 | 20.32 | 3.97 | 15.90 | 32.69 | 3.92 | 3.40 |
| CEM '02 | 127 | 15.34 | 8.28 | 107 | 169 | 39.96 | 4.83 | 33.67 | 53.18 | 3.29 | 3.18 |
| CEM '03 | 276 | 42.78 | 6.45 | 213 | 385 | 90.30 | 14.0 | 69.69 | 125.97 | 2.84 | 3.06 |
| SP '03 | 52 | 7.96 | 6.53 | 46 | 82 | 17.70 | 2.71 | 15.66 | 27.91 | 2.94 | 2.94 |

[a] $\hat{N}$ = Estimated population size
[b] CV = Coefficient of Variance
[c] Lower 95% CI = Lower bound of the estimated 95% Confidence Interval
[d] Lower 95% CI = Upper bound of the estimated 95% Confidence Interval
[e] MMDM = Mean maximum distance moved
[f] Ha = Area sampled in hectares, calculated from grid dimensions +1/2 MMDM

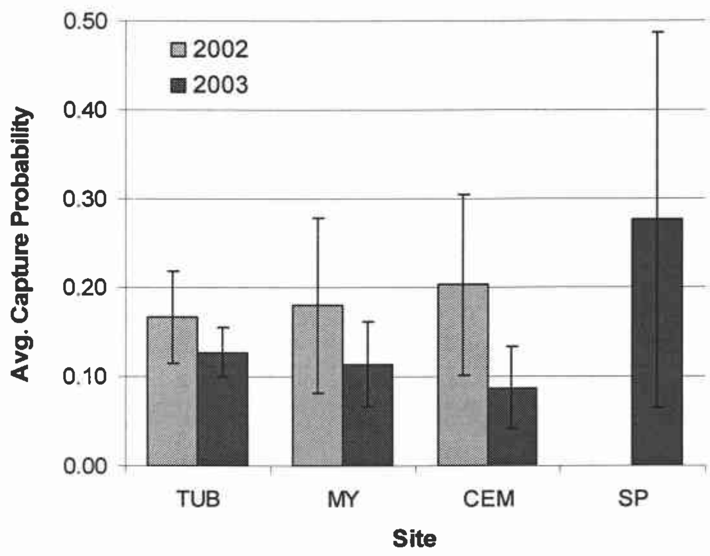


Figure 2.4. Average capture probabilities by site and year of Washington ground squirrels on Boardman Naval Weapons Systems Training Facility. Error bars represent 95% CI estimated among trapping occasions.

*Sex and Age*.-- Heterogeneity in capture probabilities between males, females, adults, and juveniles was tested with an *a priori* set of a candidate models (Table 2.3) (Appendix C). The best model {*Phi*(age+sex) *p*(.)} indicated no differences in capture probabilities between males and females or adults and juveniles ($\hat{p}_{.}$ = 0.263, 95% CI = 0.229 to 0.300) and suggested that the observed sex and age ratios represented population demography rather than heterogeneity in capture rates. This model had 1.77 times more support than the competing model, as indicated by $QAIC_c$ weights. Two competing models had ΔQAIC<2. The first competing model {*Phi*(age+sex) *p*(age)} suggested that juveniles had higher *p* than adults ($\hat{p}_{juv}$ = 0.295, 95% CI = 0.232 to 0.367; $\hat{p}_{adult}$ = 0.254, 95% CI = 0.222 to 0.289). The estimated β for the effect of age in this model substantially overlapped 0 ($\hat{\beta}_{adult}$ = -0.210, 95% CI = -0.581 to 0.161) and provided little evidence of a difference between age groups. The second competing model {*Phi*(age+sex) *p*(sex)} suggested that females had higher *p* than males ($\hat{p}_{fem}$= 0.283, 95% CI = 0.231 to 0.341; $\hat{p}_{male}$ = 0.254, 95% CI = 0.220 to 0.291). The estimated β for the effect of sex in this model was -0.149 (95% CI = -0.481 to 0.184) and did not provide sufficient evidence to suggest that capture probability differed between sexes.

The average proportions of females at Tub Spring, Mystery Road, Cemetery, and Spigot were 0.60, 0.42, 0.58, and 0.51, respectively. Confidence interval comparisons indicated that average sex ratios did not differ among sites or between years. Average proportions of females in 2002 and 2003 were 0.58 (95% CI = 0.35 to 0.81) and 0.49 (95% CI = 0.32 to 0.66), respectively. When all captures were combined (n = 621), 56% of captures were female (95% CI = 0.43 to 0.62), suggesting that the population was

Table 2.3. Model set used to assess differences in capture probability between sex and age groups of Washington ground squirrels. QAIC was used to measure the relative ability of each model to explain the variability in the data. Models are listed from best to worst. The best model indicated that capture probability (*p*) did not differ among sex and age groups.

| Model | QAICc | Delta QAICc | QAICc Weights | Num. Par | Deviance |
|---|---|---|---|---|---|
| {Phi(age+sex) p(.) } | 2105.353 | 0.000 | 0.174 | 4 | 193.975 |
| {Phi(age+sex) p(age) } | 2106.496 | 1.143 | 0.099 | 5 | 193.103 |
| {Phi(age+sex) p(sex) } | 2106.815 | 1.462 | 0.084 | 5 | 193.422 |
| {Phi(age*sex) p(.)} | 2106.898 | 1.545 | 0.081 | 5 | 193.505 |
| {Phi( age) p(.) } | 2107.429 | 2.075 | 0.062 | 3 | 198.062 |
| {Phi(sex) p(age) } | 2107.568 | 2.215 | 0.058 | 4 | 196.190 |
| {Phi(age*sex) p(age+sex) } | 2107.823 | 2.470 | 0.051 | 6 | 192.412 |
| {Phi(age*sex) p(sex) } | 2108.155 | 2.801 | 0.043 | 6 | 192.744 |
| {Phi(age*sex) p(age)} | 2108.220 | 2.867 | 0.042 | 6 | 192.809 |
| {Phi(age+sex) p(age+sex) } | 2108.293 | 2.940 | 0.040 | 6 | 192.882 |
| {Phi(.) p(age)} | 2108.313 | 2.960 | 0.040 | 3 | 198.946 |
| {Phi(age) p(sex) } | 2108.550 | 3.197 | 0.035 | 4 | 197.172 |
| {Phi(.) p(age+sex) } | 2108.818 | 3.465 | 0.031 | 4 | 197.440 |
| {Phi(age) p(age) } | 2108.828 | 3.475 | 0.031 | 4 | 197.450 |
| {Phi(age) p(age+sex)} | 2109.322 | 3.969 | 0.024 | 5 | 195.929 |
| {Phi(sex) p(age+sex) } | 2109.581 | 4.228 | 0.021 | 5 | 196.188 |
| {Phi(.) p(age*sex) } | 2109.854 | 4.501 | 0.018 | 5 | 196.461 |
| {Phi(age+sex) p(age*sex)} | 2110.109 | 4.756 | 0.016 | 7 | 192.678 |
| {Phi(age) p(age*sex) } | 2110.576 | 5.223 | 0.013 | 6 | 195.166 |
| {Phi(sex) p(age*sex) } | 2110.711 | 5.358 | 0.012 | 6 | 195.301 |
| {Phi(age*sex) p(age*sex) } | 2110.906 | 5.553 | 0.011 | 8 | 191.451 |
| {Phi(.) p(.) } | 2111.764 | 6.411 | 0.007 | 2 | 204.406 |
| {Phi(sex) p(.) } | 2112.889 | 7.536 | 0.004 | 3 | 203.522 |
| {Phi(.) p(sex) } | 2113.745 | 8.392 | 0.003 | 3 | 204.379 |
| {Phi(sex) p(sex) } | 2114.190 | 8.837 | 0.002 | 4 | 202.811 |
| {Phi(age*sex*t) p(age*sex*t) } | 2134.210 | 28.856 | 0.000 | 30 | 169.471 |

slightly female-biased. The observed proportions of adults versus juveniles did not differ among sites or between years. Proportions of adults on each site were: Tub Spring = 0.21, Mystery Road = 0.20, Cemetery = 0.24, Spigot = 0.14. Proportions of adults in each year were: 2002 = 0.22 (95% CI = 0.16 to 0.28), 2003 = 0.19 (95% CI = 0.10 to 0.28). The average proportion of adults and juveniles captured on all sites in both years was 0.20 (95% CI = 0.16 to 0.25) and 0.80, respectively (95% CI = 0.76 to 0.84).

*Survival rates.*-- Survival rates of all collared squirrels were found to differ among sites. The best model {S (site + TT)} indicated that survival could be modeled by a quadratic function with unique mean survival rates for each site (Figure 2.5). The mean proportion of animals surviving from week to week was: Tub Spring = 0.91, Mystery Road = 0.87, Cemetery = 0.95. The estimated proportion of animals from each site surviving to the end of the season was: Tub Spring = 0.34 (95% CI =0.22 to 0.48, n = 55), Mystery Road = 0.20 (95% CI = 0.09 to 0.39, n = 25), Cemetery = 0.56 (95% CI = 0.38 to 0.72, n = 35). The parameter estimates (β's) provided evidence for the effect of site on survival (Appendix D). The ratio of Akaike weights indicated 2.1 times more support for this model than for the next best model (Table 2.4). There was one competing model {S (site+year+TT)} with ΔAIC = 1.445. It indicated that survival rates differed among sites and between years. The estimated β for the effect of year in this model was -0.20 (95% CI = -0.72 to 0.32), which provided little evidence to support the inclusion of this variable. The best model and the competing model both indicated that mortality of juvenile male squirrels was greatest between 27 May and 10 June.

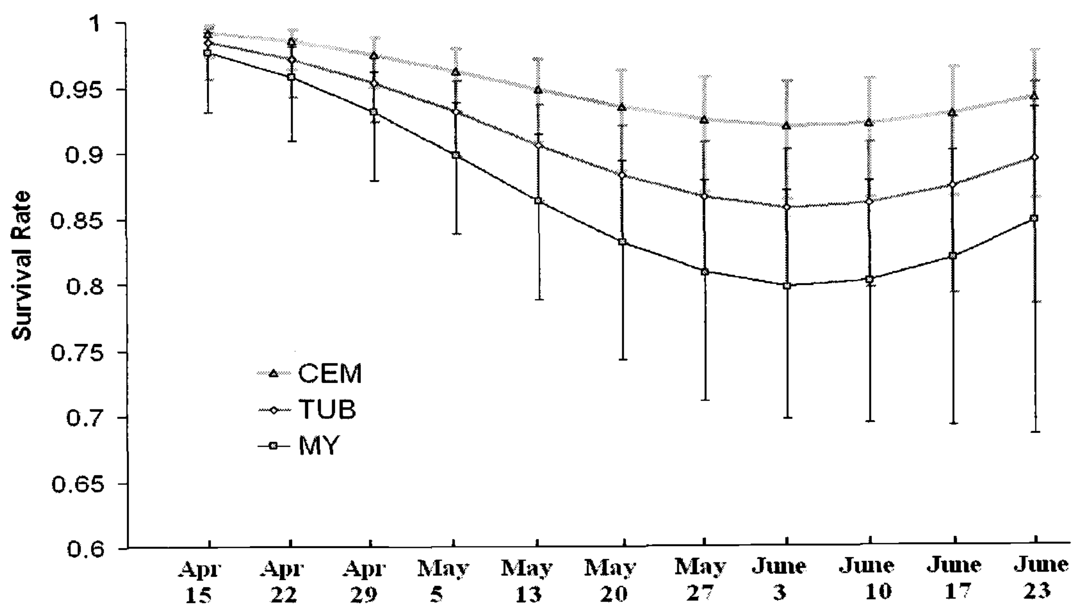


Figure 2.5. Mean weekly survival rates of all Washington ground squirrels with known fates according to the best model {S (site + TT)}. Error bars represent estimated 95% CIs. Differences in survival rates between sites were indicated.

Table 2.4. Model set used to determine survival rates of Washington ground squirrels in north-central Oregon. The best models indicated that survival (S) differed among sites and exhibited a quadratic trend in time.

| Model | AICc | Delta AICc | AICc Weights | Model Likelihood | Num. Par | Deviance |
|---|---|---|---|---|---|---|
| {S(site+TT)} | 434.051 | 0.000 | 0.381 | 1.000 | 5 | 61.643 |
| {S(site+year+TT) } | 435.495 | 1.445 | 0.185 | 0.486 | 6 | 61.057 |
| {S(site*year+TT)} | 436.490 | 2.439 | 0.113 | 0.295 | 8 | 57.976 |
| {S(site*TT) } | 437.558 | 3.508 | 0.066 | 0.173 | 7 | 61.085 |
| {S(site+T) } | 438.121 | 4.071 | 0.050 | 0.131 | 4 | 67.738 |
| {S(TT) } | 438.314 | 4.263 | 0.045 | 0.119 | 3 | 69.951 |
| {S(site+year+T) } | 439.511 | 5.460 | 0.025 | 0.065 | 5 | 67.103 |
| {S(year+TT) } | 439.802 | 5.751 | 0.022 | 0.056 | 4 | 69.419 |
| {S(site+t) } | 439.866 | 5.815 | 0.021 | 0.055 | 13 | 51.073 |
| {S(site+year)*(TT) } | 440.057 | 6.007 | 0.019 | 0.050 | 9 | 59.498 |
| {S(site*year+T) } | 440.294 | 6.244 | 0.017 | 0.044 | 7 | 63.821 |
| {S(year*TT) } | 440.999 | 6.949 | 0.012 | 0.031 | 5 | 68.591 |
| {S(site*T)} | 441.051 | 7.000 | 0.012 | 0.030 | 6 | 66.613 |
| {S(site+year+t)} | 441.391 | 7.340 | 0.010 | 0.026 | 14 | 50.527 |
| {S(site*year+t) } | 442.364 | 8.313 | 0.006 | 0.016 | 16 | 47.342 |
| {S(T)} | 442.768 | 8.717 | 0.005 | 0.013 | 2 | 76.420 |
| {S(t) } | 443.900 | 9.849 | 0.003 | 0.007 | 11 | 59.234 |
| {S(site*year*TT) } | 443.917 | 9.867 | 0.003 | 0.007 | 13 | 55.125 |
| {S(year+T) } | 444.172 | 10.121 | 0.002 | 0.006 | 3 | 75.809 |
| {S(site+year)*T } | 444.182 | 10.131 | 0.002 | 0.006 | 8 | 65.668 |
| {S(year+t) } | 445.461 | 11.410 | 0.001 | 0.003 | 12 | 58.735 |
| {S(year*T) } | 445.955 | 11.905 | 0.001 | 0.003 | 4 | 75.572 |
| {S(site*year*T) } | 448.423 | 14.372 | 0.000 | 0.001 | 12 | 61.697 |
| {S(site) } | 451.221 | 17.170 | 0.000 | 0.000 | 3 | 82.858 |
| {S(year*t) } | 451.744 | 17.693 | 0.000 | 0.000 | 22 | 44.120 |
| {S(site*year) } | 453.723 | 19.673 | 0.000 | 0.000 | 6 | 79.285 |
| {S(.) } | 454.085 | 20.034 | 0.000 | 0.000 | 1 | 89.747 |
| {S(year) } | 455.620 | 21.570 | 0.000 | 0.000 | 2 | 89.272 |
| {S(site+year) } | 462.155 | 28.104 | 0.000 | 0.000 | 6 | 87.717 |
| {S(site*t) } | 470.335 | 36.284 | 0.000 | 0.000 | 33 | 39.099 |
| {S(site+year)*t} | 498.617 | 64.567 | 0.000 | 0.000 | 46 | 38.594 |
| {S(site*year*t) } | 506.285 | 72.234 | 0.000 | 0.000 | 66 | 0.000 |

Survival rates of dispersers and non-dispersers were also estimated. The best model {S (disp*TT)} and one competing model {S (TT)} were selected from an *a priori* set of candidate models (Appendix D). The best model provided evidence that survival rates of dispersers and non-dispersers varied in time according to different quadratic functions (Figure 2.6). The mean weekly survival rate was 0.92 for dispersers and 0.89 for non-dispersers. The overall probabilities of survival to hibernation were 0.41 (95% CI from 0.29 to 0.54, n = 67) for dispersers, and 0.26 (95% CI from 0.13 to 0.46, n = 28) for non-dispersers. The estimated β parameter for the effect of dispersal provided moderate evidence that survival probabilities differed between groups ($\hat{\beta}$= 0.88, 95% CI = -0.29 to 2.05). The period of lowest survival for dispersers corresponded to 20 – 27 May, while lowest survival for non-dispersers occurred later; 10 – 17 June. The ratio of Akaike weights indicated 1.76 times more support for this model than for the competing model (Table 2.5). The competing model {S (TT)} had a ΔAIC = 1.13 and suggested that a single quadratic equation could be used to model the survival rates of both dispersers and non-dispersers. The probability of surviving the duration of the study for all juvenile males according to the competing model was 0.36 (95% CI = 0.27 to 0.47). The lowest survival rates were estimated to occur between 20 May and 10 June.

*Predation rates.--* Of 128 collared animals in this study, 36% were assumed to have survived to hibernation. Of 89 radio-collared juvenile males that died before hibernation (excluding trap mortalities), raptors accounted for the highest average percent of mortality ($\bar{x}$ = 49.8%, 95% CI = 32.9% to 66.7%), followed by badgers ($\bar{x}$ = 28.3%, 95% CI = 16.6% to 40.1%). Unknown causes of mortality accounted for 16.5% of the total (95% CI = 0.0 to 33.8%), and unidentified predators caused 4.7% of mortality (95% CI = 0.3% to 9%). Of 63 dispersers, 21 were killed by raptors, 6 by badgers, 4 by unidentified predators, 5 died from unknown causes, and 1

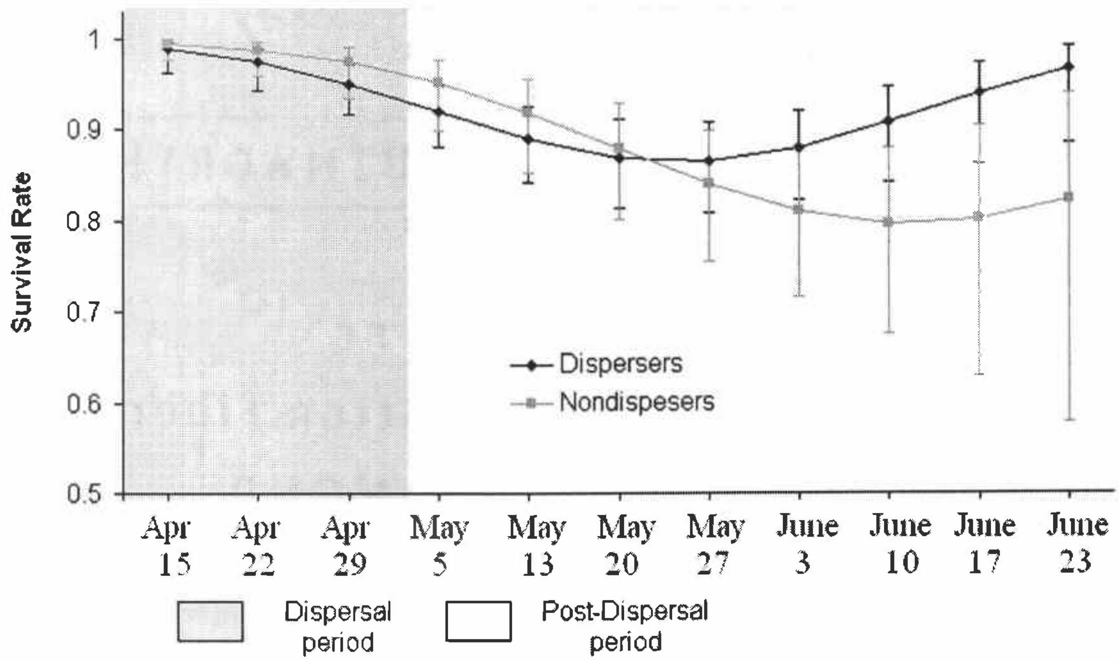


Figure 2.6. Survival rates of dispersers and non-dispersers and dispersal dates. The dispersal period (shaded) represents the range of dispersal dates observed in 2002 and 2003. Survival rates differed between dispersers and non-dispersers according to the model {S (disp* TT)}. Error bars represent estimated 95% CIs.

Table 2.5. Results of model selection for survival rates of dispersers and non-dispersers. The best model indicated that survival rates (S) differed between dispersers and non-dispersers.

| Model | AICc | Delta AICc | AICc Weights | Number Params | Deviance |
|---|---|---|---|---|---|
| {S(disp*TT)} | 376.907 | 0.000 | 0.509 | 5 | 17.712 |
| {S(TT)} | 378.041 | 1.134 | 0.289 | 3 | 22.897 |
| {S(disp+TT)} | 379.716 | 2.809 | 0.125 | 4 | 22.550 |
| {S(t)} | 381.659 | 4.752 | 0.047 | 11 | 10.168 |
| {S(disp+t)} | 383.330 | 6.423 | 0.021 | 12 | 9.769 |
| {S(T)} | 386.729 | 9.822 | 0.004 | 2 | 33.603 |
| {S(disp*T)} | 386.945 | 10.038 | 0.003 | 4 | 29.778 |
| {S(disp+T)} | 388.239 | 11.332 | 0.002 | 3 | 33.095 |
| {S(disp*t)} | 394.597 | 17.690 | 0.000 | 22 | 0.000 |
| {S(.)} | 397.657 | 20.750 | 0.000 | 1 | 46.542 |
| {S(disp)} | 399.196 | 22.289 | 0.000 | 2 | 46.070 |

animal was killed by a gopher snake (*Pituophis melanoleucus)*. The remaining 26 survived to hibernation. Of 26 philopatric individuals, 8 were killed by raptors, 9 by badgers, 2 died from unknown causes, and 7 survived to hibernation (Figure 2.7).

*Correlation of dispersal rate with sex, age, and density.*-- A non-significant negative relationship was observed between dispersal rate and the proportion of females ($r$ = -0.657, CI = -0.958 to 0.331). No correlation between the dispersal rate and the proportion of adults on each site was detected ($r$ = -0.401, 95% CI = -0.915 to 0.609). The observed correlation between dispersal rate and density indicated a strong negative relationship ($r$ = -0.915, 95% CI = -0.991 to -0.40). Survival was estimated from the competing model {S(site+year)+TT} to allow examination of individual year and site survival rates. Dispersal rate and survival rate on each site exhibited a moderate negative relationship ($r$ = -0.807, 95% CI = 0.012 to -0.978).

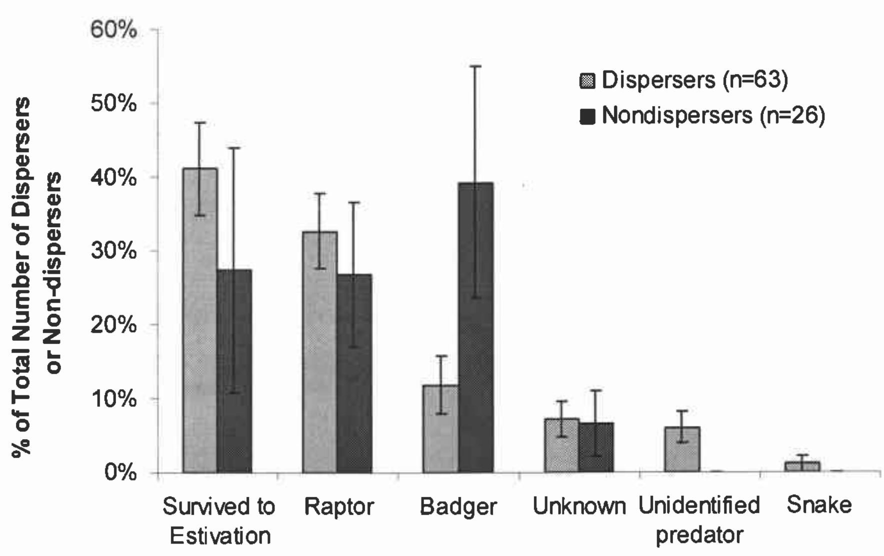


Figure 2.7. Average survival and mortality rates for dispersers and non-dispersers. Error bars are the standard error of the mean estimated for all sites and years.

# DISCUSSION

## Dispersal Rates

Approximately 72% of juvenile male Washington ground squirrels dispersed from 3 sites on Boardman. There were no significant differences in dispersal rates among sites or between years. Contrary to my prediction, the dispersal rate and the estimated density on each site were negatively correlated. This relationship is uncommon, but not unheard-of among small mammals (reviewed by Gaines and McClenaghan 1980). Female dispersal has been positively correlated with density among Belding's ground squirrels (*S. beldingi)*, but no relationship was found between male dispersal and density in *S. beldingi* or in round-tailed ground squirrels (*S. tereticaudus*) (Dunford 1977, Wiggett and Boag 1992*b*, 1993*b*; Nunes et al. 1997). While density-dependant dispersal can serve to reduce competition on the natal site (Hamilton and May 1977), a negative correlation or lack of a relationship suggests that dispersal serves another purpose. Dobson (1979) concluded that dispersal by juvenile male California ground squirrels (*S. beecheyi*) promoted outcrossing rather than regulated density. Among *S. columbianus,* an association between dispersal rates and female bias in the sex ratio indicated that mate competition may have motivated dispersal (Wiggett and Boag 1993*b*). In this study, dispersal rates were not correlated with the proportions of females, and contrary to my hypothesis, dispersal rates were not correlated with the proportion of adults. The results of this study do not contradict the findings of other researchers that have concluded that natal dispersal among male *Spermophilus* does not serve to reduce competition on the natal site, but instead increases access to mates, maximizes outbreeding, or reduces inbreeding (Holekamp 1986, Nunes et al. 1997, Byrom and Krebs 1999).

**Distances**

No differences were detected among sites or between years in dispersal distances in this study. Factors thought to influence dispersal distances include the availability of travel corridors (Wiggett et al. 1989), familiarity of dispersers with habitat type (Olson and Van Horne 1998), distance to aggregates of conspecifics (Murie and Harris 1984, Weddell 1991), and degree of predation pressure (Byrom and Krebs 1999). Physiological constraints from exhaustion, water stress, or nutrient requirements may also influence dispersal distances (Solomon 2003). Murray (1967) suggested that dispersers should travel only as far as necessary to obtain a patch of uncontested habitat. Waser (1987) hypothesized that distances are determined by population density and habitat availability. Both of these hypotheses result in geometric distributions that do not account for rare long-distance dispersal events (Koenig et al. 1996) such as those observed in this study. This suggests that processes other than competition for space influenced dispersal distances of *S. washingtoni*. Similarities in dispersal rates and distances between years and sites in this study suggested that dispersal behavior had an intrinsic component (Caughley 1977).

**Timing of Dispersal**

Timing of dispersal occurred significantly earlier in 2003 than 2002. Weather conditions may have affected timing of dispersal by accelerating the timing of adult emergence or growth rates of juveniles in 2003 relative to 2002. The long-term average precipitation between December and May on Boardman was 13.6 cm. The area received below-average rainfall throughout the active season of 2002 (approximately 8.1 cm) and above-average rainfall in 2003 (approximately 17 cm). Long-term average daily high temperatures on Boardman in February and March were 8.6 and 14.1°C. Temperatures during this period in 2003 were above average (10.5 and 16°C) (Oregon Climate Service 2004) (Appendix E). Juvenile males in 2003 dispersed an average of 8 days earlier than in 2002. Female *S. washingtoni* breed immediately after emergence, and gestation lasts approximately 25 days (Scheffer 1941). Natal dispersal among most members of *Spermophilus* occurs after attainment of adequate body mass or composition (Holekamp 1983, 1984*a, b*, 1986; see also Wiggett and Boag 1992*b*). If all other factors are similar, early emergence leads to early dispersal. Temperature and rainfall has also been shown to affect food quantity and quality, thus influencing growth rates and timing of dispersal (Bennett 1999). Accelerated growth rates and dispersal at younger ages have been documented for *S. beldingi* on areas supplemented with high-quality forage (Nunes and Holekamp 1996).

**Density**

Density of squirrels on all sites on Boardman was greater in 2003 than in 2002, and may also have been related to weather conditions. Above-average early-season temperatures may have brought about earlier emergence from hibernation or increased spring survival and reproduction rates. Late winter precipitation coupled with cold temperatures has been shown to reduce overwinter survival of female *S. beldingi* and juvenile *S. mollis* (Morton and Sherman 1978, Van Horne et al. 1997, Sherman and

Runge 2002). Weather conditions hindered emergence and prolonged hibernation which increased dependency on fat stores and reduced survival (Van Horne et al. 1997). Weather conditions also determine availability and quality of early-season forage. Food availability has been shown to affect adult female body mass, which influenced litter size and juvenile survival rates (Sauer and Slade 1987, Michener 1989, Rieger 1996, Neuhaus 2000). Lower reproductive success and higher mortality after spring snowstorms have been observed among adult female *S. beldingi* and *S. columbianus* (Morton and Sherman 1978, Neuhaus et al. 1999).

**Survival and Mortality**

Within-season survival rates of juvenile male squirrels in this study did not appear to be influenced by weather conditions; no substantial differences were detected between years. The estimated probability of survival was dependant on site of origin. Survival differences among sites were likely due to different intensities of predation. In this study, 87% of natural mortality of juveniles (not related to human disturbance) was due to predation. Raptors were the primary predators of juvenile males in both 2002 and 2003, while badgers were secondary. Badger predation accounted for a greater proportion of mortality on Mystery Road than on other sites (Figure 2.8). Predation rates of *S. washingtoni* were similar to those estimated for other *Spermophilus* species. Byrom and Krebs (1999) found that 97% of mortality among juvenile *S. parryii* was due to predation. Badgers have been found to be top predators of *S. mollis* (Smith and Johnson 1985). Badgers and raptors were primary predators of *S. richardsoni* (Schmutz et al. 1979).

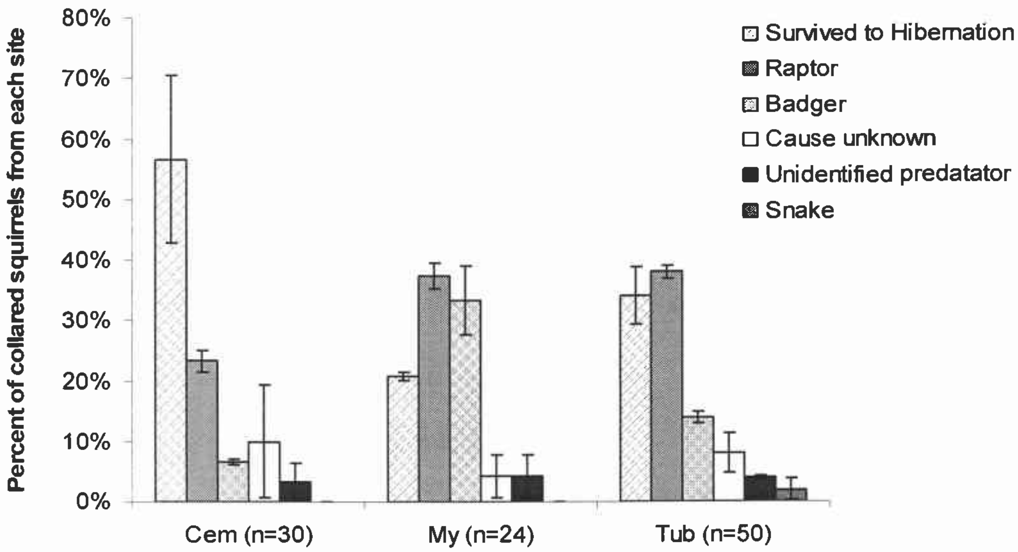


Figure 2.8. Fates of collared Washington ground squirrels from 3 sites on Boardman Naval Weapons Systems Training Facility. Error bars represent the standard error of the mean across years.

Red-tailed hawks and long-tailed weasels were the major predators of *S. beldingi* (Bachman 1993).

Timing of maximum mortality of dispersers in this study occurred during May, which corresponded to the settlement period following dispersal. This suggests that the settlement phase may be more costly than the dispersal event for Washington ground squirrels. Decreased survival during dispersal has commonly been attributed to increased predation risk, stress levels, intraspecific aggression levels, movement rates, or unfamiliarity with local habitat while in transit (Gaines and McClenaghan 1980, Van Vuren and Armitage 1994, Waser et al. 1994), but most studies on survival of dispersers have not distinguished between the dispersal and settlement periods (e.g. Schmutz et al. 1979, Slade and Balph 1974, Byrom and Krebs 1999). Dispersing ground squirrels in this study may have experienced high mortality during settlement due to a prolonged increase in exploratory activity needed to gain familiarity with local resources. Lack of familiarity with local habitat during the settlement phase was found to be the most important factor influencing predation risk for ruffed grouse (*Bonasa umbellus*) (Yoder et al. 2004). Higher predation rates of more active individuals have also been found in kangaroo rats (*Dipodomys merriami*) (Daly et al. 1990), field voles (*Microtus agrestis*), and sibling voles (*M. rossiaemeridionalis*) (Norrdahl and Korpimaki 1998).

Dispersers in this study had a higher estimated probability of survival to hibernation than non-dispersers. Dispersers were at higher risk of predation by raptors, but non-dispersers are at higher risk of predation by badgers. Of all squirrels killed by badgers, 65% were non-dispersers. Of all raptor mortalities, 72% were dispersers. Lower survival rates of philopatric squirrels may have occurred because predators concentrated their efforts on high density natal sites rather than low density post-dispersal areas. Heavy predation on high density sites has been observed among several species of terrestrial small mammals (McGuire et al. 2002; Swilling and Wooton 2002). Evidence of badger activity was observed on every trapping site in each year, but was rarely observed in post-dispersal settlement areas. Badgers are known to have concentrated predatory impacts on localized populations (Van Horne et al. 1997). Timing of highest mortality of non-dispersers occurred in June, about 3 weeks later than that of dispersers, and was associated with desiccation of vegetation and increased badger activity on natal sites. Tradeoffs between the costs and benefits of dispersal were evident in the comparative survival rates of dispersers and non-dispersers in this study.

**Resident versus Emigrant Fitness Hypotheses**

Survival rates of dispersers and non-dispersers were estimated in order to determine whether natal dispersal by Washington ground squirrels supported the predictions of the resident fitness hypothesis or the emigrant fitness hypothesis. The estimated survival rates of several *Spermophilus* species provided evidence in support of the resident fitness hypothesis. Dispersing *S. richardsonii* and *S. parryii* had lower survival rates and higher predation rates than non-dispersers (Schmutz et al. 1979, Byrom and Krebs 1999). The predictions associated with this hypothesis have also been supported. Adult female *S. columbianus* behaved agonistically toward yearlings prior to dispersal, dispersal was correlated with juvenile emergence, and reduced adult male density corresponded with lower rates of dispersal (Wiggett and Boag 1993*b*). Conspecific aggression leading to dispersal also has been documented among *S. richardsonii* (Michener 1973) and Wyoming ground squirrels (*S. elegans*) (Pfeifer 1982). Dispersal has also been associated with high mortality rates for several species (reviewed in Gaines and McClenaghan 1980) and was hypothesized to decrease survival rates of *S. washingtoni* in this study.

Contrary to my initial prediction, survival rates of dispersing Washington ground squirrels were greater than for non-dispersers. In this study, reproductive success of dispersers and non-dispersers was not monitored, but higher survival rates of dispersers suggests that dispersers may have had higher fitness than non-dispersers. In this case, the emigrant fitness hypothesis would be supported. This hypothesis was supported in a study of *S. columbianus* where immigrant males had higher indications of reproductive success than natal residents, suggesting that dispersal provided a fitness advantage (Wiggett and Boag 1993*a*). Researchers have also provided evidence in support of the predictions associated with this hypothesis. Holekamp (1986) concluded that dispersal was beneficial for *S. beldingi* because it improved access to mates and reduced likelihood of incest. Michener (1979) found that *S. richardsonii* dispersed at greater rates when the likelihood of incest was high. Additional research on reproductive success of dispersing and non-dispersing *S. washingtoni* is needed to fully understand the adaptive significance of dispersal for this species. However, this study provides evidence of a direct survival advantage gained by dispersers, which is unprecedented among *Spermophilus.*

# CHAPTER 3

# DISPERSAL BY WASHINGTON GROUND SQUIRRELS: THE INFLUENCE OF RESOURCE SELECTION AND BARRIERS

## ABSTRACT

Dispersal is the primary mechanism that allows subdivided populations to interact and persist. In heterogeneous environments dispersing animals maximize survival and reproduction through selection of favorable settlement conditions. I examined the influence of resource selection on the natal dispersal patterns of male Washington ground squirrels (*Spermophilus washingtoni*) in 2002 and 2003 on Boardman Naval Weapons Systems Training Facility, Oregon. Environmental resources hypothesized to influence dispersal patterns via resource selection included soil and vegetation type, distance to the nearest road or historic colony, location relative to a 1998 fire, slope, and aspect. Primitive roads and agricultural lands were also examined as potential barriers to dispersal. Directionality of dispersal did not differ from random on two sites, but was non-random on a third. Evidence of selection against low-shrub and perennial grass-dominated sites was detected. Dispersers did not select settlement sites based on soil series, but animals on one site did select for soils with a silt-loam texture. Settlement locations were closer to primitive roads and historically-occupied sites than expected. No selection for or avoidance of slope, aspect, or areas that had been burned was detected. Primitive roads did not act as a barrier to dispersal, but land in agricultural production likely altered dispersal patterns.

## INTRODUCTION

Many wildlife populations exhibit a metapopulation structure as a result of human activities or naturally heterogeneous habitat conditions. Dispersal is the primary mechanism that allows such populations to persist. Dispersal among subpopulations is crucial for maintaining genetic outcrossing (Templeton 1987), which is vital to sustaining genetic variability within small populations (Lacy 1987). Reduced dispersal can increase probability of extinction from genetic, environmental, or demographic stochasticity or catastrophe (Fahrig and Merriam 1985, Shaffer 1987). Dispersal has been shown to lower extinction rates in fragmented metapopulations (Levins 1969) and facilitate recolonization of previously-occupied habitat patches (Hanski 1998).

Survival and reproductive success of dispersers can be highly dependant on local environmental conditions (Lin and Batzli 2001, Haughland and Larsen 2004). Active dispersers in a heterogeneous environment should therefore exhibit selection for resources and environmental conditions that maximize fitness (Fretwell and Lucas 1970, Van Horne 1983, Pulliam and Danielson 1991). Much research attention has focused on how dispersal is affected by population demography (e.g., Fretwell and Lucas 1970, Van Horne 1983, Greene and Stamps 2001), habitat connectivity (Bjornstad et al. 1998, Boudjemadi et al. 1999, Walker et al. 2003, Kramer-Schadt et al. 2004) and individual experience (Larsen and Boutin 1994, Olson and Van Horne 1998, Haughland and Larsen 2004), but the influence of resource selection on dispersal has rarely been investigated. The few studies relating dispersal and resource selection have shown that the quality of habitat selected by dispersers affects survival rates (Miller et al. 1997, Larsen and Boutin

1994) and population persistence (Gammon and Maurer 2002). Conversely, changes in habitat quality can also affect dispersal rates (Breininger and Carter 2003, Murphy 2001). Dispersers that selected high quality habitat have been shown to have higher reproductive success than philopatric individuals (Spear et al. 1998) or others that settled in low-quality habitat (Lin and Batzli 2001). Resource selection methods have been used to identify environmental resources crucial to dispersing members of threatened and endangered species (Ferrer and Harte 1997, Miller et al. 1997, Palomares et al. 2000). In general, resource selection by dispersers has been underutilized as a tool for identifying and predicting movement patterns, space needs, and crucial habitat components.

Selection of optimal habitat conditions by dispersers depends on access to a variety of habitats (Fretwell and Lucas 1970), as selection choices can be limited by features of the landscape that act as barriers. Dispersal barriers not only alter settlement patterns, but can also affect population demography (Fahrig and Merriam 1985), alter survival rates of dispersers (Johnson and Gaines 1987, but see also Andreassen et al. 1996), and reduce colonization of available habitat (Walker et al. 2003). Identification of barriers can help maintain access to suitable settlement habitats and prevent subdivision and isolation within metapopulations.

Natal dispersal is the movement of juveniles away from their place of birth prior to reproductive maturity (Greenwood 1980) and is the primary mode of dispersal for ground squirrels (Holekamp 1984*a*). Dispersal is generally sex-biased within subgenus *Spermophilus.* Dispersal rates of males range from 58 to 100% (Holekamp 1984*b,* Olson and Van Horne 1998), while dispersal rates of females range between 8 and 12%

(Holekamp 1984*b*, Olson and Van Horne 1998, Byrom and Krebs 1999). Dispersal is a key event in the life history of most members of *Spermophilus,* yet there has been no prior research on dispersal in the Washington ground squirrel. The Washington ground squirrel occupies isolated patches of shrubsteppe habitat in the Columbia River Basin of Washington and Oregon (Betts 1999). It is a state-listed endangered species in Oregon and has a limited geographic range and small population numbers (Oregon Department of Fish and Wildlife 1999).

I studied the natal dispersal patterns of juvenile male *S. washingtoni* on Boardman Naval Weapons Systems Training Facility (Boardman) in order to address the following questions: (1) Are post-dispersal settlement patterns influenced by selection of particular resources? (2) Do landscape features such as roads act as barriers to dispersal? The influence of resource selection on dispersal patterns was examined by identifying disproportionate use of resources relative to availability (Johnson 1980). Used resources were those present at post-dispersal settlement locations. Available resources were identified using an individual-based model of dispersal distances and directions. Environmental resources that were investigated for their potential influence on dispersal patterns included vegetation type, soil series and texture, distance to roads, distance to historically-occupied squirrel sites, slope, aspect, and a previously burned area.

Vegetative composition determines food availability, overwinter survival, and vulnerability to predators for many *Spermophilus* spp. (Murie and Boag 1984, Schooley et al. 1996, Van Horne et al. 1997, Bennett 1999). Higher densities of Washington ground squirrels have been found in sagebrush than in other vegetation types (Greene

1999). Fires in shrubsteppe ecosystems result in fragmentation, loss of sagebrush, and replacement of perennial grasses and native forbs with invasive annual grasses (Oregon Department of Fish and Wildlife 1999). I hypothesized that settlement patterns of *S. washingtoni* would reflect selection for vegetation dominated by sagebrush, and avoidance of recently burned areas.

Soil type and topography were thought to influence post-dispersal settlement patterns. Presence of Washington ground squirrels on Boardman has been significantly associated with Warden and Sagehill soils, which have high silt contents and deep profiles (Greene 1999). Soil characteristics are partly determined by slope and aspect. Burrow sites selected by another semi-fossorial mammal, the Pygmy rabbit (*Brachylagus idahoensis*), were located on slopes which accumulated windblown soil (Heady et al. 2001). On Boardman, southwest winds predominate, and soil deposition occurs on leeward slopes (Hosler 1983). I therefore hypothesized that squirrels would select slight to moderate slopes with northeast aspects.

The current or historic spatial distribution of conspecifics may also influence dispersal. Social attraction can reduce vulnerability to predation (Smith 1986) and improve reproductive success of dispersers (Stamps 1991). Dispersers may be attracted to vacant burrows that provide refuge or indicate habitat quality. Reintroduction and transplant efforts have demonstrated the importance of vacant burrows for establishing ground squirrels into new areas (Carpenter and Marin 1969, Salmon and Marsh 1981). I hypothesized that dispersers would select locations near historically-occupied sites.

Agricultural development has contributed to the decline of the Washington ground squirrel (Betts 1990). Observations by Carlson et al. (1980) indicated that wheat fields inhibited movements of *S. washingtoni*. Roads can isolate habitat patches (Mader 1984) and reduce the frequency of movements between patches (Merriam et al. 1989). I therefore predicted that roads and agriculture may act as barriers to dispersal.

**STUDY AREA**

Boardman Naval Weapons Training Facility was a 46,127-acre area managed by the Department of Defense as an aerial target range. It was located near Boardman, Oregon, 72 km west of Pendleton, and was the largest unfragmented tract of high quality native habitat remaining in the range of *S. washingtoni* (Carlson et al. 1980, Kagan 1987). Elevation on Boardman ranged from 162 to 308 m. Average annual precipitation was 22 cm and fell mostly in autumn and winter. Vegetation varied from bitterbrush (*Persia tridentata*) shrubsteppe on sandy soils at the north end to perennial grasses and sagebrush (*Artemesia tridentata*) on the silt-loam soils of the south end. Ground squirrel populations have been studied here in the past (Calson et al. 1980, Greene 1999, Morgan and Nugent 1999).

My research was conducted in March-July 2002 and 2003 on 3 sites within Boardman: Tub Spring, Mystery Road, and the Cemetery (Figure 3.1). These sites were selected based on abundance of squirrels, vegetation type, soil series, vicinity to potential barriers to dispersal, and the type of potential barrier. Tub Spring was consistently occupied by Washington ground squirrels between 1997 and 2003 (V. Marr, pers.

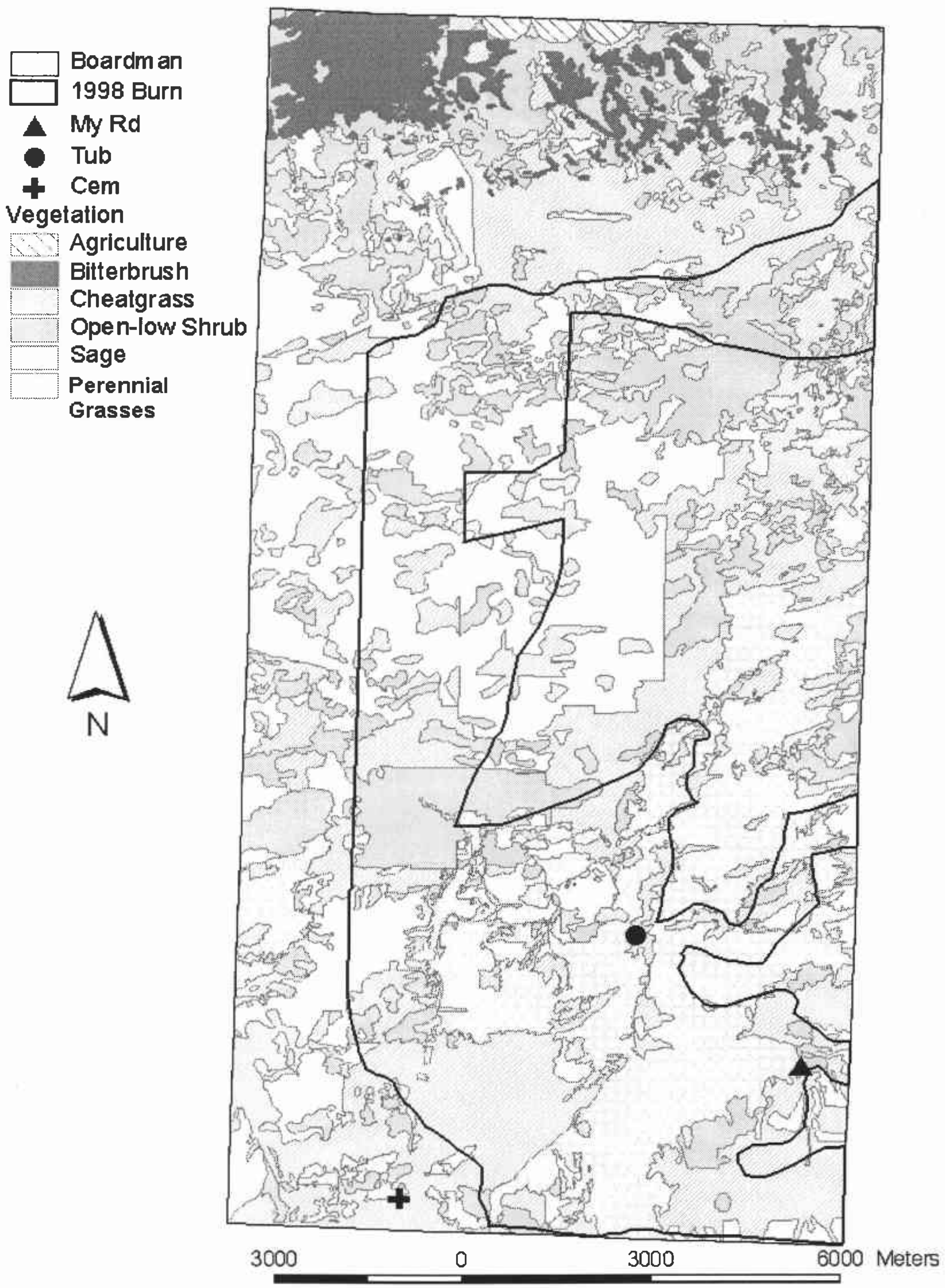


Figure 3.1. Trapping sites and vegetation types on Boardman Naval Weapons Systems Training Facility. The periphery of a 1998 fire is also outlined in black.

commun.). Vegetation at Tub Spring was dominated by annual grasses and forbs, especially cheatgrass (*Bromus tectorum*) and foxtail barley (*Hordeum jubatum).* Much of this area was burned by a large fire in 1998. This site was on Warden soil, but 3 additional series were located within 500 m. It was bordered on 3 sides by primitive roads of various sizes. Tub Spring represented habitat with no nearby cultivated land; it was 3,500 m from the nearest agriculture.

The Cemetery was located near a historic pioneer cemetery on the south end of Boardman. Despite being heavily grazed in the past, intact assemblages of native bunchgrasses and sagebrush occurred nearby. This site was entirely within Warden silt loam soil and was close to a graded road and agricultural lands. The trapping grid was placed approximately 320 m north of a gravel road and cultivated wheat fields lying beyond the southern boundary of Boardman.

Most squirrel sightings and occupied burrows at Mystery Road occurred along the East face of a small north-south oriented bluff. The upland areas were dominated by perennial grasses and low shrubs. A primitive road and ephemeral creek occurred at the base of the bluff, which was dominated by sagebrush. I established the trapping site astraddle the road to capture animals that used the uplands, the bluff, the road, and the drainage bottom. The area was partially burned in 1998. Mystery Road was within Warden soils, but had 2 additional soil series within 400 m. It was located 675 m from the nearest agriculture.

## METHODS

### Field Methods

At all sites, rectangular trapping grids were established over the of greatest squirrel activity. Tomahawk® single door squirrel traps (model 202, 48.3 x 15.3 x 15.3 cm) were placed 15 m apart and covered with plywood, cardboard, or natural debris to protect animals from heat. Trapping was conducted from the time of juvenile emergence through the juvenile dispersal period (Appendix A). Trapping was conducted during daylight hours when ground temperature did not exceed 32°C. Each trapping session consisted of baiting all traps with apples (Greene 1999) and leaving them open 1-2 hrs.

Upon capture, animals were weighed, sexed, and aged (adult or juvenile). Juvenile males >78 g were fitted with a 3.8 g radio transmitter (Advanced Telemetry Systems®, model M1610, 40 pulses/min). Squirrels were recaptured later in the season to adjust or replace collars. The Institutional Animal Care and Use Committee at Oregon State University approved all animal handling procedures (permit no. 2691).

I followed signals using Telonix® receivers and hand-held or vehicle-mounted H antennas. Locations were determined by tracking each animal to its burrow or hideout, and recording the location using Garmin® geographic positioning system (GPS) units. Data were collected in Universal Transverse Mercator (UTM) coordinates using NAD27 Continental United States (CONUS) projection data. The mean of 68 points taken daily from a reference location was identical to that location on a 7.5-minute topographic map. The daily GPS location differed from the actual location by an average of 5.0 m (95%

confidence interval [CI] = 3.4 to 6.7 m). The procedure for recording reference locations and locations of squirrels was the same; therefore there was a similar margin of error.

I determined the status of collared squirrels by visual confirmation of a living animal, movement from previous location, or recovery of the collar. Washington ground squirrels hibernate between mid summer and late winter of the following year. If a squirrel stopped moving prior to immergence into hibernation, I attempted to recover the collar and determine the fate of the animal. Dispersal was defined as a unidirectional, non-overlapping shift in home range (Lidicker 1975). I identified such movements from the daily telemetry location and defined philopatric squirrels as those that did not move between 2 or more non-overlapping home ranges, or returned to the natal area after a dispersal movement. The post-dispersal settlement location was defined as the first location in the post-dispersal home range to be followed by movement in multiple directions that overlapped the settlement location. When a squirrel was engaged in >1 dispersal event, the final location that met this criterion was designated as the post-dispersal settlement location. Successful dispersers were located in post-dispersal settlement areas ≥5 times.

**Data Analysis**

*Resource availability model.*-- I compared characteristics of settlement locations with characteristics of random locations to determine which resources influenced the selection of settlement locations. I assumed that post-dispersal settlement indicated resource selection by dispersing juvenile male ground squirrels. I also assumed that random locations assigned on the landscape were available to dispersing squirrels. Several steps were taken to ensure these assumptions were met.

Resource selection was unlikely to occur among animals that were lost or died en route or shortly after dispersal; therefore, unsuccessful dispersers were eliminated from analysis. This step eliminated locations that may have been used only temporarily during dispersal and retained locations where dispersers established new home ranges. Dispersing animals were not tracked onto private land, so no conclusions could be made about resources used by animals that did so. Four dispersers were last located on private land and were eliminated from analysis. One animal dispersed off of Boardman to a known location. This animal's dispersal distance was included in modeling efforts, but its settlement location was excluded from analysis of resource selection. Four animals dispersed less than 200 meters and were excluded. These short-distance dispersals consisted of non-overlapping unidirectional shifts in home range, but were within the range of maximum daily movement distances from the natal locations. These settlement locations may have been selected during pre-dispersal forays and resource selection may have been based on different information for these animals than for the average disperser, prompting me to exclude them.

To ensure that random locations on the landscape were distributed in a manner that characterized available habitat, I modeled distances and directions traveled by successful dispersers and assigned random locations according to this model. Dispersal distances were estimated previously (this study, chapter 2). Parameter estimation and model selection was conducted with program DISTANCE (Thomas et al. 1998). Several families of models were biologically feasible. They included half-normal, negative exponential, and uniform models with a cosine or polynomial series adjustment. Model selection was performed among families of models and then among individual models with estimated parameters. Model selection was based on Chi-squared ($X^2$) goodness of fit and minimum Akaike's Information Criterion (AIC) values (Akaike 1973, Sakamoto et al. 1986, Burnham and Anderson 2002). Ten percent of the longest distances were truncated and manually-selected distance intervals were used to improve model fit (Buckland et al. 2001). The detection function of the best model (Buckland et al. 1993) was used to model the observed dispersal distance distribution. Characteristics of available habitat were then determined at distances away from the natal sites drawn randomly from the top model.

Points were distributed in random directions for an analysis of all combined sites. Resource selection by squirrels from each individual site was also examined. For site-specific analyses, points were assigned in directions equal to those of dispersers when evidence of non-random direction of dispersal was detected. Dispersal directions were calculated from compass bearings measured from the center of each trapping grid to the first settlement location using Arcview 3.2 (2002) bearings extension. To determine if directions differed among sites, cumulative histograms of bearings were created for each site and compared with a uniform distribution of bearings. A test statistic from a Kuiper's N-table was used to determine significance at the $\alpha = 0.05$ level (Batchelet 1981).

The number of points needed to represent available habitat was determined by drawing 6 samples of 510 numbers—each representing a distance—from the half-normal model. Distances were distributed in random directions from the center of each natal site. The vegetation type of each point was determined with a Geographic Information System (GIS). Sample size was estimated by determining the variance in the amount of each vegetation type (Ramsey and Schafer 2002:685). Greater than 457 points were needed to represent available resources on each site. Random points representing available habitat that fell beyond the perimeter of Boardman were eliminated from analysis. The final number of points distributed in random directions from the center of each site was: Tub Spring = 510, Mystery Road = 494, and Cemetery = 476. These points were used for analysis of all sites combined and site-specific analyses at Tub Spring and Mystery Road. Site-specific analysis on Cemetery was conducted with 488 points distributed in directions equal to those traveled by dispersers.

*Resource characterization.*--Habitat characteristics of settlement locations and random points were determined in a GIS. Data layers consisted of vegetation types, locations of roads, soils, elevation, locations of known historic ground squirrel sites, and the perimeter of a 1998 fire. Before use, data layers were assessed for quality, accuracy, completeness, and appropriateness. Roads and vegetation classes were identified from 1996 photo-orthoquad images with 1 m resolution. Roads ranged from barely-visible 2-tracks to 2-lane gravel roads. Vegetation was classified into 5 cover classes (Table 3.1). Classes were digitized into polygons in Arcview 3.2 (2002) based on vegetation type. Digital GIS soil layers were obtained from a soil survey of Morrow County Oregon (Hosler 1983, Natural Resource Conservation Service 2003). I calculated slope and aspect in ArcGIS (2002) from a digital elevation map (DEM) with 10 m pixels (U.S.

Table 3.1. Major vegetative types on the Boardman Naval Weapons Systems Training Facility (Greene 1999, Morgan and Nugent 1999).

| **Vegetative Community Type** | **Dominant Vegetation** | **Current Condition Relative to Native Condition** |
|---|---|---|
| Big-sagebrush | Variable amounts of sagebrush with cryptogrammic crust, bunchgrasses and forbs in the understory | Most representative of the original conditions |
| Bunchgrass | Bluebunch wheatgrass (*Pseudoroegneria spicata)*, needle and thread grass *(Stipa comata),* Sandberg's bluegrass (*Poa secunda*) | Most species in this habitat type are native. |
| Low shrub | Rabbitbrush (*Chrysothamnus sp.*) and matchweed (*Gutierrezia sarothrae*) with a cheatgrass (*Bromus tectorum*) understory | Represents habitat that has been grazed or burned in the past |
| Annual grass | Cheatgrass and weed species with few shrubs | Habitat type shows the impacts of heavy grazing and/or recent fire |
| Bitterbrush | Variable amounts of bitterbrush with cryptogrammic crust, bunchgrasses, and forbs in the understory | Represents original conditions |

Geological Survey 1999). Locations of historic squirrel sites and the 1998 fire perimeter were ground-truthed by Oregon Department of Fish and Wildlife with hand-held GPS units between 1997 and 2003 (V. Marr and R. Morgan, unpublished data, 2003). I imported all data layers into a GIS and converted each to North American Datum 1927 UTM Zone 11 using CONUS projection transformations. See Appendix F for metadata.

Distances to the nearest road and historic squirrel site were measured in Arcview 3.2 (2002) with Bearing and Distance Extension 1.1. Vegetation, soil, and burn status were determined by joining random point locations with data layers using Arcview 3.2 (2002) Geoprocessing Extension. Analysis of selection for soil type was conducted on 2 levels. Soil categories were grouped by series (e.g., Warden or Sagehill soils) and texture (e.g., silt, sand, clay) within each series. Less common soils were grouped into a miscellaneous category (Dixon and Massey 1969).

Slope and aspect were determined with consideration for the scale of biological relevance and error associated with GPS location estimation. The appropriate scale was determined by estimating average natal home range sizes for all squirrels for which ≥3 locations were recorded (Erickson et al. 1998). The minimum convex polygon estimate of home range size ranged from 0.0032 to 14.1 ha. The median was estimated to be 0.375 ha ($\bar{x}$ = 1.12, 95% CI = 0.75 to 1.50, $n$ = 122). To allow for estimation error in the GIS, I converted post-dispersal and random points to 10 x 10 m pixels. To address resource availability on a biologically relevant scale, I calculated neighborhood averages of 30 x 30 m pixels within the DEM. The slope and aspect of the pixels representing each point location was calculated from the 30 m DEM pixel that overlapped the majority of the 10 m pixel area. Resource selection was therefore assessed on an area equal to approximately 25% of the median natal home range area.

R*esource selection.*--Habitat characteristics of settlement locations were compared with characteristics of random (available) locations distributed according to the half-normal model. Comparisons were made for each site individually and for all sites combined. Evidence of selection for categorical resource types, including vegetation, soils, and burned areas was identified by comparing proportions of post-dispersal locations in each resource type to the estimated proportion available. Selection ratios ($\hat{w}$) were calculated, and selection for a resource was indicated when Pearson's Chi-squared statistic ($X_P^2$) was significantly large (Marcum and Loftsgaarden 1980). Simultaneous CIs were calculated for categories that showed evidence of selection and were corrected with Bonferroni adjustments for family-wise comparisons (Neu et al. 1974, Byers et al.

1984). Confidence intervals incorporated error from estimation of habitat availability as well as error from resource selection estimation (Manly et al. 2002).

Indication of selection for resources that were measured on a continuous scale, including distance to roads, distance to historically-occupied squirrel locations, and slope, was determined by comparing 95% CIs of settlement points with those of random points. Selection for aspect was tested by comparing the distribution of aspects of settlement locations with that of random locations using a Kuiper's test (Batschelet 1981).

**RESULTS**

Sixty-seven juvenile male Washington ground squirrels dispersed from 3 sites on Boardman during this study. Thirty-two dispersed in 2002; 15 at Tub Spring, 9 at Mystery Road, and 8 at Cemetery. Eighty-seven, 89 and 100% of dispersers from each respective natal site were successful in locating a settlement site. Thirty-five dispersed in 2003; 17 at Tub Spring, 8 at Mystery Road, and 10 at Cemetery; 65, 75, and 70% settled successfully. There were a total of 53 successful dispersers (Figure 3.2).

*Resource availability model.*--Random points representing available habitat were distributed at distances away from the natal site that were generated from the top model. The top model was a half-normal model in the form: $g(y) = \exp(-y^2/2\sigma^2)$, where the dispersal distance ($y$) was $0 \leq y < 3700$ m, and standard error ($\hat{\sigma}$) was 1109.4 m (Table 3.2) (Figure 3.3). Evidence of non-random direction of dispersal was detected at Cemetery ($K_n = 2.634 > K_p = 1.65$, $P < 0.005$, $n = 15$) but not at Mystery Road ($K_n = 1.164 < K_p = 1.645$, $P > 0.2$, $n = 14$) or Tub Spring ($K_n = 1.497 < K_p = 1.672$, $0.1 < P$

<0.2, $n = 24$). Analysis of resource selection on each site was therefore conducted using points assigned in random directions from the natal site at Tub Spring and Mystery Road. Points were assigned to the directions of successful dispersal at Cemetery (Figure 3.4).

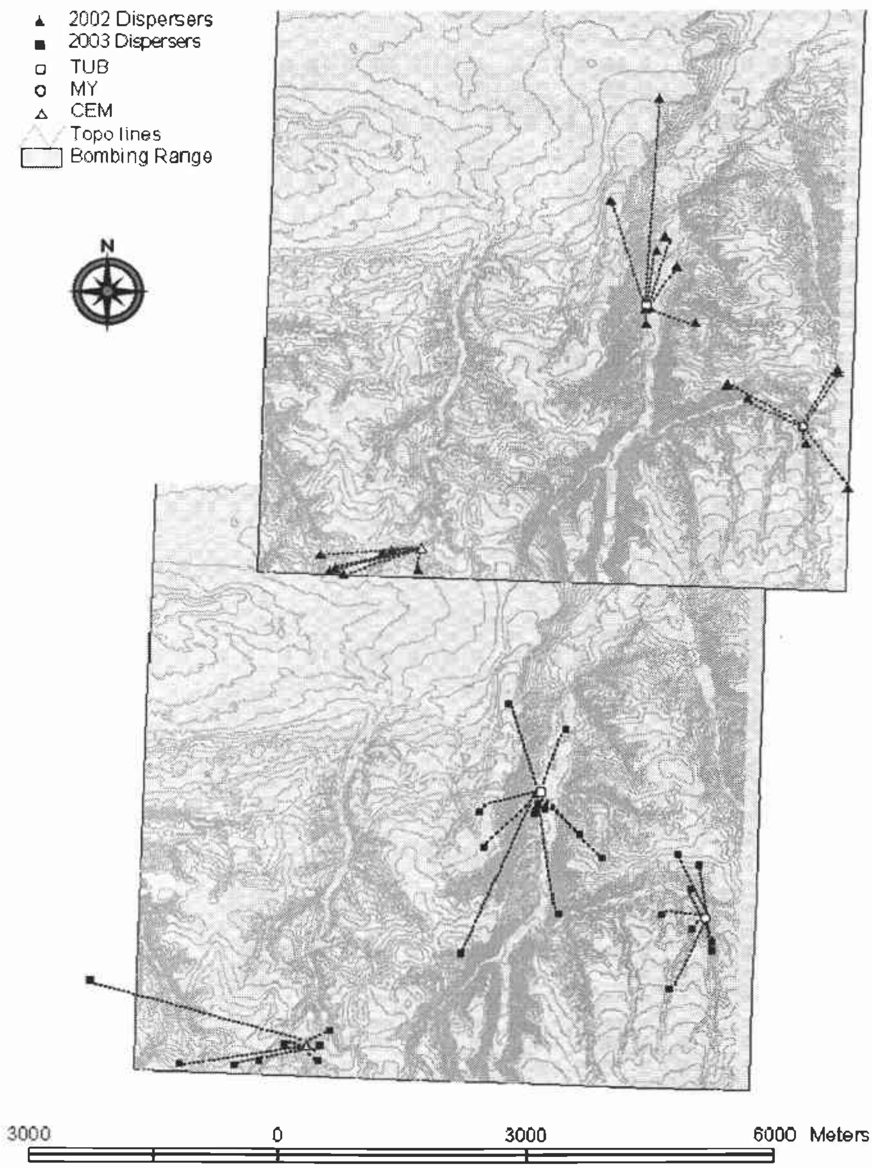


Figure 3.2. Directions of dispersal by juvenile male Washington ground squirrels on the southern end of Boardman Naval Weapons Systems Training Facility in 2002 (top) and 2003 (bottom). Lines depict distance and general direction of travel.

Table 3.2. Dispersal distances were modeled using program DISTANCE. Each model represents the best model of a model set. Selection within model sets was conducted with $X^2$ goodness of fit tests. The p-value of the $X^2$ GOF test for each top model is shown. Selection among model sets was conducted using AIC values.

| Key Model | Series adjustment [a] | # Model params | AIC | Delta AIC | GOF Chi-p [b] |
|---|---|---|---|---|---|
| Halfnormal | none | 1 | 186.34 | 0 | 0.47 |
| Uniform | none | 1 | 187.22 | 0.88 | 0.41 |
| Negative exponential | none | 1 | 187.67 | 1.33 | 0.27 |
| Uniform | simple polynomial | 3 | 187.98 | 1.64 | 0.12 |
| Halfnormal | simple polynomial | 3 | 189.28 | 2.94 | 0.22 |
| Halfnormal | hermite polynomial | 3 | 189.38 | 3.04 | 0.22 |
| Negative exponential | simple polynomial | 3 | 189.38 | 3.04 | 0.24 |
| Negative exponential | cosine | 3 | 189.63 | 3.29 | 0.28 |
| Uniform | hermite polynomial | 3 | 189.96 | 3.62 | 0.24 |
| Halfnormal | cosine | 3 | 190.12 | 3.78 | 0.25 |
| Negative exponential | hermite polynomial | 3 | 190.84 | 4.5 | 0.20 |
| Uniform | simple polynomial | 1 | 194.57 | 8.23 | 0.07 |
| Uniform | simple polynomial | 1 | 195.31 | 8.97 | 0.06 |

[a] Series adjustment = form of curvelinear adjustment to the key model.
[b] GOF Chi-p = Goodness of Fit Chi-squared test probability

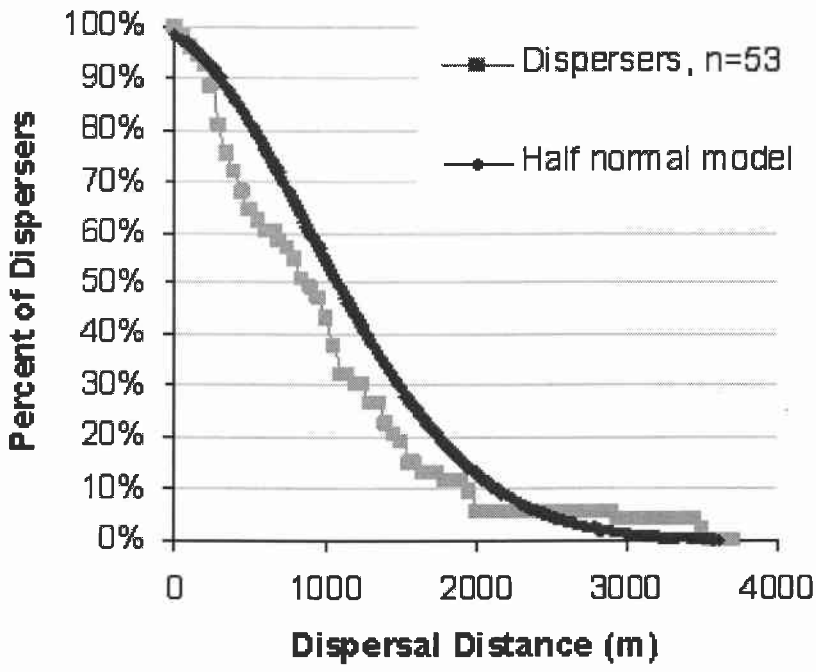


Figure 3.3. Cumulative histogram of the half-normal model and the observed dispersal distances of Washington ground squirrels. The percent of dispersers (grey) that traveled ≥ the distance on the x-axis is contrasted with the half-normal model of the distribution of distances (black). The model was estimated using program DISTANCE.

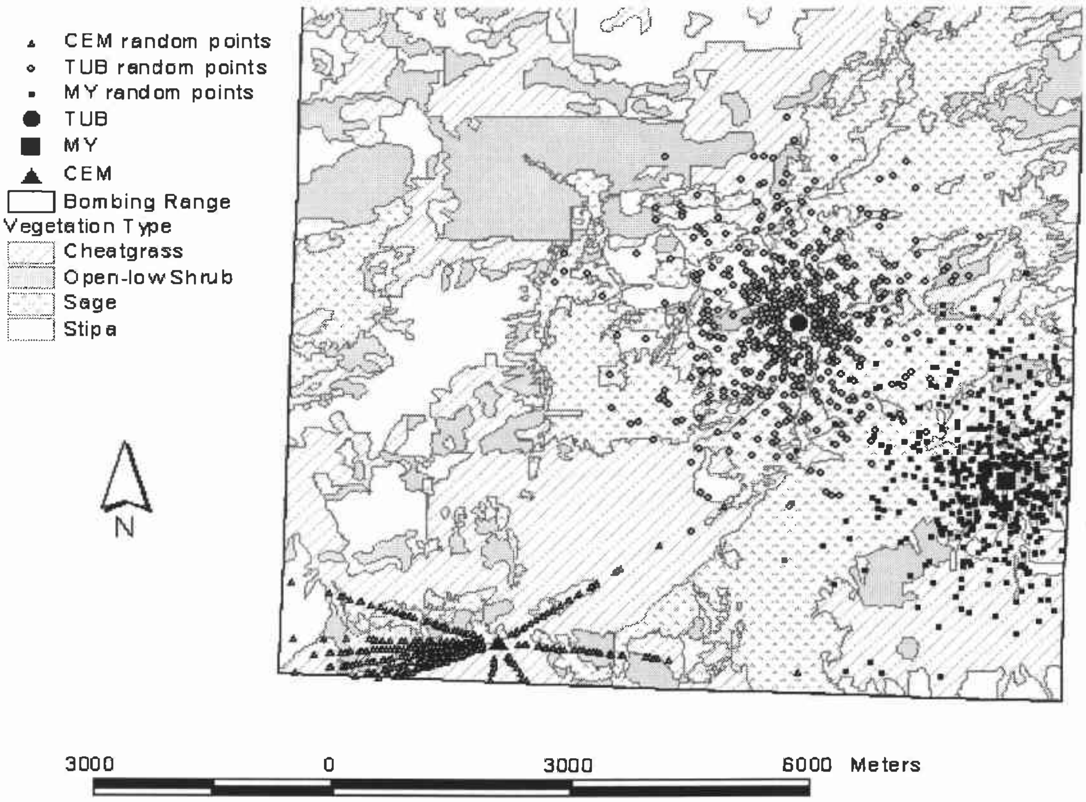


Figure 3.4. Random points distributed according to a model of observed dispersal distances. The model was used to predict resources available to dispersing *Spermophilus washingtoni*. Points were distributed in the direction of travel by successful dispersers when evidence of non-random directional travel was detected. Vegetation classes are also shown.

*Resource selection.*-- Environmental resources were characterized on post-dispersal settlement locations of 52 successful dispersers; 24 from Tub Spring and 14 each from Mystery Road and Cemetery. Four of 5 vegetation cover classes (Table 3.1) were available to dispersers. I estimated that 8.4% of available vegetation on all sites was dominated by low shrubs, 41.2% by sagebrush, 42.5% by annual grass, and 7.8% by perennial bunch grass. Forty-two percent of settlement sites were located in sagebrush, 58% in annual grass, and 0% in other communities. There was evidence of selection for vegetation classes on all sites combined, Tub Spring, and Mystery Road, but not at Cemetery (Table 3.3). Successful dispersers from all sites combined, Tub Spring, and Mystery Road disproportionately settled on fewer sites dominated by low shrub and bunchgrass than sagebrush and annual grass. Dispersers from Mystery Road settled on more annual grass sites than expected.

Locations of post-dispersal settlement on and off of areas burned in 1996 were distributed in proportion to their estimated availability. Burned areas comprised 56% of available habitat, and 60% of dispersers settled on them. There was no evidence to suggest selection for or against previously burned habitat on any site or on all sites combined (all: $X^2 = 0.228$, df = 1, $P = 0.633$; Tub Spring: $X^2 = 0.148$, df = 1, $P = 0.7$; Mystery Road: $X^2 = 0.587$, df = 1, $P = 0.444$; Cemetery: $X^2 = 1.345$, df = 1, $P = 0.246$).

There was insufficient evidence to suggest that selection of soil series by dispersers was occurring on all sites combined or individually, regardless of the scale of classification (Appendix G). When all sites were considered together, 87, 4, 4, and 6% of disperses settled in Warden, Sagehill, Royal, and all other soil series, which constituted 89, 7, 2, and 3% of available locations, respectively. When soil textures on each site were considered, evidence of selection by dispersers from Tub Spring was detected ($X^2 = 19.76$, df = 5, $P = 0.001$). Squirrels exhibited selection for Warden silt loams; 71% of dispersers settled on soil with this texture which comprised 47% of available soils ($\hat{w} = 1.52$, 95% CI = 1.01 to 2.02). Squirrels also selected against Warden sandy loams. This soil texture comprised 27% of the available habitat, and only 4% of dispersers settled

Table 3.3. Results of $X^2$ testing for selection of resource characteristics by Washington ground squirrels. Selection for the resource variable is occurring if LCL > 1.0, and against the variable if UCL < 1.0.

| Site | $X^2$ | df | $P$ | Resource Variable | $\hat{w}$ [a] | 95% CI LCL [b] | 95% CI UCL [c] |
|---|---|---|---|---|---|---|---|
| All combined | 19.06 | 3 | 0.0003 | low shrub | 0.0002 | 0 | 0.016 |
| | | | | sagebrush | 1.026 | 0.647 | 1.406 |
| | | | | annual grass | 1.357 | 0.985 | 1.73 |
| | | | | bunch grass | 0.0002 | 0 | 0.018 |
| Tub Spring | 9.336 | 3 | 0.025 | low shrub | 0.001 | 0 | 0.102 |
| | | | | sagebrush | 0.85 | 0.516 | 1.184 |
| | | | | annual grass | 2.043 | 0.867 | 3.22 |
| | | | | bunch grass | 0.001 | 0 | 0.037 |
| Mystery Road | 8.613 | 3 | 0.025 | low shrub | 0.001 | 0 | 0.053 |
| | | | | sagebrush | 0.619 | 0 | 1.334 |
| | | | | annual grass | 1.702 | 1.138 | 2.266 |
| | | | | bunchgrass | 0.001 | 0 | 0.054 |
| Cemetery | 4.129 | 3 | 0.248 | low shrub | 0.001 | -0.053 | 0.054 |
| | | | | sagebrush | 1.477 | 0.260 | 2.693 |
| | | | | annual grass | 1.018 | 0.557 | 1.480 |
| | | | | bunchgrass | 0.002 | -0.152 | 0.157 |

[a] $\hat{w}$ = selection ratio
[b] LCL = lower confidence limit for the estimated selection ratio
[c] UCL = upper confidences limit for the estimated selection ratio

on it ($\hat{w}$= 0.15, 95% CI = 0 to 0.51). A similar pattern was detected on Mystery Road, but there was insufficient evidence to suggest that selection was occurring ($X^2$ = 2.53, df = 3, $P$ = 0.47). Warden silt loams and sandy loams on this site comprised 86 and 7% of available habitat, respectively, and 93 and 0% of dispersers settled on it.

Dispersers from all sites combined did not select settlement locations that had a different mean slope ($\bar{x}$ = 12.0°, 95% CI = 9.42 to 14.7°) than was available on the landscape ($\bar{x}$ = 11.1°, 95% CI = 10.6 to 11.5°). There was inadequate evidence to suggest that selection for a particular slope was occurring on any individual site (Figure 3.5) There was inadequate evidence to suggest disproportionate selection of dispersal location by aspect for all sites combined ($K_n = 1.154 < K_p = 1.697$, $P > 0.2$, $n = 52$). On all sites combined, 28.8% dispersed to locations with a northeast (NE) aspect, 28.8% to sites with a southeast (SE) aspect, 26.9% to sites with a southwest (SW) aspect, and 15.4% to locations with a northwest (NW) aspect. Post-dispersal locations for animals from Tub Spring were not located on sites with a particular aspect ($K_n = 0.853 < K_p = 1.672$, $P > 0.2$, $n = 24$). Neither were locations selected by squirrels from Mystery Road ($K_n = 0.986 < K_p = 1.645$, $P > 0.2$, $n = 14$) and Cemetery ($K_n = 1.18 < K_p = 1.645$, $P > 0.15$, $n = 14$). On Tub Spring, 33.3, 29.2, 16.7, and 20.8% of squirrels dispersed to locations that had NE, SE, SW, and NW aspects, respectively. At Mystery Road, 14.3, 21.4, 35.7, and 28.6% of squirrels dispersed to locations with NE, SE, SW, and NW aspects,

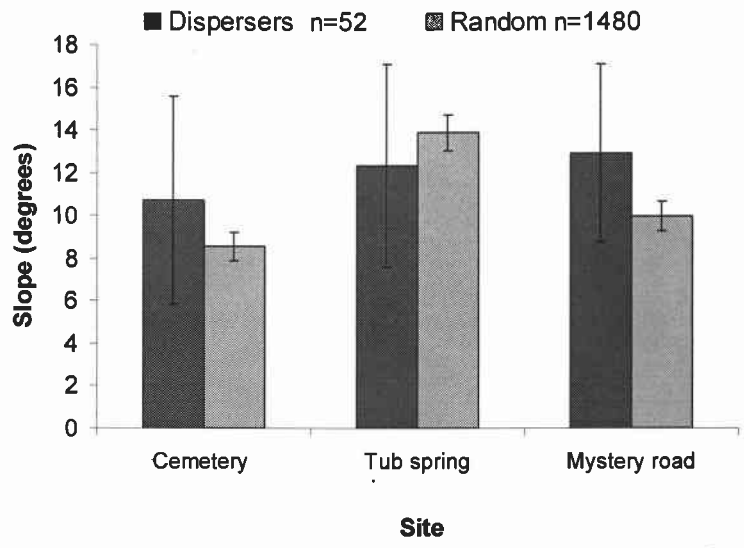


Figure 3.5. Comparison of mean slope of settlement locations of Washington ground squirrels versus random sites on Boardman Naval Weapons Systems Training Facility. Error bars represent the 95% CI for the mean on each site.

respectively. On Cemetery, 7.1, 57.1, 7.1, and 28.6% of squirrels dispersed to locations with NE, SE, SW and NW aspects, respectively. Available locations on all sites were distributed approximately uniformly among 5° aspect classes.

Evidence for selection of settlement locations close to historically-occupied squirrel sites was detected among all sites combined, but not at all individual sites. The mean distance for all settlement locations to the nearest squirrel site was 211.94 m (95% CI = 170.3 to 253.6 m), whereas the distance from random points to the nearest squirrel site was 302.1 m (95% CI = 293.8 to 310.3 m). Squirrels at Tub Spring showed selection for sites that averaged 158.7 m closer to historically-occupied sites than expected if selection was not occurring. The mean distance for dispersers was 167.0 m (95% CI = 109.2 to 224.7 m), whereas the mean was 325.7 m (95% CI = 309.9 to 341.6 m) for randomly selected available locations. Squirrels at the other sites did not disperse significantly closer to historic squirrel sites than expected. Mean distances for settlement locations for squirrels from Mystery Road and Cemetery were 265.4 m (95% CI = 167.7 to 363.1 m) and 235.5 m (95% CI = 156.8 to 314.3 m), respectively. Mean distances from random locations at Mystery Road and Cemetery were 297.3 m (95% CI = 283.4 to 311.3 m) and 247.2 m (95% CI = 235.8 to 258.5 m), respectively. Of 52 post-dispersal settlement locations, 85% were located nearer to an occupied site than a vacant one. The mean distance from settlement locations to the nearest occupied site ($\bar{x}$ = 277.2 m, 95% CI = 209.4 to 344.9) was significantly shorter than the mean distance to the nearest vacant site ($\bar{x}$ = 657.3 m, 95% CI = 512.9 to 801.7).

Mean distance to the nearest road for post-dispersal locations on all sites was 153.1 m (95% CI = 101.7 to 204.5 m). The mean for random points was 324.9 m from the nearest road (95% CI = 311.2 to 338.5 m). Non-overlapping CIs indicated that dispersers selected locations that were on average 171.7 m closer to roads than were random locations. Evidence of selection of settlement location by distance to nearest road was also detected on individual sites. Squirrels at Tub Spring showed evidence of selection of settlement locations averaging 119.7 m closer to roads than expected. The average distance to the nearest road of settlement locations was 131.1 m (95% CI = 76.4 to 185.7), while random points averaged 289.5 m (95% CI = 266.2 to 312.9) from the nearest road. Settlement locations on Mystery Road also were closer to the nearest road than expected. Settlement locations averaged 128.9 m from the nearest road (95% CI from 4.5 to 253.3 m), whereas the average random location was 279.3 m from the nearest road (95% CI from 258.4 to 300.2 m). Dispersers from Cemetery did not show selection for settlement locations closer to roads than expected. The mean distance for settlement locations was 215.2 (95% CI = 83.2 to347.2 m), while that for random locations was 238.6 m (95% CI = 221.2 to 255.3 m).

Eleven dispersers were known to have come in contact with cultivated lands outside of Boardman; 4 returned to Boardman to establish post-dispersal home ranges, 4 settled outside the bombing range, 2 were lost, and 1 died before settlement. Of the 4 that settled beyond the periphery of the bombing range, 2 settled on land in the Conservation Reserve Program dominated by crested wheat grass (*Agropyron cristatum*) and 2 in a county road right of way. No animals were known to settle in agricultural areas, but 2 animals were last located adjacent to agriculture and could not be located thereafter.

## DISCUSSION

### Resource Selection

Vegetation type was important for selection of settlement location by dispersing ground squirrels. All post-dispersal settlement sites were located in annual grass or sagebrush vegetation rather than in low-shrub or perennial grass dominated areas. Burned areas comprised 56% of available habitat, and 60% of dispersers settled on them. Contrary to my hypotheses, squirrels did not select areas dominated by sage or perennial grass and did not avoid areas that had recently burned. Care should be taken in interpreting these results because low shrubs and perennial grasses comprised only 16.2% of available habitat, so dispersers may not have encountered these vegetative types.

Wildfire in the low-elevation sagebrush steppe of the Columbia River Basin reduces sagebrush and increases non-native annual grasses (Rickard et al. 1975). In years of adequate precipitation (such as 2002 and 2003), nitrogen released from burned vegetation can increase growth of annual grasses (Young et al. 1976, Melgoza and Nowak 1991). I observed *S. washingtoni* eating the leaves and seeds of cheatgrass, and using these plants for nesting material, suggesting that they provide short-term benefits to dispersers. In the long term, invasion of annual grasses can reduce diversity of plant species and stability of food biomass, leaving squirrel populations susceptible to high-amplitude fluctuations (Yensen et al. 1992, Sherman and Runge 2002). Vegetation change due to fire in sagebrush steppe has been associated with decreased abundance of Piute ground squirrels (*S. mollis)* (Yensen et al. 1992, Van Horne et al. 1997). Use of invasive plant species by Northern Idaho ground squirrels (*S. brunneus*) has been associated with a population decline due to inadequate long-term nutrition (Sherman and Runge 2002). Selection for annual grass dominated settlement locations by *S. washingtoni* may lead to a similar evolutionary trap.

Squirrels on 1 site exhibited selection for soil texture. Squirrels at Tub Spring selected silt loams and avoided sandy loams. Soil texture is likely important to semi-fossorial mammals for the construction and maintenance of burrows. Pygmy rabbits (*Brachylagus idahoensis*) and American badgers (*Taxidea taxus*) selected soils with sandy or silt-loam textures and avoided rocky soils (Heady et al. 2001, Apps et al. 2002). Washington ground squirrel populations have previously been associated with Warden and Sagehill soil series (Betts 1990, Greene 1999), but squirrels in this study did not exhibit selection for soil series. Warden soils comprised 89% of the available habitat, so this limited my ability to assess the importance of soil heterogeneity on selection of settlement sites. Because of the apparent importance of soil texture, further research on the effects of heterogeneity of soil type on *S. washingtoni* populations is warranted.

The results of this study suggested that dispersal patterns of juvenile male Washington ground squirrels were influenced by the distribution of historically-occupied squirrel sites. Dispersers from Tub Spring selected settlement locations that were significantly closer to historically-occupied squirrel sites than were random sites. On Cemetery and Mystery Road, settlement locations were also closer to historic sites than were random sites, but selection was not indicated. My initial hypothesis that squirrels would select settlement sites closer to historically-occupied sites was supported, but the cause of the attraction was not immediately clear. Availability of vacant burrows and proximity to conspecifics are both likely to influence settlement. Dispersers settled nearer to occupied sites than to vacant sites, suggesting that proximity to conspecifics was more influential on settlement location than proximity to vacant burrows. Conspecifics have been shown to attract dispersers among other *Spermophilus* spp. (Murie and Harris 1984, Weddell 1991). Conspecific attraction can reduce vulnerability to predation (Smith 1986) and improve reproductive success of dispersers (Stamps 1991). Conspecifics may also provide cues about local habitat quality which can be used by dispersers to reduce settlement costs (Danchin et al. 2001, Stamps 2001). Social attraction however, is not universal among ground squirrels, nor is it necessarily beneficial. Wiggett and Boag (1993*a*) found that dispersing Columbian ground squirrels (*S. columbianus)* that settled in unoccupied habitat had higher indications of reproductive success than those that settled in occupied areas. Aggression and territoriality have been shown to discourage settlement by round-tailed ground squirrels (*S. teretecaudus)* (Drabek 1970, Dunford 1977).

Slope and aspect did not appear to influence selection of post-dispersal settlement location. My hypothesis that squirrels would exhibit selection for moderate slopes and northeast aspects due to accumulation of windblown soil was not supported. Squirrels may not favor a particular slope or aspect because doing so might preempt selection of another resource, such as vegetation type, that has more direct fitness consequences. Various ground dwelling mammals have been shown to select slope or aspect when it is associated with food availability or suitable burrow sites (Heady et al. 2001, Catling et al. 2002, Apps et al. 2002), but rarely is slope or aspect directly selected for. Topography however, may have influenced dispersal routes in this study. Topographic features, including game trails and banks along drainages, have been shown to influence dispersal routes of *S. columbianus* (Wiggett et al. 1989). On Boardman, the Cemetery site was located in a slight draw that drained toward the SW, whereas topography surrounding the other sites was more variable. Squirrels from this site dispersed predominately toward the SW, but no evidence of non-random directionality was exhibited by dispersers from other sites. Squirrels from Cemetery did not show selection for vegetation type, soil type or texture, distance to roads, or distance to conspecifics. It is possible that topography along dispersal routes on this site had more influence on dispersal patterns than selection for environmental resources.

**Barriers**

Primitive roads did not appear to be act as barriers to dispersal for Washington ground squirrels. Thirty-three of 52 animals crossed gravel, dirt, or 2-track roads between their natal and post-dispersal locations. Roads have been shown to alter community composition (Adams and Geis 2003) and reduce movement between habitat patches for some species of small mammals (Merriam et al. 1989), leading me to predict that roads would act as barriers. This hypothesis was not supported. Dispersers exhibited selection for sites significantly closer to primitive roads than expected, and they were observed traveling on dirt roads and occupying burrows in roadside banks. The primitive, rarely traveled roads on Boardman may have acted as corridors for dispersal. Range extensions of pocket gophers (*Thomomys talpoides*) and meadow voles (*M. pennsylvanicus*) have been linked to the corridor effect of roads (Huey 1941, Getz et al. 1978). However, selection of post-dispersal settlement sites is an incomplete indicator of the effect of roads on dispersal patterns. Washington ground squirrels are capable of long-distance dispersal through unfamiliar habitat and are expected to refine their post-dispersal home range based on resources available after the initial settlement period. Post-dispersal locations averaged 153.1 m (95% CI = 101.7 to 204.5 m) to the nearest road, but the mean distance of historically-occupied sites to the nearest road was 254.3 m (95% CI = 219 to 289.7 m). This suggests that squirrels may move away from roads during establishment of post-dispersal home ranges. Additionally, the sizes of roads were not considered in this study. Larger, more frequently traveled roads may have a different effect on dispersal patterns than primitive roads.

Carlson et al. (1980) observed that dry-land wheat fields were an effective barrier to movements of *S. washingtoni*. My results do not confirm or disprove this observation. The unknown fates of 2 lost animals make it impossible to know if land in agriculture serves as an absolute barrier to dispersal. My observations do suggest that squirrels altered their dispersal patterns in response to agriculture, either by avoiding it or settling adjacent to it. Likewise, Morgan and Nugent (1999) observed individual squirrels occupying the periphery of an abandoned wheat field.

**Resource Selection Techniques**

In this study, I found that resource selection influenced dispersal patterns of male Washington ground squirrels. Selection for settlement site based on vegetation type, soil texture, and distance to historically-occupied sites was detected. While the importance of environmental features during dispersal has not often been assessed among terrestrial mammals, researchers have determined that selection for environmental resources influenced dispersal patterns of several avian species (Ferrer and Harte 1997) (Takagi 2003). A wider application of this approach would help to determine the importance of habitat selection during dispersal across taxa. However, dispersal patterns may not be wholly determined by available resources. Haughland and Larsen (2004) found that dispersal patterns among juvenile red squirrels (*Tamiasciurus hudsonidus)* reflected individual experience and opportunity rather than resource selection. Habitat selection decisions made by several species of mammals and birds may be influenced more by density or reproductive success of conspecifics than by quality or availability of environmental resources (Larsen and Boutin 1994, Doligez et al. 1999, Forero et al. 2002). Among *S. washingtoni*, selection for environmental resources was important in determining dispersal patterns, but additional factors should be considered in future research.

I employed use versus availability as a metric to determine when resource selection occurred. This approach has been used by other researchers (e.g., Erickson et al. 1998, Kazmaier et al. 2001, Johnson et al. 2000) and can be problematic if use or availability is defined on an inappropriate scale (Johnson 1980, Porter and Church 1987), or if past experience or conspecific encounters dictate availability (Van Horne 1983). The individual-based habitat availability model developed for this study allowed analysis to be conducted on a temporal and spatial scale that was relevant to dispersers. This approach also allowed me to incorporate the effects of long-distance dispersal, which may have different impacts on the demography and distribution of the population than local dispersal (Caswell et al. 2003). However, resource selection by an animal is a hierarchical process that employs multiple scales (Johnson 1980) and ideally, analyses should also be conducted on several scales (Erickson et al. 2001, Garshelis 2000).

The results of this study provide a basis from which to refine predictions about dispersal patterns of *S. Washingtoni*. The next step could be to test the predictive value of these results and determine the potential for wider applicability and inference. A multivariate analysis of habitat selection could yield insight on environmental characteristics that are not individually selected for, but are important in an ecological context. Additionally, an assessment of the fitness consequences of resource selection during dispersal is needed. Several researchers have found that habitat selection by dispersers improves fitness. Juvenile spotted owls (*Strix occidentalis caurina*) that settled in preferred habitat had higher survival rates than those that settled in less preferred habitat (Miller et al. 1997). Prairie voles (*Microtus ochrogaster*) that exhibited selection for high quality habitat experienced increased reproductive success (Lin and Batzli 2004). However, resource selection does not always yield fitness benefits (Wiens et al. 1986). An assessment of the fitness consequences of dispersal, together with an understanding of when and how habitat characteristics and barriers influence dispersal patterns could be used to conserve and manage fragmented populations of Washington ground squirrels.

# CHAPTER 4

## SUMMARY AND CONCLUSIONS

The research included in this thesis was motivated by a need to better understand dispersal patters of Washington ground squirrels and the influence that habitat features have on dispersal. Available habitat for the Washington ground squirrel has declined by an estimated 69% since historic times (Wisdom et al. 2000), and the negative population trends that have occurred are not likely to be reversed under current management (Raphael et al. 2001). Quality of remaining low-elevation sagebrush steppe habitat has changed over time; invasive weeds have become more prevalent and fire intervals have increased in many areas. However, little is known about the potential impacts of natural and human-induced landscape changes. Ongoing research and monitoring efforts help to identify effective ways to enhance and protect ground squirrels and their habitat while considering human needs.

Hereafter, each of the bulleted objectives of this study is followed by a summary of the results and conclusions from this study:

- Estimate dispersal rates and variability among sites and years.

The natal dispersal rates of males in this study suggested that dispersal is important in the ecology of Washington ground squirrels. Approximately 72% of juvenile male Washington ground squirrels on Boardman dispersed from 3 sites in 2002 and 2003. The relatively low degree of variability detected in dispersal rates among sites and between years indicated that there likely is an innate tendency to disperse. Variability in dispersal rates among sites was negatively correlated with density, suggesting that this behavior was somewhat influenced by population demography.

- Determine timing and distances of dispersal events.

Dispersal primarily occurred in mid- to late-April and appeared to be influenced by differences in weather conditions between years. Dispersal took place an average of 8 days earlier in 2003 than in 2002 and was associated with above-average early season rainfall and temperatures. Environmental conditions varied among areas occupied by Washington ground squirrels, so it is possible that distance and timing of dispersal by squirrels on Boardman differed from those of squirrels in other areas.

Dispersal distances ranged from 40-3521 m with a median of 880 m and mean of 991 m (standard error [SE] = 90.33 m). Frequency distributions of distances were fairly similar among sites and between years. Several factors were shown to influence selection of settlement location and may have therefore influenced the distances traveled by individuals. Dispersers exhibited selection for post-dispersal sites in the vicinity of conspecifics. They selected against several vegetation types, including low shrub and bunchgrass-dominated areas. Squirrels from Tub Spring exhibited selection for silt-loam soil texture. Environmental heterogeneity therefore influenced dispersal distances.

- Describe population density and structure among several sites.

Three sites on Boardman were selected for trapping in 2002 and 4 in 2003. These sites were selected because they had high densities which ranged from 11-82 squirrels per hectare in April of 2002 and 20-90 per hectare in April of 2003. The capture rates of squirrels on all sites were influenced by individual heterogeneity and differed among capture occasions (time), but did not differ substantially between males and females or adults and juveniles. The population was slightly female-biased on all sites except Mystery Road, which was consistently male-biased. The average ratio of juveniles to adults in April of both years was 4:1. A negative correlation was detected between dispersal rate and density. No significant correlation was detected between dispersal rate and sex or age ratios.

- Compare survival rates and causes of mortality of dispersers with non-dispersers.

Survival rates of dispersers were higher than that of non-dispersers. The overall probability of survival to hibernation was 0.41 (SE = 0.063) for dispersers and 0.26 (SE = 0.087) for non-dispersers. Timing of maximum mortality occurred in late-May for dispersers, which corresponded to the post-dispersal settlement period. Philopatric squirrels experienced maximum mortality in mid-June. Philopatric squirrels were at higher risk of predation by badgers, whereas dispersers were at higher risk of predation by raptors, suggesting that a trade-off existed between risks associated with dispersal versus philopatry. These results add support for the emigrant fitness hypothesis presented by Anderson (1989) and suggest that dispersal may be an adaptive strategy in this species.

- Discern patterns in dispersal directions, selection of post-dispersal settlement habitats, and avoidance of dispersal barriers.

The dispersal patterns of Washington ground squirrels were influenced by habitat heterogeneity. Squirrels from Tub Spring exhibited selection for sites based on vegetation type, soil texture, distance to historic colonies, and distance to roads. Mystery Road squirrels selected settlement locations based on vegetation type and distance to roads. Those from Cemetery tended to disperse toward the southwest, whereas squirrels from other sites dispersed in random directions. In contrast to animals at other sites, squirrels from Cemetery did not select for vegetation type, soil series, distance to roads, or distance to conspecifics. It is possible that topography along dispersal routes at this site had more influence on dispersal patterns than selection for environmental resources.

No landscape features could be identified as absolute barriers to dispersal. Primitive roads did not limit dispersal, but agriculture may have altered dispersal patterns. Of 11 dispersing squirrels that traveled outside of Boardman and may have encountered cultivated areas, 4 settled nearby in a county road right of way or land in the Conservation Reserve Program, 4 returned to uncultivated areas within Boardman, 1 died, and 2 were lost and may have dispersed into agricultural fields. These results suggest that most squirrels altered their dispersal patterns in response to agriculture, either by avoiding it or settling adjacent to it.

## MANAGEMENT RECOMMENDATIONS

The high rates of dispersal and low survival rates of juvenile male *S. washingtoni* emphasize the importance of dispersal to the ecology of this species. Land owners and managers should consider the distances and timing of dispersal by Washington ground squirrels when evaluating the potential impacts of land use activities. Efforts to mediate the effects of habitat fragmentation would support the successful establishment of dispersers. In Oregon's Columbia River Basin, areas with intact sage-brush steppe and native grasses on Sagehill and Warden soils are the preferred habitat of this species (Greene 1999) and were used as settlement habitat by dispersing squirrels in this study. Protection of these habitats against invasion of non-native plants and recurrent fire would ensure that diverse drought-resistant food plants are available. Agricultural, urban, and suburban development has reduced the range of this species. Areas with occupied or historically-occupied colonies of Washington ground squirrels should be reserved from development wherever possible. This species, as well as many other that occupy sagebrush steppe habitats and semi-arid grasslands would benefit from the establishment and protection of additional conservation areas. Washington ground squirrels appear capable of utilizing recovered agricultural sites (Morgan and Nugent 1999) and habitat restoration may provide additional habitat for the species. Additional research on female and adult movement patterns is needed to better understand the influence of dispersal on population demography and to evaluate the potential for establishment of new breeding sites. Research on demographic variability, reproductive success, and genetic variability would also help to further define and prevent the causes of decline among *S. washingtoni* populations. Managers and landowners must continue to take an active role in raising awareness of the ecological importance of *S. washingtoni,* providing for the habitat needs of this species, and minimizing conservation-related conflict to ensure that the long-term outlook for this species is positive.

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# APPENDICES

**APPENDIX A.** Summary of numbers of Washington ground squirrels captured on Boardman Naval Weapons Systems Training Facility, Oregon. Squirrels were trapped on each of 3 sites (TUB, MY, and CEM) in 2002 and 2003, and at a fourth site (SP) in 2003. Numbers along the first diagonals represent newly captured individuals. This format is similar to that used by Brownie et al. (1985).

**2002**

| TUB | 4/2 | 4/3 | 4/10 | 4/15 | 4/16 | 4/17 | 6/6 | Total |
|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| R1 | 39 | 8 | 9 | 7 | 8 | 4 | 0 | |
| R2 | | 24 | 5 | 4 | 9 | 4 | 3 | |
| R3 | | | 32 | 6 | 8 | 4 | 3 | |
| R4 | | | | 25 | 3 | 1 | 0 | |
| R5 | | | | | 27 | 4 | 2 | |
| R6 | | | | | | 6 | 0 | |
| R7 | | | | | | | 5 | |
| | | | | | | | | 158 |

| MY | 4/8 | 4/9 | 4/10 | 4/11 | 4/18 | 4/19 | 4/23 | 4/24 | 5/8 | 6/5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| R1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| R2 | | 5 | 0 | 5 | 2 | 0 | 0 | 0 | 1 | 0 | |
| R3 | | | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| R4 | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| R5 | | | | | 5 | 4 | 3 | 1 | 1 | 0 | |
| R6 | | | | | | 10 | 3 | 4 | 3 | 1 | |
| R7 | | | | | | | 3 | 2 | 1 | 1 | |
| R8 | | | | | | | | 3 | 1 | 0 | |
| R9 | | | | | | | | | 6 | 0 | |
| R10 | | | | | | | | | | 1 | |
| | | | | | | | | | | | 37 |

| CEM | 4/11 | 4/17 | 4/18 | 4/23 | 4/24 | 4/25 | 5/7 | 6/11 | Total |
|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| R1 | 24 | 13 | 9 | 1 | 6 | 5 | 7 | 1 | |
| R2 | | 25 | 13 | 2 | 4 | 6 | 5 | 0 | |
| R3 | | | 12 | 2 | 1 | 2 | 0 | 0 | |
| R4 | | | | 2 | 0 | 0 | 1 | 0 | |
| R5 | | | | | 7 | 4 | 2 | 0 | |
| R6 | | | | | | 21 | 2 | 2 | |
| R7 | | | | | | | 7 | 0 | |
| R8 | | | | | | | | 1 | |
| | | | | | | | | | 99 |

j = Trapping event number.

Ri = Number of new animals captured during event j, followed by number of those animals recaptured during subsequent events.

Total = total number of all unique individuals captured on that site in that year.

**2003**

| TUB | 4/7 | 4/8 | 4/9 | 4/11 | 4/12 | 4/15 | 4/21 | 4/23 | 5/3 | 6/6 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| R1 | 37 | 1 | 7 | 12 | 6 | 7 | 4 | 3 | 5 | 0 | |
| R2 | | 24 | 2 | 3 | 5 | 3 | 3 | 4 | 4 | 0 | |
| R3 | | | 21 | 4 | 5 | 4 | 1 | 4 | 4 | 1 | |
| R4 | | | | 30 | 6 | 8 | 8 | 3 | 3 | 1 | |
| R5 | | | | | 23 | 0 | 2 | 1 | 2 | 0 | |
| R6 | | | | | | 11 | 0 | 0 | 2 | 1 | |
| R7 | | | | | | | 12 | 2 | 2 | 1 | |
| R8 | | | | | | | | 9 | 1 | 0 | |
| R9 | | | | | | | | | 3 | 0 | |
| R10 | | | | | | | | | | 0 | |
| | | | | | | | | | | | 170 |

| MY | 4/7 | 4/8 | 4/9 | 4/10 | 4/14 | 4/15 | 4/21 | 4/22 | 4/23 | 4/28 | 4/30 | 5/7 | 6/4 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| R1 | 7 | 1 | 1 | 2 | 3 | 2 | 0 | 1 | 2 | 0 | 1 | 1 | 0 | |
| R2 | | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| R3 | | | 8 | 0 | 2 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | |
| R4 | | | | 10 | 3 | 2 | 0 | 1 | 5 | 0 | 4 | 2 | 1 | |
| R5 | | | | | 7 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | |
| R6 | | | | | | 5 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | |
| R7 | | | | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| R8 | | | | | | | | 2 | 0 | 0 | 1 | 0 | 0 | |
| R9 | | | | | | | | | 2 | 0 | 0 | 1 | 0 | |
| R10 | | | | | | | | | | 0 | 0 | 0 | 0 | |
| R11 | | | | | | | | | | | 1 | 0 | 0 | |
| R12 | | | | | | | | | | | | 0 | 0 | |
| R13 | | | | | | | | | | | | | 0 | |
| | | | | | | | | | | | | | | 45 |

| CEM | 4/8 | 4/9 | 4/10 | 4/12 | 4/14 | 4/17 | 4/22 | 4/30 | 5/2 | 6/3 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| R1 | 4 | 1 | 2 | 3 | 1 | 1 | 0 | 0 | 1 | 0 | |
| R2 | | 44 | 7 | 11 | 5 | 7 | 8 | 2 | 7 | 0 | |
| R3 | | | 27 | 4 | 4 | 3 | 0 | 2 | 1 | 0 | |
| R4 | | | | 22 | 1 | 0 | 1 | 0 | 1 | 1 | |
| R5 | | | | | 18 | 1 | 3 | 3 | 1 | 1 | |
| R6 | | | | | | 2 | 0 | 0 | 0 | 0 | |
| R7 | | | | | | | 0 | 0 | 1 | 2 | |
| R8 | | | | | | | | 10 | 1 | 0 | |
| R9 | | | | | | | | | 10 | 5 | |
| R10 | | | | | | | | | | 0 | |
| | | | | | | | | | | | 137 |

| SP | 4/8 | 4/11 | 4/13 | 4/17 | 4/22 | 5/1 | 5/2 | 5/3 | 5/6 | 5/9 | 6/5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| j | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| R1 | 7 | 3 | 5 | 1 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | |
| R2 | | 15 | 8 | 1 | 1 | 3 | 2 | 2 | 0 | 0 | 0 | |
| R3 | | | 15 | 6 | 2 | 1 | 5 | 5 | 4 | 0 | 1 | |
| R4 | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| R5 | | | | | 5 | 0 | 0 | 0 | 1 | 0 | 0 | |
| R6 | | | | | | 8 | 2 | 2 | 1 | 0 | 0 | |
| R7 | | | | | | | 6 | 1 | 1 | 2 | 0 | |
| R8 | | | | | | | | 2 | 1 | 1 | 0 | |
| R9 | | | | | | | | | 2 | 1 | 0 | |
| R10 | | | | | | | | | | 0 | 0 | |
| | | | | | | | | | | | 0 | |
| | | | | | | | | | | | | 61 |

**APPENDIX B.** Simulations of model performance for selection of best abundance estimator in program CAPTURE.

Simulations were conducted to test robustness of models that estimate abundance and capture probability. Simulations were carried out in program CAPTURE. The following parameters were estimated from trapping data from April for each top model available in CAPTURE: population size (N-hat), capture probabilities across time (p-hat), the level of individual heterogeneity, and a measure of behavioral influence. The estimates were averaged to create plausible population parameters for each site.

Simulations were then conducted to test the ability of each model to reproduce the estimated population size under the observed conditions. Heterogeneity, behavioral, and time influences were altered up or down from the average estimate to determine model robustness to possible variations in the parameters.

Models were ranked according to their ability to estimate the averaged population size, the percent confidence interval coverage, the coefficient of variance, and the absolute value of the percent relative bias. Robust models yielded estimates with low % relative bias, low coefficient of variance, and high 95 % confidence interval coverage (Pollock and Otto 1983). The model chosen under the selection criteria in program CAPTURE (Otis et al. 1978) was rejected if another model was consistently more robust. The chosen model was then used to estimate N-hat and p-hat for each site.

The M(th) Chao estimator (Chao et al. 1992) was selected as the best model and was used to estimate capture probability and abundance. This estimator was among the best models for each site according to CAPTURE's model selection criteria (Otis et al. 1978). Simulations showed it to consistently be among the most robust models under various levels of heterogeneity, time, and behavioral effects particularly when the simulated population sizes were small.

APPENDIX B. Continued

## TUB 2002

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Structure: | | Structure: | | Structure: p-hat/class | | | | | 95% Conf. Int. | | | | | | |
| N[a] | Replications | Classes[b] | class size/p-hat[c] | Classes | p-hat | Classes | 1,2,3,4,5,6 | True Model[d] | Test Model[e] | Avg. N-hat[f] | SE | LCB | UCB | % CI coverage | CV[g] | % Rel. Bias[h] | Abs val % Rel. Bias | Rank Rel. Bias[i] |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Darroch | 217.40 | 36.99 | 5.88 | 216.25 | 218.54 | 45.60 | -13.04 | 13.04 | 7 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Jacknife | 278.20 | 28.27 | 9.84 | 275.73 | 280.68 | 69.80 | 11.28 | 11.28 | 5 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | M h Chao | 245.38 | 21.62 | 11.35 | 243.49 | 247.28 | 95.80 | -1.85 | 1.85 | 1 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | M t Chao | 227.85 | 17.81 | 12.79 | 226.29 | 229.41 | 83.40 | -8.86 | 8.86 | 4 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | M tb Burnham | 338.29 | 563.12 | 0.60 | 288.93 | 387.65 | 81.00 | 35.32 | 35.32 | 10 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | M th Chao | 239.54 | 20.90 | 11.46 | 237.71 | 241.38 | 93.20 | -4.18 | 4.18 | 2 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Mbh Pollack | 198.83 | 16.75 | 11.87 | 197.36 | 200.29 | 33.00 | -20.47 | 20.47 | 9 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Null | 220.28 | 13.41 | 16.43 | 219.11 | 221.46 | 54.00 | -11.89 | 11.89 | 6 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Removal | 202.32 | 36.99 | 5.47 | 199.08 | 205.57 | 41.40 | -19.07 | 19.07 | 8 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M th | Zippen | 228.63 | 30.71 | 7.44 | 225.94 | 231.32 | 83.00 | -8.55 | 8.55 | 3 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Darroch | 186.75 | 9.04 | 20.65 | 185.96 | 187.54 | 0.00 | -25.30 | 25.30 | 10 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Jacknife | 232.14 | 20.80 | 11.16 | 230.32 | 233.97 | 76.80 | -7.14 | 7.14 | 1 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | M h Chao | 209.63 | 15.32 | 13.68 | 208.29 | 210.98 | 43.40 | -16.15 | 16.15 | 5 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | M t Chao | 198.80 | 12.89 | 15.42 | 197.67 | 199.93 | 13.80 | -20.48 | 20.48 | 8 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | M tb Burnham | 228.47 | 108.64 | 2.10 | 218.95 | 237.99 | 79.20 | -8.61 | 8.61 | 3 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | M th Chao | 209.65 | 15.00 | 13.98 | 208.34 | 210.97 | 43.60 | -16.14 | 16.14 | 4 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Mbh Pollack | 198.83 | 16.75 | 11.87 | 197.36 | 200.29 | 33.00 | -20.47 | 20.47 | 7 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Null | 189.19 | 9.25 | 20.45 | 188.37 | 190.00 | 0.00 | -24.32 | 24.32 | 9 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Removal | 202.32 | 36.99 | 5.47 | 199.08 | 205.57 | 41.40 | -19.07 | 19.07 | 6 |
| 250 | 500 | 3 | 100 0.1, 75 0.2, 75 0.3 | 1 | 1.5 | 6 | 0.9, 0.75, 1.1, 1, 1.3, 0.5 | M tbh | Zippen | 228.63 | 30.71 | 7.44 | 225.94 | 231.32 | 83.00 | -8.55 | 8.55 | 2 |

[a] - True population size
[b] - Number of subdivisions of N, each of which are assigned a unique capture probability (p-hat)
[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.
[d] - True Model = the model suggested by the input parameters
[e] - Model being evaluated
[f] - Average population size estimated by the model
[g] - Coefficient of variance = Avgerage N-hat/SE
[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))
[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

APPENDIX B. Continued

## MY 2002

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | % 95 Conf. Int. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Structure: | | Structure: | | Structure: p-hat/class | | | | | | | | | | | |
| N[a] | Replications | Classes[b] | class size/p-hat[c] | Classes | p-hat | Classes | 1,2,3,4,5,6,7,8 | True Model[d] | Test Model[e] | Avg. N-hat[f] | SE | LCB | UCB | % CI coverage | Cv[g] | % Rel. Bias[h] | Abs val % Rel. Bias | Rank Rel. Bias[i] |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | Jacknife | 42.08 | 7.22 | 5.83 | 41.45 | 42.71 | 88.20 | 5.20 | 5.20 | 3 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | Zippen | 81.71 | 35.75 | 2.29 | 77.83 | 85.59 | 71.78 | 104.28 | 104.28 | 8 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | Removal | failed | | | | | | | | |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | Darroch | 35.12 | 2.65 | 13.25 | 34.89 | 35.35 | 55.80 | -12.20 | 12.20 | 6 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | M th Chao | 40.50 | 4.48 | 9.03 | 40.10 | 40.89 | 94.20 | 1.25 | 1.25 | 1 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | M tb Burnham | failed | | | | | | | | |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | M t Chao | 37.05 | 5.05 | 7.34 | 36.61 | 37.49 | 90.80 | -7.38 | 7.38 | 4 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | M h Chao | 41.15 | 6.60 | 6.24 | 40.57 | 41.72 | 92.80 | 2.88 | 2.88 | 2 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M th | Mbh Pollack | 47.64 | 10.37 | 4.59 | 46.73 | 48.55 | 59.20 | 19.10 | 19.10 | 7 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Null | 34.04 | 2.38 | 14.32 | 33.84 | 34.25 | 55.80 | -14.90 | 14.90 | 5 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Jacknife | 37.97 | 4.82 | 7.88 | 37.54 | 38.39 | 96.00 | -5.08 | 5.08 | 1 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Zippen | 81.71 | 35.75 | 2.29 | 77.83 | 85.59 | 71.78 | 104.28 | 104.28 | 8 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Removal | failed | | | | | | | | |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Darroch | 33.51 | 2.20 | 15.27 | 33.32 | 33.71 | 5.00 | -16.23 | 16.23 | 6 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | M th Chao | 37.57 | 3.39 | 11.09 | 37.27 | 37.87 | 94.20 | -6.08 | 6.08 | 3 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | M tb Burnham | failed | | | | | | | | |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | M t Chao | 36.10 | 3.47 | 10.40 | 35.80 | 36.40 | 79.00 | -9.75 | 9.75 | 4 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | M h Chao | 37.97 | 5.09 | 7.46 | 37.52 | 38.42 | 91.60 | -5.08 | 5.08 | 1 |
| 40 | 500 | 3 | 20 0.1, 10 0.2, 10 0.3 | 1 | 1.5 | 8 | 0.5, 1, 0.25, 1, 1.5, 3, 1.75, 2 | M tbh | Mbh Pollack | 47.64 | 10.37 | 4.59 | 46.73 | 48.55 | 59.20 | 19.10 | 19.10 | 7 |

[a] - True population size

[b] - Number of subdivisions of N , each of which are assigned a unique capture probability (p-hat)

[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.

[d] - True Model = the model suggested by the input parameters

[e] - Model being evaluated

[f] - Average population size estimated by the model

[g] - Coefficient of variance = Avgerage N-hat/SE

[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))

[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

# APPENDIX B. Continued

## CEM 2002

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | 95% Conf. Int. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Structure: | | Structure: | | Structure: p-hat/class | | | | | | | | | | | | |
| N[a] | Replications | Classes[b] | class size/p-hat[c] | Classes | p-hat | Classes | 1,2,3,4,5,6 | True Model[d] | Test Model[e] | Avg. N-hat[f] | SE | LCB | UCB | % CI coverage | Cv[g] | % Rel. Bias[h] | Abs val % Rel. Bias | Rank Rel. Bias[i] |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Null | 94.09 | 9.02 | 10.44 | 93.3 | 94.88 | 92.2 | -5.91 | 5.91 | 3 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Jacknife | 106.25 | 14.42 | 7.37 | 104.99 | 107.51 | 84.4 | 6.25 | 6.25 | 4 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Zippen | 86.46 | 13.31 | 6.50 | 85.29 | 87.62 | 73.8 | -13.54 | 13.54 | 6 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Removal | 84.72 | 13.77 | 6.15 | 83.51 | 85.92 | 56.6 | -15.28 | 15.28 | 9 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Darroch | 85.45 | 6.35 | 13.46 | 84.9 | 86.01 | 44.6 | -14.55 | 14.55 | 8 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M th Chao | 98.39 | 11.83 | 8.32 | 97.35 | 99.43 | 94.4 | -1.61 | 1.61 | 2 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M tb Burnham | failed | | | | | | | | |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M t Chao | 91.57 | 9.42 | 9.72 | 90.74 | 92.4 | 87 | -8.43 | 8.43 | 5 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M h Chao | 98.5 | 12.00 | 8.21 | 97.45 | 99.55 | 95 | -1.5 | 1.5 | 1 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | Mbh Pollack | 113.91 | 15.15 | 7.52 | 112.58 | 115.24 | 74.2 | 13.91 | 13.91 | 7 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Null | 78.27 | 5.05 | 15.51 | 77.83 | 78.71 | 2 | -21.73 | 21.73 | 9 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Jacknife | 93.94 | 11.40 | 8.24 | 92.94 | 94.94 | 83.8 | -6.06 | 6.06 | 1 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Zippen | 80.02 | 7.04 | 11.36 | 79.4 | 80.63 | 33.8 | -19.98 | 19.98 | 8 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Removal | 84.72 | 13.77 | 6.15 | 83.51 | 85.92 | 56.6 | -15.28 | 15.28 | 5 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Darroch | 76.79 | 4.80 | 16.00 | 76.37 | 77.21 | 0 | -23.21 | 23.21 | 10 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 88.72 | 8.33 | 10.65 | 87.99 | 89.45 | 81.4 | -11.28 | 11.28 | 2 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M tb Burnham | 84.17 | 20.93 | 4.02 | 82.34 | 86 | 65.26 | -15.83 | 15.83 | 6 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M t Chao | 83.51 | 7.23 | 11.55 | 82.87 | 84.14 | 54.4 | -16.49 | 16.49 | 7 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M h Chao | 88.2 | 9.20 | 9.59 | 87.39 | 89.01 | 78.4 | -11.8 | 11.8 | 3 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | Mbh Pollack | 113.91 | 15.15 | 7.52 | 112.58 | 115.24 | 74.2 | 13.91 | 13.91 | 4 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M th Chao | 98.39 | 11.83 | 8.32 | 97.35 | 99.43 | 94.4 | -1.61 | 1.61 | 2 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M th Chao | 90.25 | 6.32 | 0.06 | 89.7 | 90.81 | 80.2 | -9.75 | 9.75 | 8 |
| 100 | 500 | 3 | 50 0.1, 25 0.1, 25 .2 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M th Chao | 104.47 | 17.84 | 5.85 | 102.9 | 106.03 | 94.6 | 4.47 | 4.47 | 4 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M th | M th Chao | 100.83 | 9.43 | 10.70 | 100 | 101.65 | 93.6 | 0.83 | 0.83 | 1 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | | 1, 1.5, 1, 1.25, 0.75, 1 | M th | M th Chao | 97.24 | 13.16 | 7.39 | 96.09 | 98.4 | 93.4 | -2.76 | 2.76 | 3 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 88.72 | 8.33 | 10.65 | 87.99 | 89.45 | 81.4 | -11.28 | 11.28 | 10 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 86.41 | 5.52 | 15.64 | 85.92 | 86.89 | 50.2 | -13.59 | 13.59 | 12 |
| 100 | 500 | 3 | 50 0.1, 25 0.1, 25 .2 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 86.68 | 11.73 | 7.39 | 85.65 | 87.71 | 85.8 | -13.32 | 13.32 | 11 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.75 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 85.8 | 7.35 | 11.68 | 85.15 | 86.44 | 65.8 | -14.2 | 14.2 | 13 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 0.25 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 222.74 | 61.26 | 3.64 | 217.37 | 228.11 | 1 | 122.74 | 122.74 | 16 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M tbh | M th Chao | 93.82 | 6.90 | 13.60 | 93.21 | 94.42 | 89.2 | -6.18 | 6.18 | 5 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1, 1.5, 1, 1.25, 0.75, 1 | M tbh | M th Chao | 85.35 | 9.50 | 8.99 | 84.52 | 86.18 | 76.2 | -14.65 | 14.65 | 14 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1.75 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 85.18 | 5.29 | 16.11 | 84.72 | 85.65 | 39.6 | -14.82 | 14.82 | 15 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1.5 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M tbh | M th Chao | 90.77 | 5.32 | 17.05 | 90.31 | 91.24 | 72.8 | -9.23 | 9.23 | 7 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.75 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M tbh | M th Chao | 91.91 | 6.42 | 14.33 | 91.35 | 92.47 | 83.6 | -8.09 | 8.09 | 6 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1.75 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M tbh | M th Chao | 89.4 | 5.01 | 17.84 | 88.96 | 89.84 | 61.6 | -10.6 | 10.6 | 9 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M h Chao | 98.5 | 12.00 | 8.21 | 97.45 | 99.55 | 95 | -1.5 | 1.5 | 3 |
| 100 | 500 | 3 | 50 0.1, 25 0.5, 25 1 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M h Chao | 103.87 | 18.54 | 5.60 | 102.25 | 105.5 | 94.8 | 3.87 | 3.87 | 4 |
| 100 | 500 | 3 | 50 0.1, 25 0.1, 25 .2 | 1 | 1 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M th | M h Chao | 106.88 | 18.36 | 5.82 | 105.27 | 108.49 | 94 | 6.88 | 6.88 | 5 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1.5, 2, 1, 0.25, 1.75, 3 | M th | M h Chao | 99.51 | 9.87 | 10.09 | 98.65 | 100.38 | 94 | -0.49 | 0.49 | 1 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1 | 6 | 1, 1.5, 1, 1.25, 0.75, 1 | M th | M h Chao | 99.17 | 14.46 | 6.86 | 97.9 | 100.44 | 94.6 | -0.83 | 0.83 | 2 |
| 100 | 500 | 3 | 50 0.1, 25 0.2, 25 0.3 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M th Chao | 88.72 | 8.33 | 10.65 | 87.99 | 89.45 | 81.4 | -11.28 | 11.28 | 6 |
| 100 | 500 | 3 | 50 0.1, 25 0.1, 25 .2 | 1 | 1.5 | 6 | 1.5, 1.75, 1.5, 0.25, 0.75, 1.75 | M tbh | M h Chao | 87.06 | 11.75 | 7.41 | 86.03 | 88.09 | 85 | -12.94 | 12.94 | 7 |

APPENDIX B. Continued

## TUB 2003

| N[a] | Replications | Heterogeneity: Classes[b] | Heterogeneity Structure: class size/p-hat[c] | Behav. Response: Classes | Behav. Response Structure: p-hat | Time Effects: Classes | Structure: p-hat/class 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | True Model[d] | Test Model[e] | Avg. N-hat[f] | SE | 95% Conf. Int. LCB | 95% Conf. Int. UCB | % CI coverage | Cv[g] | % Rel. Bias[h] | Abs val % Rel. Bias | Rank Rel. Bias[i] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 233 | 1000 | 1 | 0.15 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(th) of Chao | 241.43 | 22.72 | 240.02 | 242.84 | 93.80 | 13.06 | 3.62 | 3.62 | 4 |
| 233 | 1000 | 1 | 0.15 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(t) Darroch | 233.58 | 17.84 | 232.47 | 234.69 | 94.40 | 13.09 | 0.25 | 0.25 | 2 |
| 233 | 1000 | 1 | 0.15 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(t) of Chao | 233.46 | 21.92 | 232.11 | 234.82 | 95.00 | 10.63 | 0.20 | 0.20 | 1 |
| 233 | 1000 | 1 | 0.15 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(tb) Burnham | failed | | | | | | | | |
| 233 | 1000 | 1 | 0.15 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(0) | 235.64 | 18.05 | 234.53 | 236.76 | 94.20 | 13.06 | 1.13 | 1.13 | 3 |
| 233 | 1000 | 2 | 116 0.2, 117 0.1 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(th) of Chao | 228.86 | 24.07 | 227.37 | 230.35 | 92.00 | 9.51 | -1.78 | 1.78 | 1 |
| 233 | 1000 | 2 | 117 0.2, 117 0.1 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(t) Darroch | 214.38 | 16.60 | 213.35 | 215.41 | 79.50 | 12.91 | -7.99 | 7.99 | 4 |
| 233 | 1000 | 2 | 118 0.2, 117 0.1 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(t) of Chao | 221.29 | 22.45 | 219.90 | 222.68 | 89.70 | 9.86 | -5.03 | 5.03 | 2 |
| 233 | 1000 | 2 | 119 0.2, 117 0.1 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(tb) Burnham | failed | | | | | | | | |
| 233 | 1000 | 2 | 120 0.2, 117 0.1 | 1 | 1 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mth | M(0) | 216.20 | 16.83 | 215.15 | 217.24 | 83.50 | 12.85 | -7.21 | 7.21 | 3 |
| 233 | 1000 | 1 | 0.15 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(th) of Chao | 251.16 | 24.81 | 249.62 | 252.69 | 87.90 | 10.12 | 7.79 | 7.79 | 4 |
| 233 | 1000 | 1 | 0.15 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(t) Darroch | 242.82 | 19.57 | 241.61 | 244.04 | 89.10 | 12.41 | 4.21 | 4.21 | 2 |
| 233 | 1000 | 1 | 0.15 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(t) of Chao | 242.29 | 23.96 | 240.81 | 243.78 | 92.80 | 10.11 | 3.99 | 3.99 | 1 |
| 233 | 1000 | 1 | 0.15 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(tb) Burnham | failed | | | | | | | | |
| 233 | 1000 | 1 | 0.15 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(0) | 245.02 | 19.81 | 243.80 | 246.25 | 87.90 | 12.37 | 5.16 | 5.16 | 3 |
| 233 | 1000 | 2 | 116 0.2, 117 0.1 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(th) of Chao | 237.09 | 25.72 | 235.49 | 238.68 | 92.20 | 9.22 | 1.76 | 1.76 | 1 |
| 233 | 1000 | 2 | 117 0.2, 117 0.1 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(t) Darroch | 222.49 | 18.17 | 221.36 | 223.62 | 89.90 | 12.25 | -4.51 | 4.51 | 4 |
| 233 | 1000 | 2 | 118 0.2, 117 0.1 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(t) of Chao | 228.77 | 23.93 | 227.29 | 230.26 | 93.20 | 9.56 | -1.82 | 1.82 | 2 |
| 233 | 1000 | 2 | 119 0.2, 117 0.1 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(tb) Burnham | failed | | | | | | | | |
| 233 | 1000 | 2 | 120 0.2, 117 0.1 | 1 | 0.93 | 8 | 0.85 | 0.59 | 0.72 | 1.19 | 1.10 | 0.82 | 0.74 | 0.66 | Mtbh | M(0) | 224.47 | 18.40 | 223.33 | 225.61 | 91.60 | 12.20 | -3.66 | 3.66 | 3 |

[a] - True population size

[b] - Number of subdivisions of N , each of which are assigned a unique capture probability (p-hat)

[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.

[d] - True Model = the model suggested by the input parameters

[e] - Model being evaluated

[f] - Average population size estimated by the model

[g] - Coefficient of variance = Avgerage N-hat/SE

[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))

[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

# APPENDIX B. Continued

## MY 2003

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | | | | | | | | | | | | 95% Conf. Int. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Structure: | | Structure: | | Structure: p-hat/class | | | | | | | | | | | | | | | | | | | | | | |
| N[a] | Replications | Classes[b] | class size/p-hat[c] | Classes | p-hat | Classes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | True Model[d] | Test Model[e] | Avg. N-hat[f] | SE | LCB | UCB | % CI coverage | Cv[g] | % Rel. Bias[h] | Abs val % Rel. Bias | Rank Rel. Bias[i] |
| 56 | 1000 | 1 | 1 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mt | M(th) of Chao | 56.00 | 0.00 | 56.00 | 56.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 56 | 1000 | 1 | 1 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mt | M(t) Darroch | failed | | | | | | | | |
| 56 | 1000 | 1 | 1 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mt | M(t) of Chao | 56.00 | 0.00 | 56.00 | 56.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 56 | 1000 | 1 | 1 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mt | M(tb) Burnham | failed | | | | | | | | |
| 56 | 1000 | 1 | 1 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mt | M(0) | 56.00 | 0.00 | 56.00 | 56.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mth | M(th) of Chao | 51.56 | 11.35 | 50.85 | 52.26 | 90.50 | 4.54 | -7.93 | 7.93 | 1 |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mth | M(t) Darroch | 44.63 | 7.12 | 44.19 | 45.07 | 64.10 | 6.27 | -20.30 | 20.30 | 4 |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mth | M(t) of Chao | 47.67 | 10.53 | 47.02 | 48.32 | 84.20 | 4.53 | -14.88 | 14.88 | 2 |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mth | M(tb) Burnham | failed | | | | | | | | |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 1 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mth | M(0) | 46.13 | 7.46 | 45.67 | 46.59 | 76.20 | 6.18 | -17.63 | 17.63 | 3 |
| 56 | 1000 | 1 | 1 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtb | M(th) of Chao | 56.00 | 0.03 | 56.00 | 56.00 | 99.90 | 1750.0 | 0.00 | 0.00 | 1 |
| 56 | 1000 | 1 | 1 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtb | M(t) Darroch | 56.00 | 0.00 | 56.00 | 56.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 56 | 1000 | 1 | 1 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtb | M(t) of Chao | 56.01 | 0.07 | 56.00 | 56.01 | 99.50 | 788.87 | 0.02 | 0.02 | 4 |
| 56 | 1000 | 1 | 1 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtb | M(tb) Burnham | failed | | | | | | | | 1 |
| 56 | 1000 | 1 | 1 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtb | M(0) | 56.00 | 0.00 | 56.00 | 56.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtbh | M(th) of Chao | 59.34 | 15.32 | 58.39 | 60.29 | 93.80 | 3.87 | 5.96 | 5.96 | 2 |
| 56 | 1000 | 3 | 18 0.25, 19 0.16, 19 0.05 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtbh | M(t) Darroch | 51.43 | 11.29 | 50.73 | 52.13 | 88.70 | 4.56 | -8.16 | 8.16 | 3 |
| 56 | 1000 | 3 | 19 0.25, 19 0.16, 19 0.05 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtbh | M(t) of Chao | 53.15 | 12.49 | 52.38 | 53.92 | 92.80 | 4.25 | -5.09 | 5.09 | 1 |
| 56 | 1000 | 3 | 19 0.25, 19 0.16, 19 0.05 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtbh | M(tb) Burnham | failed | | | | | | | | |
| 56 | 1000 | 3 | 20 0.25, 19 0.16, 19 0.05 | 1 | 0.76 | 11 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | 0.98 | 0.17 | 0.34 | 0.93 | 0.10 | 0.65 | Mtbh | M(0) | 39.49 | 27.13 | 37.81 | 41.17 | 93.80 | 1.46 | -29.48 | 29.48 | 4 |

[a] - True population size

[b] - Number of subdivisions of N , each of which are assigned a unique capture probability (p-hat)

[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.

[d] - True Model = the model suggested by the input parameters

[e] - Model being evaluated

[f] - Average population size estimated by the model

[g] - Coefficient of variance = Avgerage N-hat/SE

[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))

[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

# APPENDIX B. Continued

## CEM 2003

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Structure: | | Structure: | | Structure: p-hat/class | | | | | | | | | | | | | 95% Conf. Int. | | | | | | |
| N [a] | Replications | Classes [b] | class size/p-hat [c] | Classes | p-hat | Classes | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | True Model [d] | Test Model [e] | Avg. N-hat [f] | SE | LCB | UCB | % CI coverage | Cv [g] | % Rel. Bias [h] | Abs val % Rel. Bias | Rank Rel. Bias [i] |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(th) of Chao | 191.28 | 19.31 | 189.59 | 192.97 | 67.80 | 9.90 | -14.99 | 14.99 | 3 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(bh) Pollock and Otto | 164.72 | 17.15 | 163.22 | 166.23 | 32.20 | 9.60 | -26.79 | 26.79 | 6 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(bh) or removal models | 135.81 | 8.72 | 135.04 | 136.59 | 6.52 | 15.57 | -39.64 | 39.64 | 7 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(t) Darroch | 167.69 | 10.91 | 166.73 | 168.64 | 1.80 | 15.37 | -25.47 | 25.47 | 5 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(t) of Chao | 179.20 | 16.30 | 177.77 | 180.63 | 41.80 | 10.99 | -20.36 | 20.36 | 4 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(h) Jacknife | 216.24 | 26.82 | 213.89 | 218.60 | 89.40 | 8.06 | -3.89 | 3.89 | 1 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(h) of Chao | 192.33 | 19.83 | 190.60 | 194.07 | 70.00 | 9.70 | -14.52 | 14.52 | 2 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(th) of Chao | 225.87 | 27.88 | 223.43 | 228.32 | 94.60 | 8.10 | 0.39 | 0.39 | 1 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(bh) Pollock and Otto | 164.72 | 17.15 | 163.22 | 166.23 | 32.20 | 9.60 | -26.79 | 26.79 | 5 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(bh) or removal models | Not attempted-not a top model | | | | | | | | |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(t) Darroch | Not attempted-not a top model | | | | | | | | |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(t) of Chao | 206.22 | 22.35 | 204.26 | 208.18 | 89.20 | 9.23 | -8.35 | 8.35 | 3 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(h) Jacknife | 256.61 | 34.58 | 253.58 | 259.64 | 71.60 | 7.42 | 14.05 | 14.05 | 4 |
| 225 | 500 | 3 | 75 0.2, 75 0.1, 75 0.03 | 1 | 0.7 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mtbh | M(h) of Chao | 228.06 | 28.14 | 225.59 | 230.52 | 95.40 | 8.10 | 1.36 | 1.36 | 2 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(th) of Chao | 206.40 | 21.25 | 204.54 | 208.26 | 87.80 | 9.72 | -8.27 | 8.27 | 3 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(bh) Pollock and Otto | 177.79 | 19.27 | 176.10 | 179.48 | 57.00 | 9.23 | -20.98 | 20.98 | 5 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(bh) or removal models | 145.26 | 10.07 | 144.37 | 146.15 | 7.06 | 14.43 | -35.44 | 35.44 | 6 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(t) Darroch | Not attempted-not a top model | | | | | | | | |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(t) of Chao | 193.9 | 18.32 | 192.29 | 195.51 | 66.40 | 10.58 | -13.82 | 13.82 | 4 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(h) Jacknife | 235.48 | 29.84 | 232.86 | 238.09 | 84.60 | 7.89 | 4.66 | 4.66 | 1 |
| 225 | 500 | 3 | 112 0.053, 113 0.171 | 1 | 1 | 8 | 0.15 | 2.05 | 1.65 | 1.80 | 1.35 | 0.65 | 0.55 | 0.75 | Mth | M(h) of Chao | 208.46 | 22.17 | 206.51 | 210.40 | 90.20 | 9.40 | -7.35 | 7.35 | 2 |

[a] - True population size
[b] - Number of subdivisions of N , each of which are assigned a unique capture probability (p-hat)
[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.
[d] - True Model = the model suggested by the input parameters
[e] - Model being evaluated
[f] - Average population size estimated by the model
[g] - Coefficient of variance = Avgerage N-hat/SE
[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))
[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

## APPENDIX B. Continued

### SP 2003

| | | Heterogeneity | | Behav. Response | | Time Effects | | | | | | | | | | 95% Conf. Int. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Structure: | | Structure: | | Structure: p-hat | | | | | | | | | | | | | | | |
| N [a] | Replications | Classes [b] | class size/p-hat [c] | Classes | p-hat | Classes | 1 | 2 | 3 | 4 | 5 | True Model [d] | Test Model [e] | Avg. N-hat [f] | SE | LCB | UCB | % CI coverage | Cv [g] | % Rel. Bias [h] | Abs val % Rel. Bias | Rank Rel. Bias [i] |
| 54 | 1000 | 1 | 1 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mt | M(th) of Chao | 56.27 | 1.03 | 56.21 | 56.34 | 100.00 | 54.58 | 4.20 | 4.20 | 3 |
| 54 | 1000 | 1 | 1 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mt | M(t) Darroch | failed | | | | | | | | |
| 54 | 1000 | 1 | 1 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mt | M(t) of Chao | 54.00 | 0.00 | 54.00 | 54.00 | | NA | 0.00 | 0.00 | NA |
| 54 | 1000 | 1 | 1 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mt | M(tb) Burnham | failed | | | | | | | | |
| 54 | 1000 | 1 | 1 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mt | M(0) | 54.00 | 0.00 | 54.00 | 54.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mth | M(th) of Chao | 55.47 | 13.36 | 54.64 | 56.29 | 93.00 | 4.15 | 2.72 | 2.72 | 1 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mth | M(t) Darroch | 44.78 | 6.29 | 44.39 | 45.17 | 66.60 | 7.11 | -17.07 | 17.07 | 4 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mth | M(t) of Chao | 47.12 | 8.09 | 46.62 | 47.62 | 85.20 | 5.83 | -12.74 | 12.74 | 3 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mth | M(tb) Burnham | failed | | | | | | | | |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mth | M(0) | 48.01 | 7.17 | 47.56 | 48.45 | | 6.70 | -11.09 | 11.09 | 2 |
| 54 | 1000 | 1 | 1 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtb | M(th) of Chao | 56.12 | 0.86 | 56.07 | 56.18 | 100.00 | 65.33 | 3.93 | 3.93 | 1 |
| 54 | 1000 | 1 | 1 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtb | M(t) Darroch | failed | | | | | | | | |
| 54 | 1000 | 1 | 1 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtb | M(t) of Chao | 54.00 | 0.00 | 54.00 | 54.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 54 | 1000 | 1 | 1 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtb | M(tb) Burnham | failed | | | | | | | | |
| 54 | 1000 | 1 | 1 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtb | M(0) | 54.00 | 0.00 | 54.00 | 54.00 | 100.00 | NA | 0.00 | 0.00 | NA |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtbh | M(th) of Chao | 49.97 | 9.96 | 49.35 | 50.59 | 92.10 | 5.02 | -7.46 | 7.46 | 1 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtbh | M(t) Darroch | 40.47 | 4.75 | 40.18 | 40.77 | 26.60 | 8.53 | -25.06 | 25.06 | 3 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtbh | M(t) of Chao | 43.22 | 6.34 | 42.83 | 43.61 | 67.00 | 6.82 | -19.96 | 19.96 | 2 |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtbh | M(tb) Burnham | failed | | | | | | | | |
| 54 | 1000 | 2 | 27/ 0.44, 27/ 0.16 | 1 | 1.3 | 5 | 0.49 | 0.22 | 0.71 | 0.87 | 1.11 | Mtbh | M(0) | 16.78 | 5.31 | 16.45 | 17.11 | 56.70 | 3.16 | -68.93 | 68.93 | 4 |

[a] - True population size

[b] - Number of subdivisions of N , each of which were assigned a unique capture probability (p-hat)

[c] - Number of animals assigned to each class and the capture probability (p-hat) assigned to those animals.

[d] - True Model = the model suggested by the input parameters

[e] - Model being evaluated

[f] - Average population size estimated by the model

[g] - Coefficient of variance = Avgerage N-hat/SE

[h] - % Reletive bias = (Avg. N-hat - N)/(N*100))

[i] - Rank Reletive bias = minimum Absolute value % reletive bias in each set of models

**APPENDIX C. Estimated survival probabilities and capture rates between groups.**

Live-capture data from April of 2002 and 2003 were modeled according to sex and age with open-population estimators (Cormack 1964, Jolly 1965, Seber 1965) in program MARK. The models in table 2.3 were designed based on *a priori* hypotheses to determine if differences existed in estimated apparent survival rates (phi) and capture probabilities (p) between groups. Groups were: adult males, adult females, juvenile males, and juvenile females (g), males and females (sex), adults and juveniles (age), and all animals (.).

The top model indicated that there were no differences between groups in p, but that there were differences in phi among adult males, adult females, juvenile males, and juvenile females. This model was 1.49 times as well supported by the data as the next best model. The estimated logit link function parameters (β's) for the top model and the competing models are in Table C.1. All competing models also supported the finding of differences in phi between groups. The competing models provided some evidence of a difference in p between groups as well. The first competing model suggested that the difference was due to different p between adults and juveniles. According to this model, juveniles had higher p than adults. The second competing model suggested that there were differences in p between males and females, and that females had higher p than males.

Table C.1. Logit link function parameters (β's) and real parameter estimates for the top model (listed first) and competing models (following) from the model set depicted in Table 2.3. Standard Errors and CI's were corrected for c-hat = 1.3942. Parameters marked with (*) had confidence intervals that did not overlap 0 and therefore indicate substantial evidence within the model of an effect for that parameter.

**{Phi(age+sex) p(.)}**

**Real Function Parameters**

| | | | | 95% Confidence Interval | |
|---|---|---|---|---|---|
| Group | Parameter | Estimate | SE | Lower | Upper |
| Ad Male | 1:Phi | 0.882 | 0.027 | 0.817 | 0.926 |
| Juv Male | 2:Phi | 0.972 | 0.023 | 0.868 | 0.995 |
| Ad Fem | 3:Phi | 0.798 | 0.042 | 0.702 | 0.869 |
| Juv Fem | 4:Phi | 0.948 | 0.039 | 0.795 | 0.989 |
| All | 5:p | 0.263 | 0.018 | 0.229 | 0.300 |

**Logit Link Function Parameters**

| | | | | 95% Confidence Interval | | |
|---|---|---|---|---|---|---|
| Group | Parameter | Estimate | SE | Lower | Upper | |
| Intercept | 1:Phi | 2.908 | 0.793 | 1.353 | 4.463 | * |
| Adult | 2:Phi | -1.536 | 0.769 | -3.044 | -0.028 | * |
| Male | 3:Phi | 0.641 | 0.311 | 0.032 | 1.250 | * |
| Intercept | 4:p | -1.032 | 0.094 | -1.215 | -0.848 | * |

Table C.1. Continued

**{Phi(age+sex) p(age) }**

**Real Function Parameters**

| Group | Parameter | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|
| Ad Male | 1:Phi | 0.892 | 0.025 | 0.832 | 0.932 |
| Juv Male | 2:Phi | 0.957 | 0.025 | 0.872 | 0.986 |
| Ad Fem | 3:Phi | 0.807 | 0.037 | 0.724 | 0.869 |
| Juv Fem | 4:Phi | 0.918 | 0.042 | 0.790 | 0.971 |
| Adults | 5:p | 0.254 | 0.017 | 0.222 | 0.289 |
| Juveniles | 6:p | 0.295 | 0.035 | 0.232 | 0.367 |

**Logit Link Function Parameters**

| Group | Parameter | Estimate | SE | 95% Confidence Interval Lower | Upper | |
|---|---|---|---|---|---|---|
| Intercept | 1:Phi | 2.415 | 0.557 | 1.323 | 3.506 | * |
| Adult | 2:Phi | -0.987 | 0.595 | -2.153 | 0.180 | |
| Male | 3:Phi | 0.683 | 0.278 | 0.138 | 1.229 | * |
| Intercept | 4:p | -0.870 | 0.166 | -1.195 | -0.544 | * |
| Adult | 5:p | -0.210 | 0.189 | -0.581 | 0.161 | |

**{Phi(age+sex) p(sex) }**

**Real Function Parameters**

| Group | Parameter | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|
| Ad Male | 1:Phi | 0.892 | 0.026 | 0.829 | 0.934 |
| Juv Male | 2:Phi | 0.969 | 0.017 | 0.909 | 0.990 |
| Ad Fem | 3:Phi | 0.778 | 0.042 | 0.686 | 0.849 |
| Juv Fem | 4:Phi | 0.930 | 0.039 | 0.806 | 0.977 |
| Male | 5:p | 0.254 | 0.018 | 0.220 | 0.291 |
| Female | 7:p | 0.283 | 0.028 | 0.231 | 0.341 |

**Logit Link Function Parameters**

| Group | Parameter | Estimate | SE | 95% Confidence Interval Lower | Upper | |
|---|---|---|---|---|---|---|
| Intercept | 1:Phi | 2.593 | 0.597 | 1.423 | 3.762 | * |
| Adult | 2:Phi | -1.340 | 0.535 | -2.389 | -0.291 | * |
| Male | 3:Phi | 0.861 | 0.364 | 0.148 | 1.574 | * |
| Intercept | 4:p | -0.930 | 0.139 | -1.203 | -0.657 | * |
| Male | 5:p | -0.149 | 0.170 | -0.481 | 0.184 | |

**APPENDIX D: Parameter estimates from best models from known fates survival estimation.**

Survival was estimated for all collared squirrels and for dispersers and non-dispersers with known fates on the Boardman in 2002 and 2003. Estimation was conducted using the Kaplan-Meier procedure in program MARK (White and Burnham 1999). Models selection was considered in the text of Chapter 1, but within each model, strength of evidence depended on parameter estimates and confidence intervals. They are addressed here.

Table D.1. Real parameter estimates, logit link function parameters (β's), and derived parameter estimates for the best model **{S(site+ TT)}** from the model set for all collared squirrels depicted in Table 2.4. The top model suggested that among all collared animals, survival rates differed between sites.

**Real Function Parameters of {S(site+TT)}**

| Parameter | Group | Week | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|
| 1:S | TUB | Apr 7-14 | 0.985 | 0.008 | 0.956 | 0.995 |
| 2:S | TUB | Apr 15-21 | 0.972 | 0.010 | 0.942 | 0.987 |
| 3:S | TUB | Apr 22-28 | 0.954 | 0.012 | 0.924 | 0.973 |
| 4:S | TUB | Apr 29-May 5 | 0.931 | 0.014 | 0.897 | 0.955 |
| 5:S | TUB | May 5-12 | 0.906 | 0.018 | 0.864 | 0.937 |
| 6:S | TUB | May 13-19 | 0.883 | 0.023 | 0.831 | 0.921 |
| 7:S | TUB | May 20-26 | 0.866 | 0.025 | 0.808 | 0.908 |
| 8:S | TUB | May27-June2 | 0.858 | 0.026 | 0.799 | 0.901 |
| 9:S | TUB | June 3-9 | 0.860 | 0.028 | 0.796 | 0.907 |
| 10:S | TUB | June 10-16 | 0.873 | 0.033 | 0.792 | 0.926 |
| 11:S | TUB | June17-23 | 0.894 | 0.041 | 0.783 | 0.952 |
| 12:S | MY | Apr 7-14 | 0.977 | 0.013 | 0.932 | 0.992 |
| 13:S | MY | Apr 15-21 | 0.958 | 0.017 | 0.910 | 0.981 |
| 14:S | MY | Apr 22-28 | 0.932 | 0.020 | 0.880 | 0.962 |
| 15:S | MY | Apr 29-May 5 | 0.899 | 0.025 | 0.838 | 0.938 |
| 16:S | MY | May 5-12 | 0.864 | 0.032 | 0.789 | 0.915 |
| 17:S | MY | May 13-19 | 0.832 | 0.038 | 0.743 | 0.894 |
| 18:S | MY | May 20-26 | 0.808 | 0.042 | 0.711 | 0.878 |
| 19:S | MY | May27-June2 | 0.798 | 0.044 | 0.697 | 0.871 |
| 20:S | MY | June 3-9 | 0.801 | 0.047 | 0.694 | 0.878 |
| 21:S | MY | June 10-16 | 0.819 | 0.053 | 0.692 | 0.901 |
| 22:S | MY | June17-23 | 0.847 | 0.062 | 0.686 | 0.934 |
| 23:S | CEM | Apr 7-14 | 0.992 | 0.005 | 0.974 | 0.998 |
| 24:S | CEM | Apr 15-21 | 0.985 | 0.007 | 0.964 | 0.994 |
| 25:S | CEM | Apr 22-28 | 0.975 | 0.009 | 0.951 | 0.988 |
| 26:S | CEM | Apr 29-May 5 | 0.963 | 0.012 | 0.932 | 0.980 |
| 27:S | CEM | May 5-12 | 0.948 | 0.015 | 0.908 | 0.971 |
| 28:S | CEM | May 13-19 | 0.935 | 0.019 | 0.886 | 0.964 |

Table D.1. Continued.

| Parameter | Group | Week | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|
| 29:S | CEM | May 20-26 | 0.925 | 0.021 | 0.870 | 0.957 |
| 30:S | CEM | May27-June2 | 0.920 | 0.022 | 0.864 | 0.954 |
| 31:S | CEM | June 3-9 | 0.921 | 0.022 | 0.865 | 0.956 |
| 32:S | CEM | June 10-16 | 0.929 | 0.024 | 0.866 | 0.964 |
| 33:S | CEM | June17-23 | 0.941 | 0.026 | 0.864 | 0.976 |

(Values of 1-33 repeated for 34-66; 1-33 correspond to 2002, 34-66 corresond to 2003)

**Logit Link Function Parameters of {S(site+TT)}**

| Parameter | Beta | SE | 95% Confidence Interval Lower | Upper | |
|---|---|---|---|---|---|
| Intercept | 4.866 | 0.767 | 3.363 | 6.369 | * |
| MY | -0.424 | 0.310 | -1.032 | 0.184 | |
| CEM | 0.643 | 0.341 | -0.027 | 1.312 | |
| T | -0.745 | 0.252 | -1.239 | -0.251 | * |
| TT | 0.045 | 0.019 | 0.007 | 0.083 | * |

**Estimates of Derived Parameters: Survival Estimates of {S(site+TT)}**

| Group | Pr. Survive | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| TUB02 | 0.340 | 0.066 | 0.224 | 0.479 |
| MY02 | 0.202 | 0.076 | 0.091 | 0.390 |
| CEM02 | 0.558 | 0.091 | 0.380 | 0.722 |
| TUB03 | 0.340 | 0.066 | 0.224 | 0.479 |
| MY03 | 0.202 | 0.076 | 0.091 | 0.390 |
| CEM03 | 0.558 | 0.091 | 0.380 | 0.722 |

Pr. Survive = Probability of surviving the season

SE = Standard Error

* = Confidence Interval does not include 0, indicating support for an effect of this parameter

Table D.2. Real parameter estimates, logit link function parameters (β's), and derived parameter estimates for the competing model **{S(site+ TT)}** from the model set for known fates of all collared squirrels depicted in Table 2.4. The top model suggested that among all collared animals, survival rates differed among sites and years.

**Real Function Parameters of {S((site+year)+TT)}**

| Parameter | Group | Year | Week | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| 1:S | TUB | 2002 | Apr 7-14 | 0.983 | 0.009 | 0.950 | 0.994 |
| 2:S | TUB | 2002 | Apr 15-21 | 0.969 | 0.012 | 0.934 | 0.986 |
| 3:S | TUB | 2002 | Apr 22-28 | 0.949 | 0.015 | 0.911 | 0.972 |
| 4:S | TUB | 2002 | Apr 29-May 5 | 0.924 | 0.018 | 0.880 | 0.953 |
| 5:S | TUB | 2002 | May 5-12 | 0.897 | 0.024 | 0.840 | 0.935 |
| 6:S | TUB | 2002 | May 13-19 | 0.871 | 0.029 | 0.803 | 0.918 |
| 7:S | TUB | 2002 | May 20-26 | 0.852 | 0.033 | 0.776 | 0.905 |
| 8:S | TUB | 2002 | May27-June2 | 0.843 | 0.034 | 0.764 | 0.899 |
| 9:S | TUB | 2002 | June 3-9 | 0.846 | 0.036 | 0.762 | 0.904 |
| 10:S | TUB | 2002 | June 10-16 | 0.860 | 0.041 | 0.760 | 0.922 |
| 11:S | TUB | 2002 | June17-23 | 0.882 | 0.048 | 0.753 | 0.949 |
| 12:S | MY | 2002 | Apr 7-14 | 0.974 | 0.015 | 0.923 | 0.992 |
| 13:S | MY | 2002 | Apr 15-21 | 0.954 | 0.019 | 0.897 | 0.980 |
| 14:S | MY | 2002 | Apr 22-28 | 0.925 | 0.024 | 0.862 | 0.960 |
| 15:S | MY | 2002 | Apr 29-May 5 | 0.889 | 0.030 | 0.814 | 0.936 |
| 16:S | MY | 2002 | May 5-12 | 0.850 | 0.039 | 0.758 | 0.911 |
| 17:S | MY | 2002 | May 13-19 | 0.815 | 0.046 | 0.708 | 0.890 |
| 18:S | MY | 2002 | May 20-26 | 0.790 | 0.051 | 0.672 | 0.874 |
| 19:S | MY | 2002 | May27-June2 | 0.778 | 0.054 | 0.656 | 0.866 |
| 20:S | MY | 2002 | June 3-9 | 0.782 | 0.056 | 0.653 | 0.872 |
| 21:S | MY | 2002 | June 10-16 | 0.800 | 0.062 | 0.653 | 0.895 |
| 22:S | MY | 2002 | June17-23 | 0.831 | 0.070 | 0.648 | 0.929 |
| 23:S | CEM | 2002 | Apr 7-14 | 0.991 | 0.005 | 0.971 | 0.997 |
| 24:S | CEM | 2002 | Apr 15-21 | 0.984 | 0.008 | 0.960 | 0.994 |
| 25:S | CEM | 2002 | Apr 22-28 | 0.973 | 0.010 | 0.944 | 0.987 |
| 26:S | CEM | 2002 | Apr 29-May 5 | 0.959 | 0.014 | 0.921 | 0.979 |
| 27:S | CEM | 2002 | May 5-12 | 0.943 | 0.018 | 0.895 | 0.970 |
| 28:S | CEM | 2002 | May 13-19 | 0.928 | 0.023 | 0.869 | 0.962 |
| 29:S | CEM | 2002 | May 20-26 | 0.917 | 0.026 | 0.850 | 0.955 |
| 30:S | CEM | 2002 | May27-June2 | 0.911 | 0.027 | 0.843 | 0.952 |
| 31:S | CEM | 2002 | June 3-9 | 0.913 | 0.027 | 0.843 | 0.953 |
| 32:S | CEM | 2002 | June 10-16 | 0.921 | 0.028 | 0.845 | 0.962 |
| 33:S | CEM | 2002 | June17-23 | 0.935 | 0.030 | 0.844 | 0.974 |
| 34:S | TUB | 2003 | Apr 7-14 | 0.986 | 0.008 | 0.959 | 0.995 |
| 35:S | TUB | 2003 | Apr 15-21 | 0.975 | 0.010 | 0.945 | 0.989 |
| 36:S | TUB | 2003 | Apr 22-28 | 0.958 | 0.012 | 0.926 | 0.977 |
| 37:S | TUB | 2003 | Apr 29-May 5 | 0.937 | 0.015 | 0.900 | 0.961 |
| 38:S | TUB | 2003 | May 5-12 | 0.914 | 0.020 | 0.866 | 0.946 |
| 39:S | TUB | 2003 | May 13-19 | 0.892 | 0.024 | 0.834 | 0.931 |
| 40:S | TUB | 2003 | May 20-26 | 0.876 | 0.027 | 0.812 | 0.920 |
| 41:S | TUB | 2003 | May27-June2 | 0.868 | 0.028 | 0.803 | 0.914 |
| 42:S | TUB | 2003 | June 3-9 | 0.870 | 0.029 | 0.801 | 0.918 |
| 43:S | TUB | 2003 | June 10-16 | 0.883 | 0.034 | 0.799 | 0.934 |

Table D.2. Continued.

| Parameter | Group | Year | Week | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|---|
| 44:S | TUB | 2003 | June17-23 | 0.902 | 0.040 | 0.793 | 0.957 |
| 45:S | MY | 2003 | Apr 7-14 | 0.979 | 0.012 | 0.936 | 0.993 |
| 46:S | MY | 2003 | Apr 15-21 | 0.962 | 0.016 | 0.914 | 0.984 |
| 47:S | MY | 2003 | Apr 22-28 | 0.938 | 0.020 | 0.884 | 0.967 |
| 48:S | MY | 2003 | Apr 29-May 5 | 0.907 | 0.026 | 0.843 | 0.947 |
| 49:S | MY | 2003 | May 5-12 | 0.874 | 0.033 | 0.795 | 0.926 |
| 50:S | MY | 2003 | May 13-19 | 0.844 | 0.040 | 0.750 | 0.907 |
| 51:S | MY | 2003 | May 20-26 | 0.822 | 0.044 | 0.719 | 0.892 |
| 52:S | MY | 2003 | May27-June2 | 0.811 | 0.046 | 0.705 | 0.885 |
| 53:S | MY | 2003 | June 3-9 | 0.815 | 0.048 | 0.703 | 0.891 |
| 54:S | MY | 2003 | June 10-16 | 0.831 | 0.052 | 0.703 | 0.911 |
| 55:S | MY | 2003 | June17-23 | 0.857 | 0.060 | 0.698 | 0.940 |
| 56:S | CEM | 2003 | Apr 7-14 | 0.993 | 0.005 | 0.976 | 0.998 |
| 57:S | CEM | 2003 | Apr 15-21 | 0.987 | 0.006 | 0.966 | 0.995 |
| 58:S | CEM | 2003 | Apr 22-28 | 0.978 | 0.009 | 0.953 | 0.990 |
| 59:S | CEM | 2003 | Apr 29-May 5 | 0.966 | 0.012 | 0.935 | 0.983 |
| 60:S | CEM | 2003 | May 5-12 | 0.953 | 0.015 | 0.912 | 0.975 |
| 61:S | CEM | 2003 | May 13-19 | 0.940 | 0.019 | 0.890 | 0.968 |
| 62:S | CEM | 2003 | May 20-26 | 0.931 | 0.021 | 0.875 | 0.963 |
| 63:S | CEM | 2003 | May27-June2 | 0.926 | 0.022 | 0.869 | 0.960 |
| 64:S | CEM | 2003 | June 3-9 | 0.928 | 0.022 | 0.870 | 0.961 |
| 65:S | CEM | 2003 | June 10-16 | 0.935 | 0.023 | 0.871 | 0.968 |
| 66:S | CEM | 2003 | June17-23 | 0.946 | 0.025 | 0.870 | 0.979 |

**Logit Link Function Parameters of {S((site+year)+TT)}**

| Parameter | Beta | SE | 95% Confidence Interval Lower | Upper | |
|---|---|---|---|---|---|
| Intercept | 4.970 | 0.784 | 3.433 | 6.507 | * |
| MY | -0.425 | 0.310 | -1.034 | 0.183 | |
| CEM | 0.645 | 0.341 | -0.024 | 1.314 | |
| YEAR | -0.202 | 0.264 | -0.720 | 0.315 | |
| T | -0.747 | 0.253 | -1.243 | -0.251 | * |
| TT | 0.045 | 0.020 | 0.007 | 0.083 | * |

**Estimates of Derived Parameters: Survival Estimates of {S((site+year)+TT)}**

| Group | Pr. Survive | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| TUB02 | 0.30 | 0.08 | 0.17 | 0.48 |
| MY02 | 0.17 | 0.08 | 0.06 | 0.39 |
| CEM02 | 0.52 | 0.10 | 0.32 | 0.71 |
| TUB03 | 0.37 | 0.08 | 0.23 | 0.53 |
| MY03 | 0.23 | 0.09 | 0.10 | 0.44 |
| CEM03 | 0.59 | 0.10 | 0.40 | 0.75 |

Pr. Survive = Probability of surviving the season

SE = Standard Error

* = Confidence Interval does not include 0, indicating support for an effect of this parameter

Table D.3. Real parameter estimates, logit link function parameters (β's), and derived parameter estimates for the best model **{S(disp*TT) }** from the model set for dispersers and nondispersers depicted in Table 2.5. The top model suggested that survival rates differed between dispersers and non-dispersers.

**Real Function Parameters of {S(disp*TT) dm}**

| | | | | | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| Parameter | Group | Week | Estimate | SE | Lower | Upper |
| 1:S | Dispersers | Apr 7-14 | 0.989 | 0.007 | 0.963 | 0.997 |
| 2:S | Dispersers | Apr 15-21 | 0.975 | 0.011 | 0.943 | 0.989 |
| 3:S | Dispersers | Apr 22-28 | 0.951 | 0.014 | 0.916 | 0.972 |
| 4:S | Dispersers | Apr 29-May 5 | 0.920 | 0.017 | 0.881 | 0.948 |
| 5:S | Dispersers | May 5-12 | 0.890 | 0.021 | 0.841 | 0.925 |
| 6:S | Dispersers | May 13-19 | 0.870 | 0.024 | 0.814 | 0.910 |
| 7:S | Dispersers | May 20-26 | 0.866 | 0.025 | 0.809 | 0.908 |
| 8:S | Dispersers | May27-June2 | 0.880 | 0.025 | 0.822 | 0.921 |
| 9:S | Dispersers | June 3-9 | 0.907 | 0.026 | 0.842 | 0.947 |
| 10:S | Dispersers | June 10-16 | 0.939 | 0.026 | 0.862 | 0.974 |
| 11:S | Dispersers | June17-23 | 0.966 | 0.022 | 0.884 | 0.991 |
| 12:S | Non-dispersers | Apr 7-14 | 0.995 | 0.004 | 0.976 | 0.999 |
| 13:S | Non-dispersers | Apr 15-21 | 0.988 | 0.007 | 0.960 | 0.997 |
| 14:S | Non-dispersers | Apr 22-28 | 0.975 | 0.012 | 0.935 | 0.990 |
| 15:S | Non-dispersers | Apr 29-May 5 | 0.951 | 0.019 | 0.899 | 0.977 |
| 16:S | Non-dispersers | May 5-12 | 0.918 | 0.025 | 0.853 | 0.956 |
| 17:S | Non-dispersers | May 13-19 | 0.879 | 0.032 | 0.802 | 0.928 |
| 18:S | Non-dispersers | May 20-26 | 0.840 | 0.036 | 0.756 | 0.899 |
| 19:S | Non-dispersers | May27-June2 | 0.810 | 0.041 | 0.717 | 0.878 |
| 20:S | Non-dispersers | June 3-9 | 0.796 | 0.052 | 0.676 | 0.879 |
| 21:S | Non-dispersers | June 10-16 | 0.801 | 0.070 | 0.629 | 0.905 |
| 22:S | Non-dispersers | June17-23 | 0.823 | 0.091 | 0.578 | 0.940 |

**Logit Link Function Parameters of {S(disp* TT) }**

| | | | 95% Confidence Interval | | |
|---|---|---|---|---|---|
| Parameter | Beta | SE | Lower | Upper | |
| Intercept | 5.485 | 0.884 | 3.752 | 7.218 | * |
| disp | 0.883 | 0.597 | -0.288 | 2.054 | |
| T | -1.082 | 0.304 | -1.678 | -0.486 | * |
| TT | 0.081 | 0.025 | 0.032 | 0.129 | * |
| g*TT | -0.022 | 0.010 | -0.043 | -0.002 | * |

**Estimates of Derived Parameters: Survival Estimates of {S(disp* TT) }**

| | | | 95% Confidence Interval | |
|---|---|---|---|---|
| Group | Pr. Survive | SE | Lower | Upper |
| Dispersers | 0.409 | 0.063 | 0.294 | 0.535 |
| Non-dispersers | 0.262 | 0.087 | 0.129 | 0.462 |

Table D.4. Real parameter estimates, logit link function parameters (β's), and derived parameter estimates for the competing model **{S(TT)}** from the model set for dispersers and nondispersers depicted in Table 2.5. This model suggested that survival rates did not differ between dispersers and non-dispersers.

**Real Function Parameters of {S(TT) }**

| Parameter | Group | Week | Estimate | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|---|---|
| 1:S | Dispersers | Apr 7-14 | 0.990 | 0.006 | 0.968 | 0.997 |
| 2:S | Dispersers | Apr 15-21 | 0.978 | 0.009 | 0.952 | 0.990 |
| 3:S | Dispersers | Apr 22-28 | 0.958 | 0.011 | 0.931 | 0.975 |
| 4:S | Dispersers | Apr 29-May 5 | 0.931 | 0.013 | 0.901 | 0.952 |
| 5:S | Dispersers | May 5-12 | 0.900 | 0.017 | 0.862 | 0.928 |
| 6:S | Dispersers | May 13-19 | 0.872 | 0.021 | 0.826 | 0.908 |
| 7:S | Dispersers | May 20-26 | 0.857 | 0.023 | 0.807 | 0.895 |
| 8:S | Dispersers | May27-June2 | 0.857 | 0.022 | 0.807 | 0.895 |
| 9:S | Dispersers | June 3-9 | 0.872 | 0.024 | 0.817 | 0.913 |
| 10:S | Dispersers | June 10-16 | 0.900 | 0.029 | 0.826 | 0.944 |
| 11:S | Dispersers | June17-23 | 0.931 | 0.032 | 0.835 | 0.973 |
| 12:S | Non-dispersers | Apr 7-14 | 0.990 | 0.006 | 0.968 | 0.997 |
| 13:S | Non-dispersers | Apr 15-21 | 0.978 | 0.009 | 0.952 | 0.990 |
| 14:S | Non-dispersers | Apr 22-28 | 0.958 | 0.011 | 0.931 | 0.975 |
| 15:S | Non-dispersers | Apr 29-May 5 | 0.931 | 0.013 | 0.901 | 0.952 |
| 16:S | Non-dispersers | May 5-12 | 0.900 | 0.017 | 0.862 | 0.928 |
| 17:S | Non-dispersers | May 13-19 | 0.872 | 0.021 | 0.826 | 0.908 |
| 18:S | Non-dispersers | May 20-26 | 0.857 | 0.023 | 0.807 | 0.895 |
| 19:S | Non-dispersers | May27-June2 | 0.857 | 0.022 | 0.807 | 0.895 |
| 20:S | Non-dispersers | June 3-9 | 0.872 | 0.024 | 0.817 | 0.913 |
| 21:S | Non-dispersers | June 10-16 | 0.900 | 0.029 | 0.826 | 0.944 |
| 22:S | Non-dispersers | June17-23 | 0.931 | 0.032 | 0.835 | 0.973 |

**Logit Link Function Parameters of {S(TT) }**

| Parameter | Beta | SE | 95% Confidence Interval Lower | Upper | |
|---|---|---|---|---|---|
| Intercept | 5.568 | 0.873 | 3.856 | 7.279 | * |
| T | -1.012 | 0.292 | -1.584 | -0.441 | * |
| TT | 0.067 | 0.023 | 0.023 | 0.112 | * |

**Estimates of Derived Parameters: Survival Estimates of {S(TT) }**

| Group | Pr. Survive | SE | 95% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| Dispersers | 0.363 | 0.052 | 0.269 | 0.470 |
| Nondispersers | 0.363 | 0.052 | 0.269 | 0.470 |

Pr. Survive = Probability of surviving the season

SE = Standard Error

* = Confidence Interval does not include 0, indicating support for an effect of this parameter

**Appendix E. Temperature and precipitation on Boardman in 2002 and 2003.**

Differences in precipitation and temperature were observed between 2002 and 2003. These differences may have contributed to observed differences in abundance and timing of dispersal of Washington ground squirrels between years.

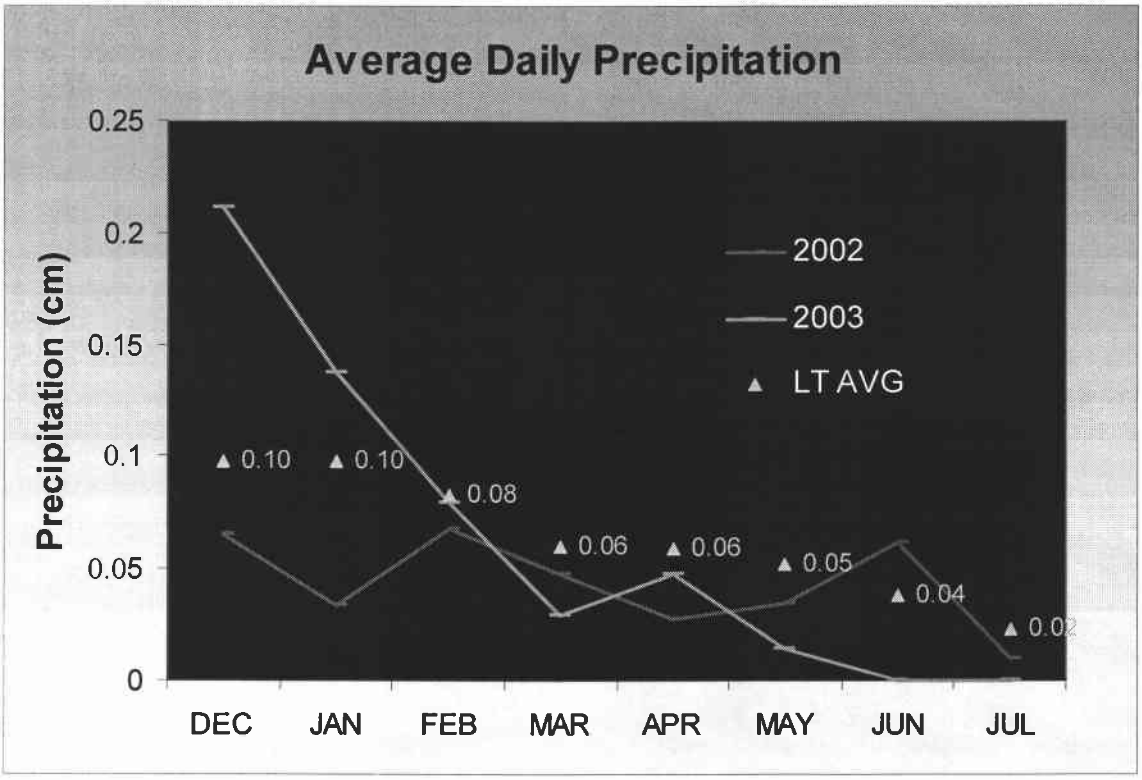


Figure E.1. Average daily precipitation on Boardman Naval Weapons Systems Training Facility in 2002 and 2003. Values are total daily rainfall amounts averaged across the month. Early-season precipitation in 2003 was higher than average, while values were lower than average in 2002. The long term average daily precipitation is plotted and labeled for comparison.

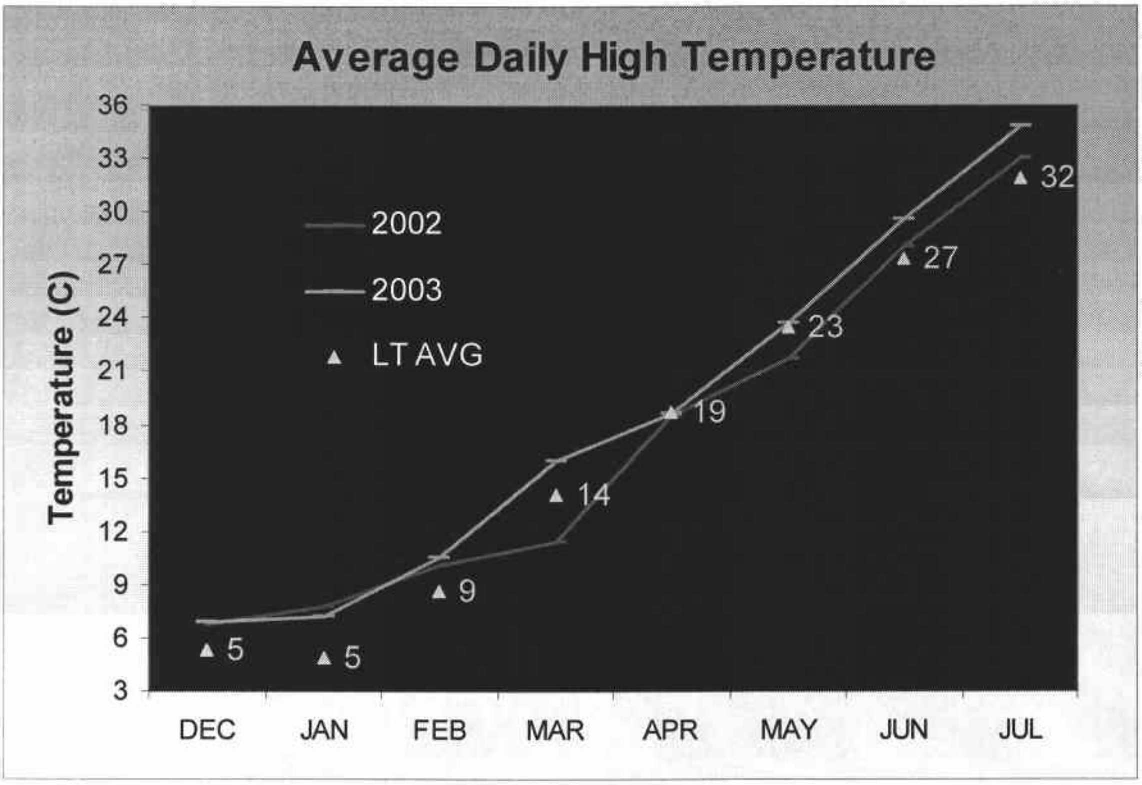


Figure E.2. Average daily temperature on Boardman Naval Weapons Systems Training Facility in 2002 and 2003. Maximum temperatures were recorded each day and averaged for each month. Temperatures during late February and March were higher than the long-term average in 2003 and may have provided conditions favorable for accelerated juvenile emergence or growth relative to 2002.

## APPENDIX F: Metadata for spatial data layers

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### Soils

*Identification_Information:*
*Citation:*
*Citation_Information:*
*Originator:* U.S. Department of Agriculture, Natural Resources Conservation Service
*Publication_Date:* 20030128
*Title:* Soil Survey Geographic (SSURGO) database for Morrow County, Oregon
*Publication_Information:*
*Publication_Place:* Fort Worth, Texas
*Publisher:* U.S. Department of Agriculture, Natural Resources Conservation Service
*Other_Citation_Details:* or049
*Online_Linkage:* URL:<http://www.ftw.nrcs.usda.gov/ssur_data.html>
*Description:*
*Abstract:* This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.

This data set consists of georeferenced digital map data and computerized attribute data. The map data are in a 7.5 minute quadrangle format and include a detailed, field verified inventory of soils and nonsoil areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. A special soil features layer (point and line features) is optional. This layer displays the location of features too small to delineate at the mapping scale, but they are large enough and contrasting enough to significantly influence use and management. The soil map units are linked to attributes in the National Soil Information System relational database, which gives the proportionate extent of the component soils and their properties.

*Data_Quality_Information:*
*Attribute_Accuracy_Report:* Attribute accuracy is tested by manual comparison of the source with hard copy plots and/or symbolized display of the map data on an interactive computer graphic system. Selected attributes that cannot be visually verified on plots or on screen are interactively queried and verified on screen. In addition, the attributes are tested against a master set of valid attributes. All attribute data conform to the attribute codes in the signed classification and correlation document and amendment(s).
*Spatial_Data_Organization_Information:*
*Direct_Spatial_Reference_Method:* Vector

*Spatial_Reference_Information:*
*Horizontal_Coordinate_System_Definition: Planar:*
*Grid_Coordinate_System:*
*Grid_Coordinate_System_Name:* Universal Transverse Mercator
*UTM_Zone_Number:* 10
*Scale_Factor_at_Central_Meridian:* 0.9996
*Longitude_of_Central_Meridian:* -123.0
*Latitude_of_Projection_Origin:* 0.0
*False_Easting:* 500000
*False_Northing:* 0.0
*UTM_Zone_Number:* 11
*Transverse_Mercator:*
*Scale_Factor_at_Central_Meridian:* 0.9996
*Longitude_of_Central_Meridian:* -117.0
*Latitude_of_Projection_Origin:* 0.0
*False_Easting:* 500000
*False_Northing:* 0.0
*Planar_Coordinate_Information:*
*Planar_Coordinate_Encoding_Method:* coordinate pair
*Coordinate_Representation:*
*Abscissa_Resolution:* 1.8288
*Ordinate_Resolution:* 1.8288
*Planar_Distance_Units:* meters
*Geodetic_Model:*
*Horizontal_Datum_Name:* North American Datum of 1983
*Ellipsoid_Name:* Geodetic Reference System 80
*Semi-major_Axis:* 6378137.0
*Denominator_of_Flattening_Ratio:* 298.257
*Distribution_Information:*
*Distributor:* U.S. Department of Agriculture,
*Contact_Information:*
*Contact_Organization_Primary:* National Cartography and Geospatial Center
*Contact_Organization:* Natural Resources Conservation Service
*Contact_Address:*
*Address_Type:* mailing address
*Address:* P.O. Box 6567
*City:* Fort Worth
*State_or_Province:* Texas
*Postal_Code:* 76115
*Contact_Voice_Telephone:* 800 672 5559
*Contact_Facsimile_Telephone:* 817 509 3469
*Resource_Description:* Morrow County, Oregon SSURGO
*Distribution_Liability:* Although these data have been processed successfully on a computer system at the U.S. Department of Agriculture, no warranty expressed or implied is made by the Agency regarding the utility of the data on any other

system, nor shall the act of distribution constitute any such warranty. The U.S. Department of Agriculture will warrant the delivery of this product in computer readable format, and will offer appropriate adjustment of credit when the product is determined unreadable by correctly adjusted computer input peripherals, or when the physical medium is delivered in damaged condition. Request for adjustment of credit must be made within 90 days from the date of this shipment from the ordering site.

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*Metadata_Reference_Information:*
*Metadata_Date:* 20030128 certified correct date
*Contact_Position:* State Soil Scientist
*Contact_Address:*
*Address_Type:* mailing address
*Address:* 101 SW Main Street, Suite 1300
*City:* Portland
*State_or_Province:* Oregon
*Postal_Code:* 97204-3221
*Contact_Voice_Telephone:* 503 414 3266
*Contact_Facsimile_Telephone:* 503 414 3277
*Metadata_Standard_Name:* Content Standard for Digital Geospatial Metadata
*Metadata_Standard_Version:* FGDC-STD-001-1998

---

**Roads and Vegetation**

*Identification_Information:*
*Citation:*
*Citation_Information:*
*Originator:* Oregon Department of Fish and Wildlife
*Publication_Date:*
*Title:* Vegetation classification of Boardman Naval weapons training facility
*Publication_Information:*
*Publication_Place:* Heppner, Oregon
*Publisher:* unpublished
*Other_Citation_Details:*
*Online_Linkage:*
*Description:*
*Abstract:* This data set is a digital map of aerial photo-orthoquad maps taken in late summer, 1996. Vegetation was identified by distinct coloration and texture.

Roads were visibly identified. The information was prepared by digitizing the maps This data set consists of georeferenced digital map data and computerized attribute data. The map data are in a 7.5 minute quadrangle format.

*Data_Quality_Information:*
*Attribute_Accuracy:*
*Attribute_Accuracy_Report:*
*Spatial_Data_Organization_Information:*
*Direct_Spatial_Reference_Method:* Vector
*Spatial_Reference_Information:*
*Horizontal_Coordinate_System_Definition:*GEOGCS["GCS_North_American_1927"]
*Grid_Coordinate_System_Name:* Universal Transverse Mercator
*UTM_Zone_Number:* 11
*Scale_Factor_at_Central_Meridian:* 0.9996
*Longitude_of_Central_Meridian:* -117.0
*Latitude_of_Projection_Origin:* 0.0
*False_Easting:* 500000
*False_Northing:* 0.0
*Planar_Distance_Units:* meters
*Geodetic_Model:*
*Horizontal_Datum_Name:* North American Datum of 1927
*Ellipsoid_Name:* Geodetic Reference System 80
*Semi-major_Axis:* 6378206.4
*Denominator_of_Flattening_Ratio:* 294.9786982
*Projection:* Transverse Mercator
*Distribution_Information:*
*Distributor:* unpublished
*Contact_Information:* Oregon Department of Fish and Wildlife
*Contact_Address:* Heppner Field Office
54173 Hwy 74, PO Box 363
Heppner, OR 97836
Tel: (541) 676-5230 Fax: (541) 676-9075
*Address_Type:* mailing address

---

**Oregon 10 m DEM**

*Identification_Information:*
*Data_Set_Credit:*
USGS, Oregon Geospatial Data Clearinghouse and the Oregon Department of Environmental Quality (DEQ).
*Native_Data_Set_Environment:*
Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 3; ESRI ArcCatalog 8.1.2.671

*Citation_Information:*

*Originator:* U.S. Geological Survey (USGS), EROS Data Center

*Publication_Date:* 1999

*Title:* National Elevation Dataset - Oregon 10 m DEM *Edition:* 1

*Geospatial_Data_Presentation_Form:* raster digital data

*Citation_Information:*

*Originator:* U.S. Geological Survey (USGS), EROS Data Center

*Publication_Date:* 1999

*Title:* Oregon 10m DEM

*Edition:* 1

*Geospatial_Data_Presentation_Form:* raster digital data

*Publication_Information:*

*Publication_Place:* Sioux Falls, SD

*Publisher:* U.S. Geological Survey

*Online_Linkage:* \\DAS-00919\E$\cd_sw\dem10sw

*Description:*

*Abstract:* The USGS developed a national elevation dataset (NED). The NED is a seamless mosaic of best available elevation data. The 7.5 minute elevation data for the conterminous US are primarily initial source data. The 10 m dems for Oregon were merged whenever possible in there native UTM projection. The resulting file was projected into the Oregon Lambert projection and clipped into 9 seperate grids for the state of Oregon

*Purpose:* Geospatial Elevation data are utilized by the scientific and resource management communities for global change research, hydrologic modeling, resource monitoring, mapping and visualization applications.

*Supplemental_Information:* These tiles are merges of the 10m DEMs for the state of Oregon in ESRI's ARC/INFO grid format They are in the Oregon Lambert Projection

*Currentness_Reference:* publication date

*Maintenance_and_Update_Frequency:* As needed

*Spatial_Domain:*

*Bounding_Coordinates:*

*West_Bounding_Coordinate:* -124.896200

*East_Bounding_Coordinate:* -117.01801421

*North_Bounding_Coordinate:* 46.14636144

*South_Bounding_Coordinate:* 41.629424

*Access_Constraints:* None

*Use_Constraints:* None. Acknowledgement of the originating agencies (USGS) would be appreciated in products derived from these data.

*Data_Quality_Information:*

*Logical_Consistency_Report:* Checked with ARC/INFO GRID

*Completeness_Report:*

In this version, quads for 41 degrees north are not included. This creates slivers of no data along the Oregon border.

*Process_Description:*

The original 10m DEM files (in .dem format) by quad sheet were obtained from the Oregon Geographical Data Clearinghouse from the BLM and/or USGS Processing had the added challenge of addressing the UTM projection "break" at the 120 degrees west longitude line. The DEMs were merged as far as possible in their native UTM projection to minimize border slivers.

All processing was done in ESRI's ARC/INFO and GRID module. The ARC/INFO "demgrid" command was used to convert each DEM quad sheet to grid format. If necessary, z-units in feet in the original file were converted, using the GRID "con" command, dem_in_meters = con(dem_in-feet > 3,dem_in_feet/3.28,1), to convert to meters to match all other sheets. The sheets converted are: 45121e8 45121f8 45121f7 45121f6 45121f5 45121f4 45122e1 45122e2 45122e3 45122e4 45122e5 45122e6 45122f7 45122f8

If necessary, the GRID "int" command, dem_integer = int(dem_floating + .5), was used to convert any floating point grids to integer grids. Individual tiles were then merged, into 1 degree wide swaths in their original UTM projection , swath = merge(list of quads). For 116, 117, 118, and 119 degrees west this is UTM 11, NAD 27; for 120, 121, 122, 123, and 124 degrees west this is UTM 10, NAD 27.

The swaths of each projection system were merged. The UTM 11 half was projected into UTM 10. At 10m resolution, the DEMs are too large to merge into a single statewide grid. The state is subdivided into 9 tiles for processing and data exchange. The polygons defining these tiles were buffered 100 meters (buffer tile tile_buffer # # 100 # poly). The resultant buffer polygons were then used to clip the two merged grids. The 120 degree and west DEM grid was clipped with the northwest, west, and southwest tile buffers and the 120 degree and east DEM grid was clipped with the northeast, east and southeast tile buffers. The center set of buffers (north, center, and south) straddle the 120 degree west longtitude line. Both the 120 degree west DEM and 120 degree east DEM were clipped with those center buffer polygons. The resultant halves were then merged into complete north, center and south tiles.

Each grid tile was projected from UTM into the state standard lambert projection for Oregon using the ARC/INFO "project grid" command with bilinear transformation. The final processing step involved converting the z-units from meters to feet and converting back to an integer grid.

*Process_Date:* 20020124

*Spatial_Data_Organization_Information:*

*Direct_Spatial_Reference_Method:* Raster

*Raster_Object_Information:*

*Raster_Object_Type:* Grid Cell

*Row_Count:* 18732

*Column_Count:* 24662

*Vertical_Count:* 1

*Spatial_Reference_Information:*

*Horizontal_Coordinate_System_Definition: Planar*

*Map_Projection:*
*Map_Projection_Name:* Lambert Conformal Conic
*Lambert_Conformal_Conic:*
*Standard_Parallel:* 43.000000
*Standard_Parallel:* 45.500000
*Longitude_of_Central_Meridian:* -120.500000
*Latitude_of_Projection_Origin:* 41.750000
*False_Easting:* 1312336.000000
*False_Northing:* 0.000000
*Planar_Coordinate_Information:*
*Planar_Coordinate_Encoding_Method:* row and column
*Coordinate_Representation:*
*Abscissa_Resolution:* 32.828670
*Ordinate_Resolution:* 32.828670
*Planar_Distance_Units:* User_Defined_Unit
*Geodetic_Model:*
*Horizontal_Datum_Name:* North American Datum of 1983
*Ellipsoid_Name:* Geodetic Reference System 80
*Semi-major_Axis:* 6378137.000000
*Denominator_of_Flattening_Ratio:* 298.257222
*Entity_and_Attribute_Overview:* Values - z -value in feet (range varies between tiles
*Entity_and_Attribute_Detail_Citation:* USGS 10 M DEM web page
*Contact_Information:*
*Contact_Organization:* Oregon Geospatial Data Clearinghouse (OGDC)
*Contact_Person:* Data Administrator
*Contact_Position:* Data Administrator
*Address_Type:* mailing address
*Address:* 955 Center ST NE Rm 470
*City:* Salem
*State_or_Province:* OR
*Postal_Code:* 97301
*Country:* USA
*Contact_Voice_Telephone:* 503-378-2166
*Contact_Electronic_Mail_Address:* gis@web1.css.das.state.or.us
*Distribution_Liability:* The OGDC and the State of Oregon assume no libality for the GIS product
*Format_Name:* ARC/INFO GRID
*Format_Version_Number:* 8.1
*Format_Specification:* ARC/INFO GRID
*Format_Information_Content:* ARC/INFO GRID
*File_Decompression_Technique:* zip
*Transfer_Size:* 517.993
*Digital_Transfer_Option:*
*Online_Option:* <http://buccaneer.geo.orst.edu/dem/>
*Computer_Contact_Information:*

*Fees:* None if download digitally
*Metadata_Reference_Information:*
*Metadata_Date:* 20021219
*Contact_Organization_Primary:*
*Contact_Organization:* Oregon Geospatial Data Clearinghouse (OGDC)
*Contact_Person:* Data Administrator
*Contact_Address:*
*Address_Type:* mailing address
*Address:* 955 Center St. NE Rm. 470
*City:* Salem
*State_or_Province:* OR
*Postal_Code:* 97301
*Country:* USA
*Contact_Voice_Telephone:* 503-378-2166
*Contact_Electronic_Mail_Address:* gis@web1.css.das.state.or.us
*Metadata_Standard_Name:* FGDC Content Standards for Digital Geospatial Metadata
*Metadata_Standard_Version:* FGDC-STD-001-1998
*Metadata_Time_Convention:* local time
*Metadata_Access_Constraints:* None
*Metadata_Use_Constraints:* None
*Metadata_Extensions:*
*Online_Linkage:* <http://www.esri.com/metadata/esriprof80.html>
*Profile_Name:* ESRI Metadata Profile

**Appendix G. Analyses of selection for soil type by dispersing Washington ground squirrels.** Two analyses were conducted for each site with the exception of Cemetery, which had only one soil type present. Chi-squared analyses were carried out for each. Selection ratios and CIs are given.

| Site | Veg Type | m[a] | pi[b] | u[c] | o[d] | w[e] | LCL[f] | UCL[g] | XI^2[h] | df[i] | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All | Warden | 1311 | 0.89 | 45 | 0.87 | 0.98 | 0.86 | 1.1 | 2.49 | 3 | 0.48 |
| | Sagehill | 97 | 0.07 | 2 | 0.04 | 0.59 | -0.33 | 1.51 | | | |
| | Royal | 27 | 0.02 | 2 | 0.04 | 2.11 | -1.29 | 5.51 | | | |
| | Other | 45 | 0.03 | 3 | 0.06 | 1.9 | -0.57 | 4.36 | | | |
| All | Warden silt loam | 1136 | 0.77 | 39 | 0.75 | 0.98 | 0.79 | 1.17 | 4.64 | 5 | 0.46 |
| | Warden sandy loam | 175 | 0.12 | 6 | 0.12 | 0.98 | 0.06 | 1.89 | | | |
| | Sagehill | 97 | 0.07 | 2 | 0.04 | 0.59 | -0.40 | 1.57 | | | |
| | Duneland | 15 | 0.01 | 0 | 0.00 | 0.10 | -0.94 | 1.14 | | | |
| | Royal | 27 | 0.02 | 2 | 0.04 | 2.11 | -1.52 | 5.74 | | | |
| | Other | 30 | 0.02 | 3 | 0.06 | 2.85 | -1.17 | 6.86 | | | |
| TUB | Warden | 238 | 0.64 | 18 | 0.75 | 1.17 | 0.84 | 1.49 | 5.91 | 3 | 0.12 |
| | Sagehill | 97 | 0.26 | 2 | 0.08 | 0.32 | -0.17 | 0.80 | | | |
| | Royal | 25 | 0.07 | 2 | 0.08 | 1.23 | -0.71 | 3.18 | | | |
| | Other | 10 | 0.03 | 2 | 0.08 | 3.08 | -2.07 | 8.24 | | | |
| TUB | Warden silt loam | 238 | 0.47 | 17 | 0.71 | 1.52 | 1.01 | 2.02 | 19.76 | 5 | 0.001 |
| | Warden sandy loam | 140 | 0.27 | 1 | 0.04 | 0.15 | -0.20 | 0.51 | | | |
| | Sagehill | 97 | 0.19 | 2 | 0.08 | 0.44 | -0.28 | 1.15 | | | |
| | Duneland | 7 | 0.01 | 0 | 0.00 | 0.07 | -1.05 | 1.20 | | | |
| | Royal | 25 | 0.05 | 2 | 0.08 | 1.70 | -1.17 | 4.57 | | | |
| | Other | 3 | 0.01 | 2 | 0.08 | 14.17 | -15.98 | 44.31 | | | |
| MY | Warden | 460 | 0.93 | 13 | 0.93 | 1.00 | 0.84 | 1.16 | 0.52 | 2 | 0.77 |
| | Duneland | 8 | 0.02 | 0 | 0.00 | 0.00 | -0.29 | 0.30 | | | |
| | Xeric torrey | 26 | 0.05 | 1 | 0.07 | 1.36 | -1.48 | 4.19 | | | |
| MY | Warden silt loam | 425 | 0.86 | 13 | 0.93 | 1.08 | 0.89 | 1.26 | 2.53 | 3 | 0.47 |
| | Warden sandy loam | 35 | 0.07 | 0 | 0.00 | 0.00 | -0.07 | 0.07 | | | |
| | Duneland | 8 | 0.02 | 0 | 0.00 | 0.00 | -0.31 | 0.32 | | | |
| | Other | 26 | 0.05 | 1 | 0.07 | 1.36 | -1.63 | 4.35 | | | |
| CEM | Warden silt loam, 0 to 2 % slope | 19 | 0.04 | 0 | 0.00 | 0.00 | -0.13 | 0.14 | 4.23 | 4 | 0.38 |
| | Warden silt loam, 2 to 5 % slope | 187 | 0.38 | 5 | 0.36 | 0.93 | 0.14 | 1.72 | | | |
| | Warden silt loam, 5 to 12 % slope | 148 | 0.30 | 4 | 0.29 | 0.94 | 0.00 | 1.88 | | | |
| | Warden silt loam, 12 to 20 % | 116 | 0.24 | 5 | 0.36 | 1.50 | 0.22 | 2.79 | | | |
| | Warden eroded silt loam | 18 | 0.04 | 0 | 0.00 | 0.00 | -0.14 | 0.14 | | | |

[a] m = Number of random points in each soil category

[b] pi = proportion of available soil types at each site

[c] u = Number of post-dispersal settlement locations in each soil type

[d] o = Proportion of settlement locations in each soil type

[e] w = o/pi; the estimated selection ratio

[f] LCL = Lower limit of the estimated 95% confidence interval for w

[g] UCL = Upper limit of the estimated 95% confidence interval for w

[h] XI^2 = Value of the Chi-squared statistic

[i] df = degrees of freedom

AN ABSTRACT OF THE THESIS OF

Eric Greene for the degree of Master of Science in Wildlife Science presented on October 26, 1999. Title: Abundance and Habitat Associations of Washington Ground Squirrels in North-Central Oregon.

Abstract approved: Signature redacted for privacy.

Robert G. Anthony

Much of the Columbia River Basin has been cultivated for agriculture, which has reduced and fragmented the native shrub-steppe habitats. As a result, the range of the Washington ground squirrel (*Spermophilus washingtoni*) has been significantly reduced, prompting the states of Washington and Oregon to review their status. Consequently, I investigated abundance and habitat selection of Washington ground squirrels on the Boardman Bombing Range, Morrow County, Oregon during February through July of 1996 - 1997. Transect surveys were used to determine relative abundance among seven habitats, and live-trapping was used to compare density of squirrels in habitats in which they were present. Habitat associations were determined by comparing vegetative and soil characteristics at occupied sites and unoccupied sites. I made comparisons at two levels of resolution: a macro-habitat and a micro-habitat comparison at the colony level.

Micro-habitat analysis used matched-pair logistic regression to compare habitat characteristics of colonies to a paired site where squirrels were not present.

I located 44 colonies to investigate the habitat associations of this species. Transect surveys indicated highest densities in sagebrush, followed by grassland habitat. No squirrels were detected in bitterbrush or low-shrub habitats during the transect surveys. Results from capture-recapture methods also suggested higher densities in sagebrush habitat. Recruitment was highest in sagebrush followed by bunchgrass and low-shrub habitats. Mean weight for adult and juvenile squirrels were highest in bunchgrass habitat, followed by sagebrush and low-shrub. Mean maximum distance moved was greater for males than females ($P = 0.0006$) for adults and juveniles alike, while sex-ratios favored females in both age classes. Habitat associations at the macro-habitat level revealed selection for sites with a higher silt content (Warden soils) of the soil ($P = 0.0006$) and higher vegetative cover ($P = 0.032$). Micro-habitat associations indicated a selection for sites with a lower clay content of the soil ($P = 0.004$).

The continued existence of Washington ground squirrels depends upon maintenance of the remaining suitable habitat, particularly large contiguous tracts. Moderate grazing does not appear to be incompatible with squirrels, though grazing intensity should be investigated in further studies.

# Abundance and Habitat Associations of Washington Ground Squirrels in North-Central Oregon

By

Eric Greene

A THESIS

Submitted to

Oregon State University

In partial fulfillment of
The requirements for the
Degree of

Master of Science

Presented October 26, 1999
Commencement June 2000

ACKNOWLEDGEMENTS

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Abundance and Habitat Associations of
Washington Ground Squirrels in North-Central Oregon

## INTRODUCTION

The Washington ground squirrel (*Spermophilus washingtoni*) inhabits the shrub-steppe and grassland habitats of the Columbia Basin in Eastern Oregon and south-central Washington. It is a member of the family Sciuridae that includes 20 congeners in Western North America, nine of which occur in Oregon and Washington (Verts and Carraway 1998; 181-203). It is a semi-fossorial species that estivates and hibernates 7 to 8 months of the year and is active from about February until mid-June, depending on weather conditions. Historically its range was on the South and East side of the Columbia River from the mouth of the John Day River, east to Walla Walla, Washington, and North to Spokane, Washington (Bailey 1936). Conversion of the native shrub-steppe habitat to cultivated agriculture has reduced and fragmented the remaining habitat causing a significant decline in the range (Figure 1) of Washington ground squirrels (Betts 1990).

Washington ground squirrels are a unique species within the Columbia River Basin and are important ecologically as a prey species. Ferruginous (*Buteo regalis*) and Swainson's (*Buteo swainsoni*) hawks, both species of special concern, are among the raptorial birds that occur in the area and have been observed to prey upon Washington ground squirrels (Russ Morgan, Aaron Holmes, pers. comm). Video monitoring of one ferruginous hawk nest in 1996 revealed that seven of

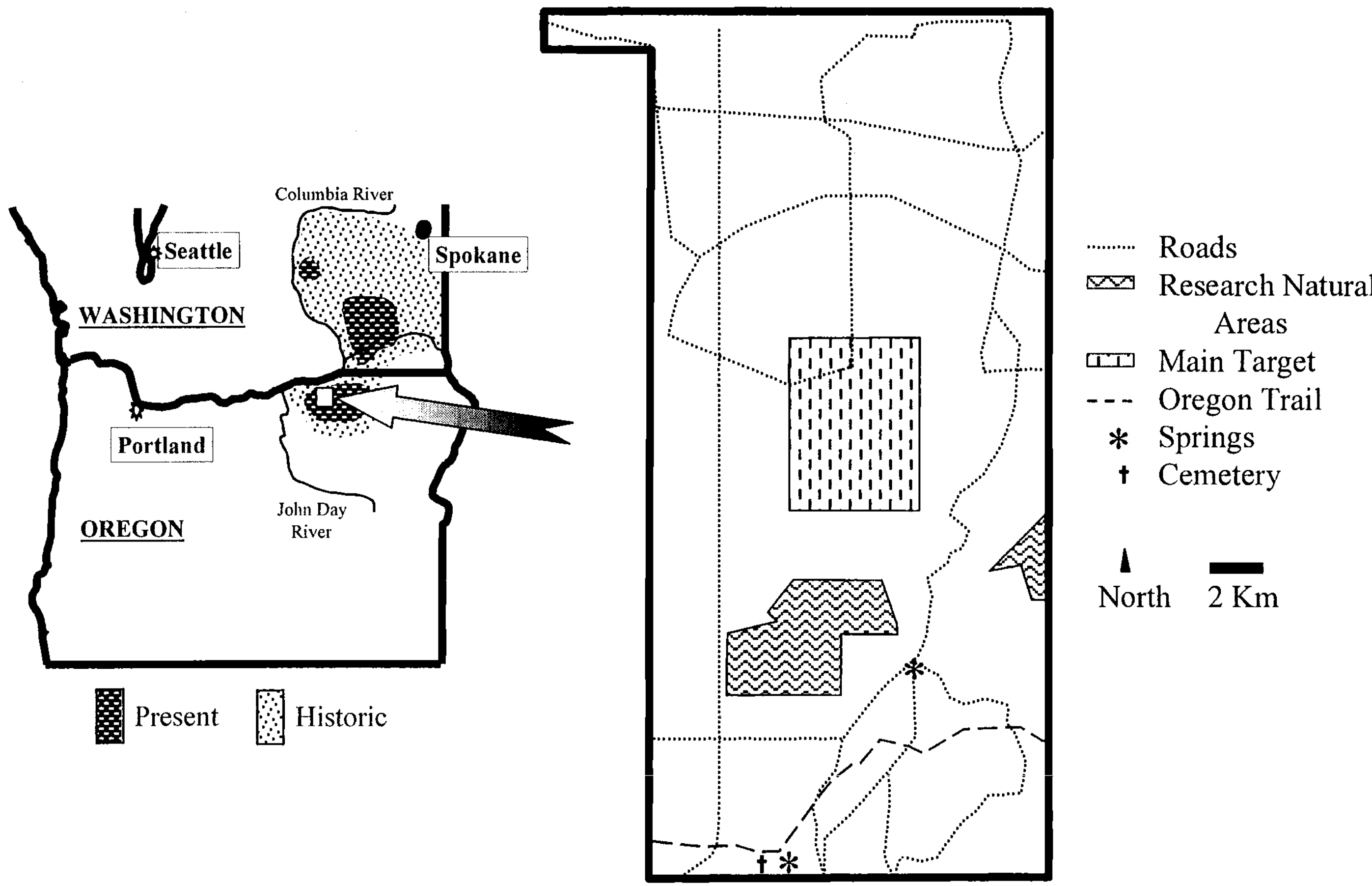


Figure 1. Present and historic ranges of Washington ground squirrels, and map of features on Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

nineteen prey items returned to the nest were Washington ground squirrels (Russ Morgan, pers. comm). The squirrels' diurnal habits, and active period, which coincide with the nesting and fledging period of these raptors, enhance its role as prey for these birds. Other major predators include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), long-tailed weasels (*Mustela frenata*), western rattlesnakes (*Erotalis viridus*), and gopher snakes (*Pituophis melanoleucus*) (Quade 1994). Depredation of Washington ground squirrels by badgers creates burrows that are reused by many species including snakes, lizards, ground squirrels, insects, and most notably, burrowing owls (*Speotyto cunicularia*) (Green and Anthony 1989).

There have been relatively few studies on the Washington ground squirrel, and most early information was anecdotal (Bailey 1936, Dalquest 1948, Howell 1938, Scheffer 1941). Bailey (1936) characterized the squirrel as an agriculture nuisance with populations estimated at 100 to 250 per hectare. After years of control and conversion of their habitat, a 1971 search for the species in Oregon proved unsuccessful (Olterman 1972); however, a search by Rohweder et al. (1979) revealed scattered colonies on the Naval Weapons System Training Facility (hereafter bombing range) in northcentral Oregon. The bombing range is particularly noteworthy because it is the largest unfragmented tract of native shrub-steppe vegetation in Oregon (Kagan 1987). Interest in the species has increased since then with studies focusing on its abundance, range, and habitat preferences (Carlson et al. 1980, Betts 1990, Quade 1994); however, Betts' (1990) study is the only study to have been published. Betts (1990) determined that of the 179 sites in

Oregon and Washington historically occupied by Washington ground squirrels, 68 were vacated. Approximately half (35) of the 68 abandoned sites had been vacated during the ten years preceding 1990. Of the remaining occupied sites he considered another 25 to be highly vulnerable to extirpation because of their small size and isolation. Moreover, during a follow up study conducted in 1998, Betts (1999) revisited sites known to be active during 1989 and found that 25 of the 36 colonies in Oregon were vacated. Currently, the Washington ground squirrel is listed as a species of special concern in Washington and is being considered for threatened or endangered status in Oregon.

The purpose of this study was to investigate relative abundance and specific habitat associations of Washington ground squirrels in the habitats that occur on the bombing range. Presumably, the habitat(s) in which they are most abundant provides a more suitable structure and/or composition of the vegetation and soils.

The specific hypotheses of my study were:

$H_1$: Washington ground squirrels have similar densities among different vegetative types (macro-habitat level), and

$H_2$: Washington ground squirrels do not show selectivity for certain soil or vegetation characteristics within the vegetative types (micro-habitat level).

To address these hypotheses I established the following objectives:

1) Compare densities of Washington ground squirrels among the seven dominant vegetative cover types found of Boardman Bombing Range.

2) Compare soil and vegetative characteristics among those habitats in which Washington ground squirrels were and were not detected (macro-habitat level).

3) Compare relative abundance, sex-age ratios, weights, and recruitment in selected vegetation types.

4) Compare soil and vegetative characteristics at sites where Washington ground squirrels were and were not detected (micro-habitat level).

Objective 2 and 4, while similar, are comparing habitat characteristics at two scales. Objective 2 is comparing *habitats* in which the species occurs and does not occur, while objective 4 is comparing specific *sites* where the species (colonies) occurs and does not occur.

# METHODS

## Study Area

The study was conducted in the spring and summer of 1996 and 1997 on the 19,070 hectare Boardman Bombing Range near Boardman, Oregon, presently managed by the U.S. Navy for use as an aerial target range. The bombing range is approximately 275 km east of Portland, Oregon in the shrub-steppe habitat of the Columbia River Basin (Figure 1). Elevation ranges from 125 m on the north end of the bombing range rising up to 275 m elevation in the south end. Mean annual rainfall is approximately 22 cm, most of which falls in winter and early spring. Summers are very hot and dry by July, which desiccates the vegetation until winter rain returns. High winds are common during spring, often exceeding 45 KPH.

The area is a mosaic of vegetative types, ranging from bitterbrush shrublands on sandy soils of the northern end, to bunchgrass and sagebrush communities on the loamy soils of the southern end. In the spring the bombing range is grazed by livestock except for two fenced Research Natural Areas (RNA's) maintained by The Nature Conservancy. Historical features of the Boardman Bombing Range include seven miles of the Oregon Trail, a pioneer cemetery, and remnants of developed springs which can still be found on the southern end of the bombing range.

**Habitats**

Five broadly defined vegetative communities were selected for investigation and comparison, including annual grassland, low shrubland, bitterbrush shrubland, sagebrush shrubland and perennial grassland (Figures 2a-f). Sagebrush shrubland and perennial bunchgrass habitats were further sub-classified into grazed and ungrazed segments for a total of seven habitats.

Annual grass habitat consists primarily of cheatgrass (*Bromus tectorum*), an exotic species introduced from Europe. Cheatgrass is considered poor quality forage which grows in a dense carpet that excludes other species. It has been described as a zootic climax and is a result of heavy grazing in the bunchgrass habitat (Poulton 1955, Daubenmire 1970).

Bunchgrass habitat is a mixture of needle-and-thread grass (*Stipa comata*) and bluebunch wheatgrass (*Agropyron spicatum*), both natives to the region. The largest intact stands of this habitat remaining in the Oregon portion of the Columbia basin are believed to occur on the bombing range where they have been protected from livestock grazing. In stands of better condition, open spaces between the bunchgrass plants are dominated by microbiotic crust, which helps prevent wind erosion and establishment of exotic plant species. Within the bunchgrass habitat, needle-and-thread is typically dominant in the sandier soils while bluebunch wheatgrass is the dominant grass species in loamy soils. Other common native bunchgrass species that occur in the region are Indian ricegrass (*Oryzopsis*

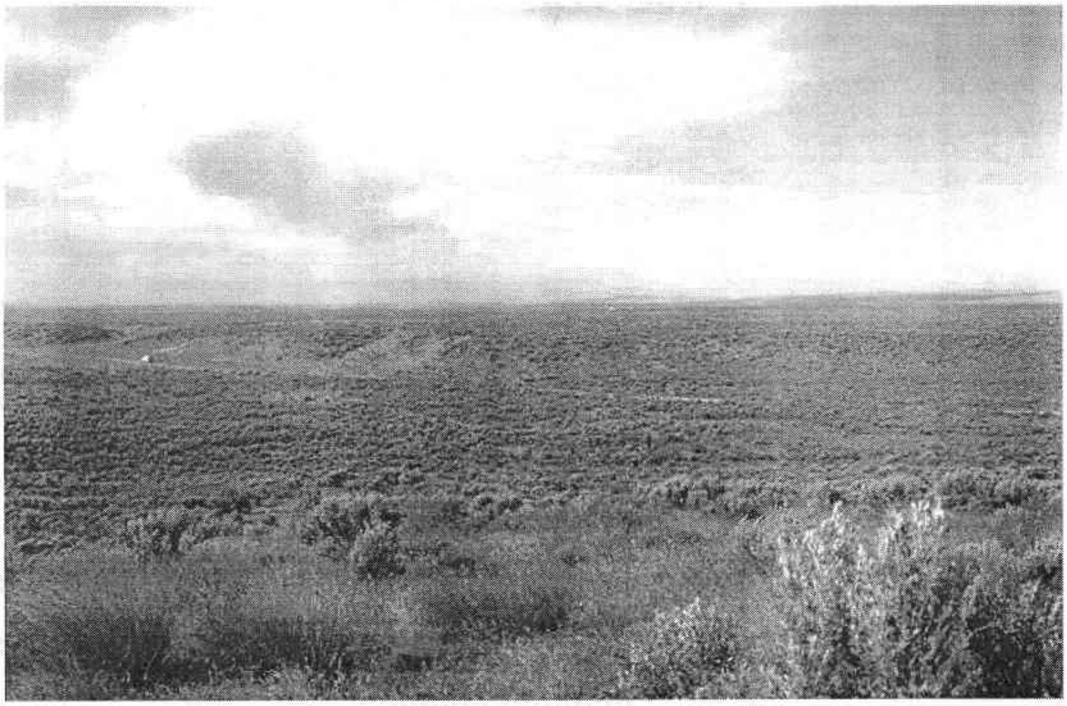

Figure 2a. Sagebrush habitat on Boardman Bombing Range, 1996.

Figure 2b. Sagebrush habitat on Boardman Bombing Range, 1996.

Figure 2c. Annual grass habitat on Boardman Bombing Range, 1996.

Figure 2d. Bunchgrass habitat on Boardman Bombing Range, 1996.

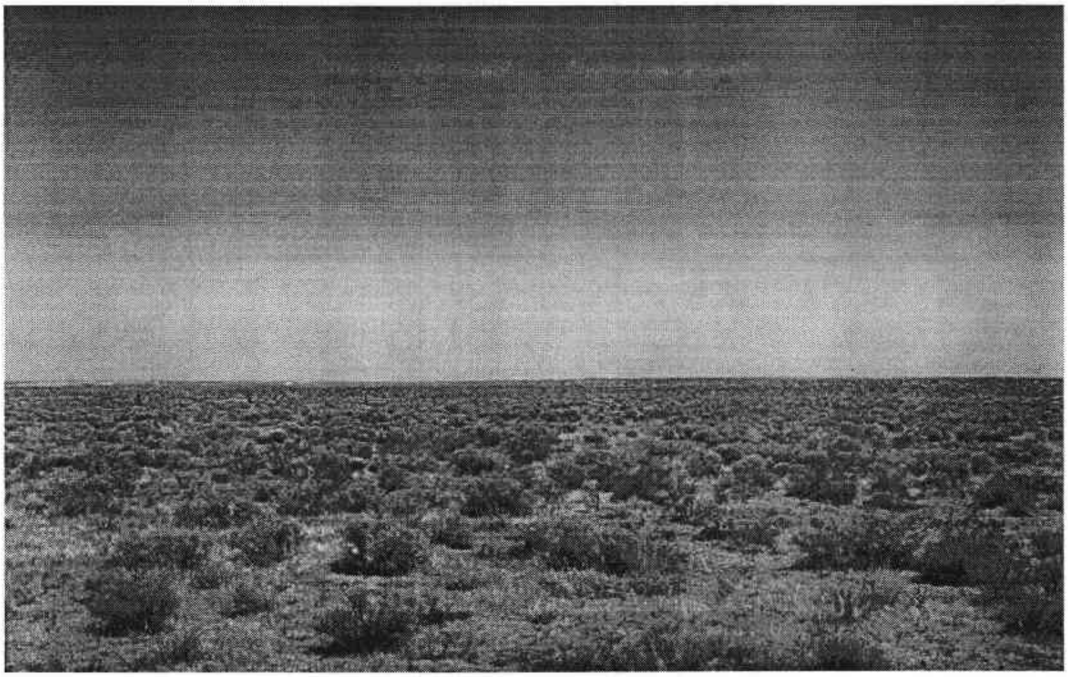

Figure 2e. Low-shrub habitat on Boardman Bombing Range, 1996.

Figure 2f. Bitterbrush habitat on Boardman Bombing Range, 1996.

*hymenoides*), Idaho fescue (*Festuca idahoensis*), and squirreltail bottlebrush (*Sitanion hystrix*).

Low shrub habitat primarily consists of two species of rabbitbrush (*Chrysothamnos spp.*) and snakeweed (*Gutierrezia sarothrae*). These species occur on the sandier soils of the study area and are indicative of heavy grazing and fire on sagebrush and bunchgrass habitats. Many native forbs like mariposa lily (*Calochortus macrocarpus*) and Douglas' brodiaea (*Brodiaea douglasii*) occur in the open space between shrubs, however cheatgrass often dominates these spaces.

Sagebrush habitat occurs throughout the study area and is dominated by big sagebrush (*Artemisia tridentata*). Understory vegetation within sagebrush habitats varies from microbiotic crust in areas of low grazing intensity to various mixtures of cheatgrass, bunchgrass and annual forbs, with cheatgrass dominating the spaces between shrubs in heavily impacted areas.

Bitterbrush habitat occurs in the sandy soils of the north end of the study area and is dominated by antelope bitterbrush (*Purshia tridentata*) with an understory of annual grasses (primarily cheatgrass) and forbs including western wallflower (*Erysimum occidentale*) and cluster tarweed (*Madia glomerata*).

## Study Area Design

Within each habitat, three study plots were established by randomly selecting coordinates for the southwest corner of a 40 hectare, square-shaped area (633 meters on a side). If the habitat could not be classified into one of the seven types, the plot was rotated so that the random coordinates became the northeast corner of the plot. If the habitat still could not be classified, new random coordinates were generated. Several of the plots were rectangular to fit within boundaries of existing fencelines which separated grazed and ungrazed treatments. These plots were used to address the first objective of this study which was to compare densities of Washington ground squirrels in the vegetative cover types on the study area.

Habitat associations were investigated at two resolutions. The 40 ha plots were used for the macro-habitat comparisons (Objective 2) which measured site selectivity *among* the habitats. A finer level of micro-habitat associations was investigated by collecting data at sites located within Washington ground squirrel colonies (Objective 4). Some of these colonies were live-trapped (Objective 3). To distinguish between the different levels of habitat associations, I will refer to locations found on the plots used in the macro-habitat analysis as "plot-points", and the locations within squirrel colonies used in the micro-habitat analysis as "colony sites".

**Abundance Measures**

**Line Transects**

Line transect surveys were performed in each of the habitats to compare relative abundance of Washington ground squirrels at a sudy-wide level. In 1996 the transects were traversed once on each plot (n = 21). In 1997 transects were traversed on each plot and one additional plot per vegetation (n = 28). Detections were counted when a squirrel was seen or heard. We conducted the surveys during the period of increased alarm calling that corresponds with juvenile emergence from natal burrows. This was a 3 to 4 week period starting approximately April 15 and lasting to May 13 during both years.

Transect lines were parallel, 60 m apart, and extended to the boundaries of the plot. We chose that distance because alarm calls could dependably be heard at distances of up to 30 m, and the distance was doubled to minimize overlap among transects. Two assumptions of this method are that the observer never strays from the transect line, and that the distances from the line are measured accurately. To meet both of these assumptions the observer placed a wire flag in the ground at the position where the detection was made then resumed the survey. Upon completion of the survey, the observer returned to the flag to confirm the presence of squirrels and make accurate measurements of distance.

### Capture-Recapture Methods

Trapping grids were placed on Washington ground squirrel colonies in sagebrush, low shrub, and bunchgrass habitats to determine relative abundance within colonies. Three replicate grids were trapped in each of these habitats in 1997 between March 28 and June 6 (Figure 3). The grid was oriented with its center at the estimated center of the colony and consisted of 100 tomahawk live traps arranged in a grid with 20-meter intervals between traps.

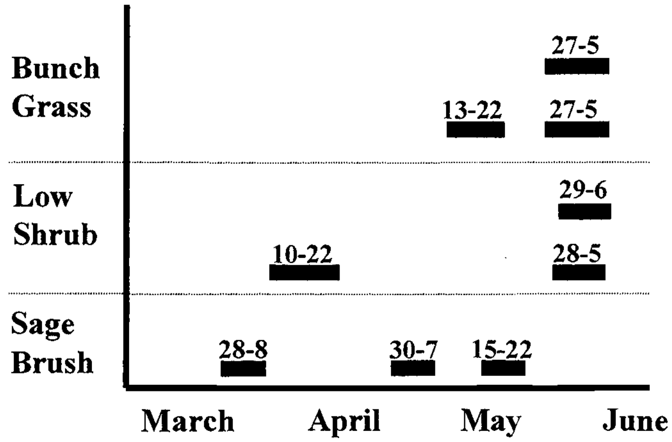


Figure 3. Timing of live-trapping for Washington ground squirrels, 1997, Boardman Bombing Range, Morrow County, Oregon.

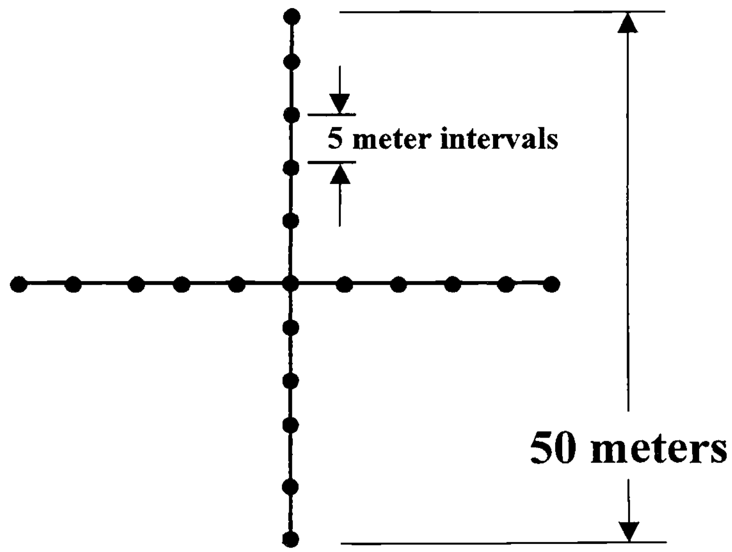


Figure 4. Layout for data collection of habitat variables, 1996-1997

We used a 10 x 10 configuration for all grids except for a 5 x 20 grid set up to mimic the shape of a colony, and a 9 x 11 grid modified to avoid a fence. Traps were opened and baited with apple in the morning and checked during the middle of the day (11:00 - 2:00) to avoid heat stress of captured animals. We placed traps under vegetation when possible or covered them with wood, cow dung, or cardboard to minimize exposure to the sun.

## Habitat Associations

### Macro-Habitat Associations

Vegetative and soil characteristics were measured on the 21 plots by collecting data at five points systematically distributed in an 'X' shape covering each plot for a total of 105 plot-points. Of the 105 plot-points, those where ground squirrels were present were compared to those where ground squirrels were not detected. Presence and absence was determined in 50 m radius around the plot-point.

### Micro-Habitat Associations

Vegetative and soil characteristics were also measured within Washington ground squirrel colonies. A site was considered a colony if there was indisputable evidence that it was inhabited by squirrels. Evidence included seeing or hearing squirrels in the vicinity of burrows or fresh scats found by burrow entrances. Colony locations were obtained by any means available, including observations from a Point Reyes Bird Observatory crew.

The study design for the colony sites was a paired analysis. For each occupied colony we located a paired unoccupied site within the same habitat type. The paired site will hereafter be referred to as an "unoccupied site". Unoccupied sites were found by moving 250 meters from the colony site in a randomly chosen direction. We determined 250 meters was an appropriate distance after observing movements of squirrels within colonies and because Carlson et al. (1980) observed

239 meters as the longest distance moved. Each prospective unoccupied site was surveyed for presence of Washington ground squirrels within a 50 meter radius by listening and looking for signs of squirrels (sightings, alarm calls, burrows, or scat). If evidence of squirrels was present on the prospective site, another site was chosen in the same manner starting from the rejected site.

**Habitat Variables**

For each plot-point, colony site, and unoccupied site we measured percent vegetative cover by species, vertical density by life form, effective height of the vegetation, percent shrub cover, and collected soil samples for texture analysis (Table 1). To obtain these measurements and samples, we established two 50 m transect lines set perpendicular to each other, oriented in the cardinal directions and crossing at their midpoints (Figure 4).

*Percent Cover* by species was determined by taking 10 measurements at 5 m intervals (n = 220) along the transect lines. We used a modification of the point intercept method, with a sighting scope instead of a rod lowered into the vegetation (Pieper 1973). The vegetation at the cross hair intersection was recorded by species. For analysis, the species were pooled into percent cover for each of the seven life form categories which were annual grass, perennial grass, forb, shrub, microbiotic crust, litter, and bare ground.

*Vertical Density* was measured four times at each 5 m interval (n = 88) with a 6mm-diameter rod (Wiens 1973). The rod, marked in 10-cm increments, was

Table 1. Habitat characteristics measured at plots and sites occupied by Washington ground squirrels and sites where squirrels were not found.

| **Variable** | **Description** |
|---|---|
| Vegetation Category | Shrub or grass classification of habitat |
| Vertical Density < 30cm<br>Vertical Density > 30cm | Vegetation contacts along 6mm rod below and above 30 cm (Wiens 1973) |
| Diversity Index of Vertical Density | Shannon-Weiner index for vertical density (Zar 1984) |
| Mean Effective Height | Height at which 90% of a 30 cm wide board is obscured by vegetation (Wiens 1973) |
| Coefficient of Variation for the Effective Height | Coefficient of variation for effective height |
| Annual Grass Cover (%)<br>Perennial Grass Cover (%)<br>Forb Cover (%)<br>Litter Cover (%)<br>Bare Ground Cover (%)<br>Microbiotic Crust Cover (%) | Percent canopy cover of grasses, forbs, litter, bare ground, and microbiotic crust (Pieper 1973) |
| Shrub Cover (%) | Percent canopy cover of shrubs from line transect (Pieper 1973) |
| Clay (%)<br>Silt (%)<br>Sand (%)<br>Coarse Material (%) | Soil content of particles < 0.002 mm<br>Soil content of particles < 0.05 - 0.002 mm<br>Soil content of particles < 2 - 0.05 mm<br>Soil content of particles >2 mm |

lowered through the vegetation vertically until it rested on the ground. We recorded the number of times the rod was touched by vegetation in each 10 cm interval. The vegetation was recorded in life form categories similar to those used in the percent cover. Three variables were created from these data for the analysis: 1) the proportion of all contacts that were below 30 cm, 2) the proportion above 30 cm, and 3) Shannon-Wiener index of diversity (Zar 1984) for the number of contacts among the 10 cm increments.

*Effective Height* was measured once at each 5 m interval (n = 22) using a red and white 30-cm wide plank with a 3 cm square checkerboard pattern. We recorded the height at which greater than or equal to 90 % of the board was obscured by vegetation when it was viewed at eye level from 10 m (Wiens 1973). The average effective height and the coefficient of variation for this variable were calculated for the habitat comparisons.

*Shrub Intercept* was measured along the transect lines for a total of 100 meters of transect at each site. The distance along the transect line that was overlaid by shrubs was recorded by species, and whether the plant was live or dead. The percent shrub cover was computed as the intercept distance divided by the total length of the transect line (Pieper 1973).

A *soil sample* was collected from a depth of 30 cm at each end of the transect lines and at their intersection for a total of five samples. For laboratory analysis, I combined the five samples from each location to make a composite sample for the location. For several locations, I analyzed the five individual samples separately to determine variation within the sites. Soil texture (i.e. percent sand, silt, and clay) was determined using the hydrometer method according to the American Society for Testing Material procedures (Day 1965).

**Statistical Analysis**

**Abundance Estimates from Transects**

Estimates of density, effective sampling width, and a probability of detection were calculated in program DISTANCE using the perpendicular distance of the squirrel from the transect line, and the total length of transect line sampled (Laake et al. 1993, Buckland et al. 1993). Perpendicular distance was calculated with the equation $X(\sin\theta)$, with 'X' equal to the distance of the observer from the squirrel, and '$\theta$' equal to the angle between the bearing of the transect line and the bearing to the squirrel. Because vegetation structure may have affected detectability, estimates were obtained for each habitat type. Distances were pooled into 20 meter intervals to account for movements of animals in response to the observer.

Habitats in which there were no detections were not included in the analysis. Not including these habitats allowed me to address a more biologically significant question which was to determine the relative abundance of Washington ground squirrels within habitats in which they do occur.

**Abundance Estimates from Mark-Recapture Methods**

Captured animals were aged, weighed, sexed, and individually marked by toe clips, with age determined by pelage and weight. For animals captured early in the season (before April 28), age was easily distinguished by pelage and weight; juveniles were 29-57 grams, while adults were 126-174 grams. Animals caught later in the season were more difficult because many juvenile animals had attained weights comparable to some adults. Later in the season, weights of adults ranged from 110-244 grams while weights of juveniles ranged from 64-169 grams. Pelage and overall body size aided in determining age of these individuals.

Population size was estimated from capture-recapture methods using program CAPTURE (Otis et al. 1978, White et al. 1982). Model selection for population estimation was based on selection procedures in CAPTURE and appropriateness of the estimate and confidence intervals. Models used for estimates accounted for any heterogeneity of behavior among animals (dominance, territoriality), response to being trapped (trap-shy or trap-happy animals), and evidence of time effects such as weather which may have affected trap-ability of animals (White et al. 1982). Density was estimated by dividing the population estimate by the effective trapping area of the grid. Movements of squirrels beyond the trapping grid perimeter were accounted for by using effective trapping area which is calculated by adding one-half of the mean maximum distance moved (MMDM) to each side of the grid (Wilson and Anderson 1985). Analysis of variance was used to compare mean maximum distance moved for each sex and age class and also among habitats.

**Habitat Associations**

At the macro-habitat level, vegetative and soil characteristics at the plot-points were compared based on the presence or absence of Washington ground squirrels using logistic regression. Outlier plot-points were first identified using scatterplots and removed from the analysis if they were more than three standard deviations from the mean. Univariate analysis and correlation were used to determine insignificant or redundant variables with SAS (1989). Variables with a *P*-value $\geq 0.25$ in the univariate analysis or those correlated with another variable at $r \geq 0.7$ were not included in the selection of a multivariate model (Hosmer and Lemeshow 1989; 83). In the case of correlation, biological significance and ease of interpretation determined which variable was retained in the model. I also expanded the model to include interactions between the soil and vegetative variables that remained in the multivariate model. Interactions were critiqued at a more critical level and considered significant if their *P*-value $\leq 0.10$ (Hosmer and Lemeshow 1989; 89). Variables in the resulting model were further pared using Wald's test, and the succeeding models were evaluated using drop in deviance and Akaike's Information Criteria (Hosmer and Lemeshow 1989; 90).

At the micro-habitat level, vegetative and soil characteristics of Washington ground squirrel colonies were compared to unoccupied sites using matched-pair logistic regression. With this analysis, the explanatory variable is the arithmetic difference between the variables measured at the paired sites. After obtaining the difference, variable reduction and model selection was conducted identically to the macro-habitat analysis described above.

# RESULTS

## Abundance

Both line transect and capture-recapture abundance estimates revealed that Washington ground squirrels were more abundant in sagebrush habitat than in the other habitats. However, these two estimators of abundance reflect two different scales; line transects provide estimates at the study-wide level, while capture-recapture provides estimates within colonies.

### Line Transects

Washington ground squirrel colonies were not abundant; therefore we had few detections along transects. In an effort to obtain the sufficient sample size for estimates in program DISTANCE, detections were pooled from both years, and the grazed/ungrazed treatment was disregarded for analysis of the transect data. Sagebrush habitat had fifteen detections of Washington ground squirrel colonies, bunchgrass had nine, and annual grass habitat had two. Sagebrush, with a taller, more concealing structure, had lower probabilities of detection and a smaller effective sampling width (Table 2) but still had the most detections. No detections were made in low shrub and bitterbrush habitats during line transect sampling.

Table 2. Transect distances, number of detections, and results of DISTANCE analysis for transect surveys of Washington ground squirrels, Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

| | **Colony Detections** | | | **Density** | | **Effective** |
|---|---|---|---|---|---|---|
| **Pooled Habitats** | **Det** | **Km** | **Det/10 Km** | **($Km^2$)[a]** | **P(Det)[a]** | **width (m)[a]** |
| Sagebrush | 15 | 113.1 | 1.3 | **0.35** | 0.31 | 18.9 |
| Bunchgrass | 9 | 149.0 | 0.6 | **0.08** | 0.67 | 40.0 |
| **Habitat** | | | | | | |
| Grazed Sagebrush | 12 | 67.2 | 1.8 | | | |
| Ungrazed Sagebrush | 3 | 45.9 | 0.7 | | | |
| Grazed Bunchgrass | 2 | 109.6 | 0.2 | | | |
| Ungrazed Bunchgrass | 7 | 39.7 | 1.8 | | | |
| Annual Grass | 2 | 43.1 | 0.5 | | | |
| Low Shrub | 0 | 53.7 | 0.0 | | | |
| Bitterbrush | 0 | 56.4 | 0.0 | | | |

a - Density, probability of detection, and effective sampling width are calculated only for the pooled habitats.

**Capture-Recapture**

The highest density estimates in colonies were for two sagebrush grids with 15.7 (95% CI; 15.4 to 17.3) and 3.9 (95% CI; 3.7 to 6.5) animals per ha (Figure 5). The highest density estimate of the other habitats was 2.6 (95% CI; 2.1 to 5.5) animals per ha in low shrub. Differences among habitats were not statistically significant because of high variation and a small number of replicates ($F = 1.64$; $P = 0.26$). The third trapping grid in sagebrush habitat is lower possibly because it was trapped (March 28 - April 8) before most juvenile emergence had occurred. The earliest young of the year was captured March 29, 1997.

**Movements, Recruitment and Sex Ratios**

Mean maximum distance moved (MMDM) between trapping occasions was significantly greater for males than females ($F = 12.78$; $P = 0.0006$, Figure 6). Males moved an average maximum distance of 85.6 meters ($n = 30$) within colonies while females moved an average maximum distance of 51.7 meters ($n = 51$). There was no significant difference in MMDM between the age classes ($F = 0.15$; $P = 0.15$) with adults moving slightly further than juveniles (67.0 versus 62.9 m, respectively; Figure 7). Movement within colonies was not significantly different among habitats and averaged from 63.6 m in sagebrush to 68.4 m in low shrub ($F = 0.05$ ; $P = 0.95$). The furthest observed distance moved within a colony was by an adult male who traveled 182 m in low shrub habitat.

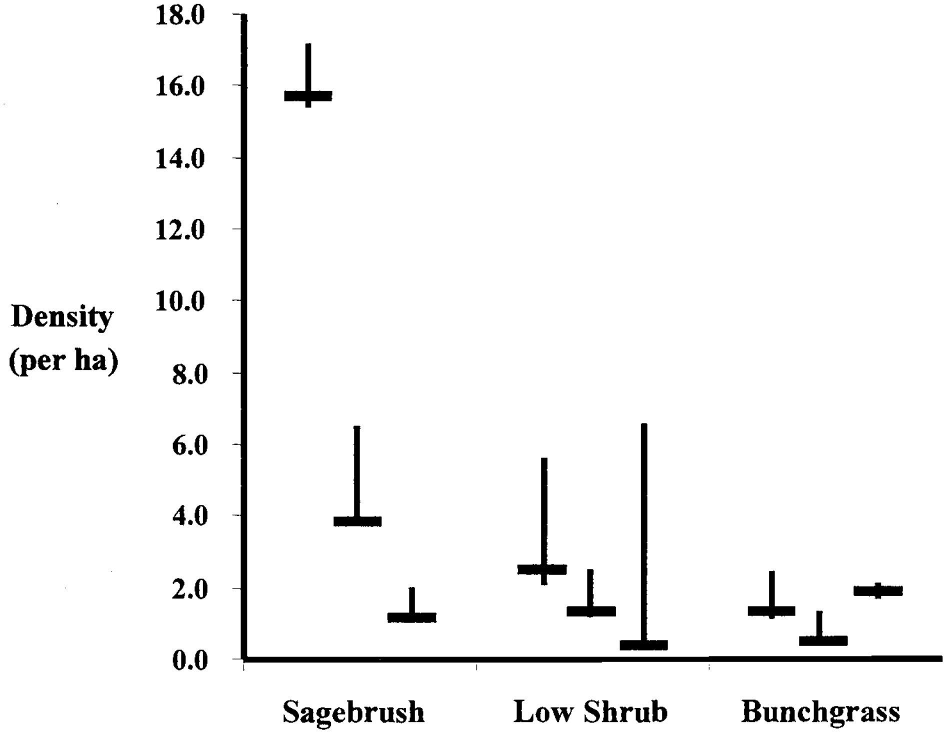


Figure 5. Density and 95% confidence intervals of Washington ground squirrel colonies in different habitats on Boardman Bombing Range, Morrow County, Oregon, 1997.

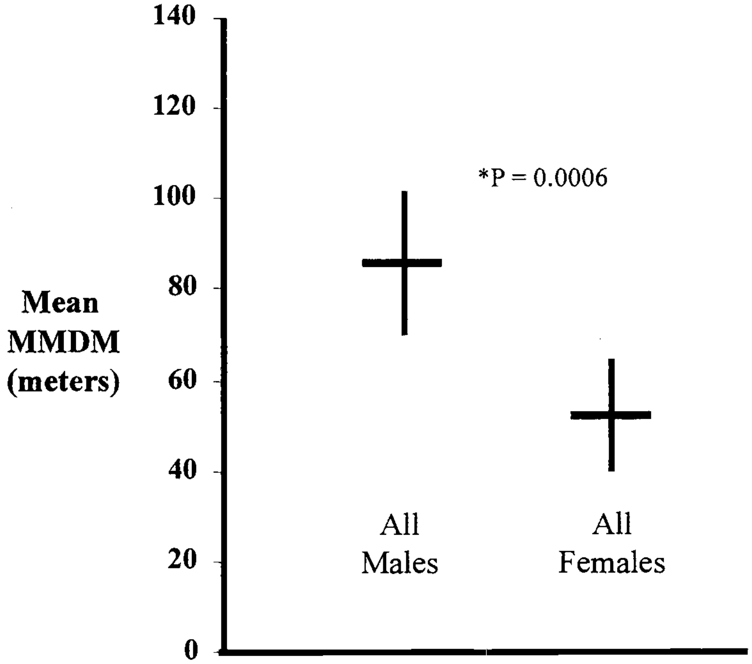


Figure 6. Mean maximum distance moved (MMDM) by Washington ground squirrels within colonies by sex on Boardman Bombing Range, Morrow County, Oregon, 1997.

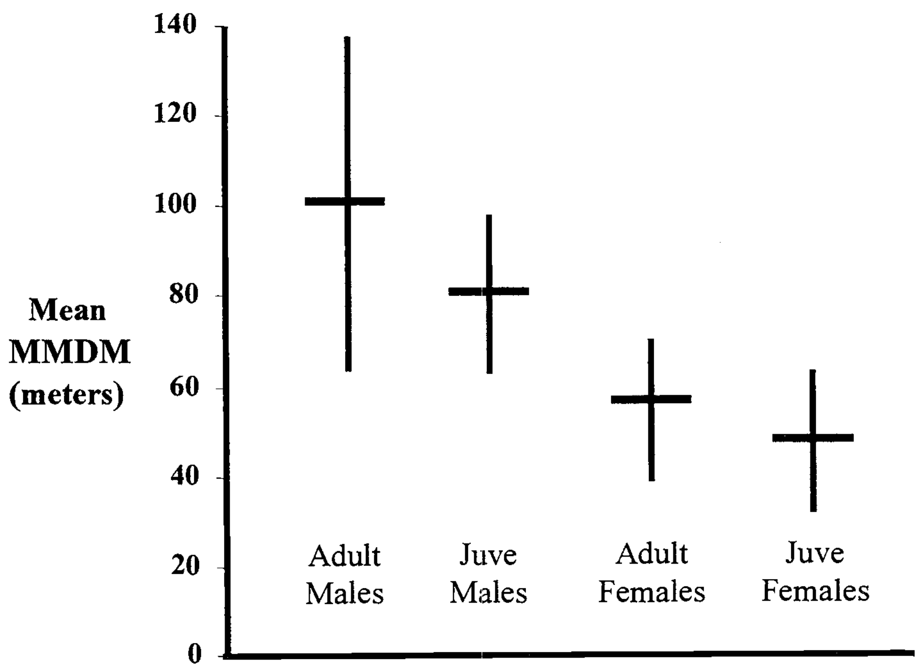


Figure 7. Mean maximum distance moved (MMDM) by Washington ground squirrels within colonies by age and sex on Boardman Bombing Range, Morrow County, Oregon, 1997.

Estimates of recruitment were calculated for all trapping grids, though the number of animals captured in most grids was not sufficient to provide reliable estimates (Table 3). Trapping grids in sagebrush habitat had the most reliable estimates with 305% and 800% for the two grids trapped after juvenile emergence. Bunchgrass habitat ranged from 200 and 500%. Low shrub habitat consistently had the lowest estimates of recruitment of 200% or less.

Sex ratios favored females in juvenile and adult age classes. There were almost twice as many adult females than adult males (0.53:1). The juvenile ratio was higher with 0.85 males to every one female.

## Weight Comparisons

Average weights of adult males were consistently higher than adult females (175.0 grams, $n = 15$; and 165.7 grams, $n = 32$ respectively), though the difference was not significant ($F = 0.79$; $P = 0.37$). For juveniles, males were significantly heavier than females, averaging 114.7 grams ($n = 52$) for males and 94.7 grams ($n = 59$) for females ($F = 19.9$; $P < 0.0001$). Weight comparisons among habitat types revealed that adults in bunchgrass (Table 4) were significantly heavier than those in other habitats ($F = 5.46$; $P = 0.0076$). Similarly, weights of juveniles were significantly higher in bunchgrass habitats than other habitats ($F = 22.99$; $P < 0.0001$). Weight change for individuals captured in two trapping occasions in sagebrush habitat was highly variable for the 30 day period between trapping

Table 3. Recruitment and sex ratios for Washington ground squirrels in different habitats, Boardman Bombing Range, Morrow County, Oregon, 199

| Habitat | Number of Adults | Number of Juveniles | Recruitment | Adult M:F | Juvenile M:F |
|---|---|---|---|---|---|
| Sagebrush | 3 | 24 | 8.0 | 0.5:1 | 1:1 |
| Sagebrush | 22 | 63 | 2.9 | 0.47:1 | 0.75:1 |
| Sagebrush | 6 | 1 | 0.2 | 0.2:1 | 0:1 |
| Low Shrub | 1 | 2 | 2.0 | 0:1 | 1:1 |
| Low Shrub | 6 | 5 | 0.8 | 0.5:1 | 0.25:1 |
| Low Shrub | 6 | 1 | 0.2 | 2:1 | 1:0 |
| Bunchgrass | 1 | 5 | 5.0 | 0:1 | 0.67:1 |
| Bunchgrass | 3 | 8 | 2.7 | 0.5:1 | 1.67:1 |
| Bunchgrass | 1 | 2 | 2.0 | 1:0 | 2:0 |
| Compiled | 49 | 111 | 2.3 | 0.53:1 | 0.85:1 |

Table 4. Weight (grams) and standard errors for adult and juvenile Washington ground squirrels on the Boardman Bombing Range, Morrow County, Oregon, 1997.

| **Age Class** | **Adults** | | | **Juveniles** | | |
|---|---|---|---|---|---|---|
| **Habitat** | **Bunch** | **Sage** | **LowShrub** | **Bunch** | **Sage** | **LowShrub** |
| **Average Male** | **232.0** | **169.8** | **164.2** | **128.0** | **110.0** | **117.0** |
| Standard Error | na | 14.1 | 12.0 | 6.8 | 3.1 | 30.4 |
| Sample Size | 1 | 9 | 6 | 9 | 39 | 3 |
| **Average Female** | **209.3** | **160.4** | **153.0** | **125.5** | **93.8** | **69.4** |
| Standard Error | 10.5 | 6.1 | 8.2 | 9.7 | 2.6 | 25.3 |
| Sample Size | 3 | 22 | 7 | 6 | 49 | 5 |
| **Sexes Combined** | **215.0** | **163.1** | **158.2** | **127.0** | **101.0** | **87.3** |
| Standard Error | 9.4 | 5.9 | 7 | 5.4 | 2.2 | 20.1 |
| Sample Size | 4 | 31 | 13 | 15 | 88 | 8 |

periods. Average weight gain was 15.2 grams (n = 14, adults and juveniles); however weight change ranged from a loss of 22 grams to a gain of 104 grams.

## Habitat Associations

### Macro-Habitat Selection

Of the 105 plot-points, two could not be accessed for data collection, and three were identified as outliers leaving 100 plot-points for the analysis. The plot-points were placed into two vegetation categories based on similarity of structure: Shrub, including bitterbrush and sage brush habitats, and grasses including annual grasses, perennial grasses, and low shrub habitats. We observed the presence of Washington ground squirrels at 20 of the 100 points. Significant variables retained in the model after univariate and correlation analysis were vegetation category, percent coarse material and silt content of the soil, coefficient of variation for the effective height, and percent cover of perennial grass, forbs, litter, bare ground, and microbiotic crust (Table 5). Percent silt content of the soil was correlated with percent sand and clay ($r = -0.997$ and 0.713, respectively); therefore it was retained in the analysis while sand and clay were removed. Interactions between percent silt and the other vegetation variables were not significant ($P > 0.10$). Further variable reduction using Wald's test produced a model with percent silt content of the soil ($P = 0.0044$) and percent cover of bare ground ($P = 0.032$) as significant explanatory variables. The mean value for silt content was higher at occupied points (50 vs.

Table 5. Mean, standard error, and univariate significance of variables in macro-habitat analysis, Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

| | Occupied | | Unoccupied | | P-value |
|---|---|---|---|---|---|
| **Variable** | **Mean** | **SE** | **Mean** | **SE** | |
| Vegetation Category | 0.6 | 0.1 | 0.4 | 0.1 | 0.19 |
| Vertical Density < 30cm | 0.9 | 0.0 | 0.9 | 0.0 | 0.57 |
| Vertical Density > 30cm | 0.1 | 0.0 | 0.1 | 0.0 | 0.57 |
| Diversity Index of Vertical Density | 0.5 | 0.0 | 0.5 | 0.0 | 0.58 |
| Mean Effective Height | 9.0 | 1.6 | 9.2 | 0.7 | 0.89 |
| Coeff of Variation; Effective Height | 1.1 | 0.1 | 1.3 | 0.1 | 0.2 |
| Annual Grass Cover (%) | 25.5 | 4.9 | 23.1 | 1.4 | 0.52 |
| Perennial Grass Cover[a] (%) | 22.6 | 4.2 | 9.6 | 1.4 | 0.001 |
| Forb Cover (%) | 4.8 | 0.8 | 8.9 | 0.8 | 0.02 |
| Shrub Cover (%) | 9.4 | 2.6 | 11.2 | 1.4 | 0.55 |
| Litter Cover (%) | 24.0 | 1.5 | 31.6 | 0.9 | 0.001 |
| Bare Ground Cover (%) | 3.1 | 0.5 | 12.9 | 1.1 | 0.0001 |
| Microbiotic Crust Cover[a] (%) | 13.4 | 2.1 | 6.1 | 0.8 | 0.001 |
| **Soil Texture** | | | | | |
| Clay (%) | 5.4 | 0.5 | 3.8 | 0.3 | 0.017 |
| Silt[b] (%) | 50.2 | 1.8 | 22.3 | 2.1 | 0.0001 |
| Sand[b] (%) | 44.4 | 2.1 | 74.0 | 2.3 | 0.0001 |
| Coarse Material (%) | 0.1 | 0.1 | 0.9 | 0.2 | 0.11 |
| **Interactions** | | | | | |
| Silt x Vegetation Category | | | | | 0.63 |
| Silt x Perennial Grass | | | | | 0.41 |
| Silt x Forb | | | | | 0.47 |
| Silt x Litter | | | | | 0.83 |
| Silt x Bare | | | | | 0.89 |
| Silt x Microbiotic Crust | | | | | 0.48 |

a - Perennial Grass:Microbiotic Crust r = 0.73

b - Silt:Sand r = -0.99

22%) and the mean percent cover of bare ground was lower at occupied points (3 vs. 13%).

The odds ratios (Table 6) represent how much more likely it is for squirrels to be present when the variable changes from its mean value at occupied points to its mean value at unoccupied points. For example, the mean silt content of the soil at occupied points was 50.2% and for unoccupied points the mean was 22.3%; therefore, the odds of Washington ground squirrels being present at locations with a silt content of 50.2% was 9.5 times higher than were locations whose silt content of the soil were 22.3 (95% CI; 2 to 45). Likewise, the odds of Washington ground squirrels being present at a location with 3.12% bare ground cover was 5.9 times higher than were locations whose percent bare ground cover was 12.8% (95% CI; 1.2 to 29.7).

Table 6. Significant results of logistic regression analysis for habitat selection of Washington ground squirrels at the macro- and micro habitat levels, Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

Macro-habitat analysis:

| **Variable** | **Estimate** | **SE** | ***P*-value** | **Odds Ratio** |
|---|---|---|---|---|
| Intercept | 3.4498 | 1.444 | 0.0169 | . |
| %Silt | 0.0808 | 0.0284 | 0.0044 | 1.084 |
| %Bare Ground | -0.1829 | 0.0854 | 0.0321 | 0.833 |

Micro-habitat analysis:

| **Variable** | **Estimate** | **SE** | ***P*-value** | **Odds Ratio** |
|---|---|---|---|---|
| %Clay | -0.2045 | 0.1011 | 0.0431 | 0.815 |

I conducted a second analysis at the macro-habitat level with the sagebrush and bunchgrass habitats which were sub-categorized into grazed and ungrazed classifications. I compared grazed versus ungrazed sagebrush and bunchgrass in a logistic regression analysis of the vegetation variables using grazing treatment as a response (n = 54). The results suggested that grazing did affect the amount of bare ground (P = 0.022). For every one percent increase in bare ground, there is a corresponding 13 percent increase in the likelihood the area is grazed (Table 7). Mean percent bare ground in ungrazed habitat was 4.6 (95% CI; 2.31 to 6.96) compared to 13.6 (95% CI; 9.12 to 18.12) in grazed habitat. Other significant variables in the grazing treatment model were percent cover of perennial grass (P = 0.041) and the coefficient of variation for the effective height of vegetation (P = 0.023); however, neither of these variables were significant for Washington ground squirrels.

Table 7. Significant results of analysis for grazing treatments on vegetation, Boardman Bombing Range 1996, 1997.

| Variable | Estimate | SE | *P*-value | Odds Ratio |
|---|---|---|---|---|
| Intercept | 2.6084 | 1.3184 | 0.0479 | . |
| Bare Ground | 0.1255 | 0.0547 | 0.0218 | 1.13 |
| Perennial Grass | -0.052 | 0.0255 | 0.0414 | 0.95 |
| Effective Ht | 1.944 | 0.8574 | 0.0234 | 6.99 |

**Micro-Habitat Selection**

We collected habitat data on 44 colonies and 44 unoccupied. The majority (64%) of the colonies located were in habitats dominated by sagebrush. The remaining colonies were distributed among the rest of the habitats with the exception of bitterbrush where we found no colonies.

Colonies and their corresponding paired sites were grouped into shrubland and grassland categories. Significant variables retained in the model after correlation and univariate analysis were percent cover of perennial grass, percent clay, and percent sand (Table 8). Interaction terms of the soil variables with perennial grass were not significant ($P > 0.10$). Further variable reduction using Wald's test produced a model with percent clay content of soil ($P = 0.043$) as the only significant variable. The mean value for percent clay content of the soil was lower at occupied sites (5.0%) than unoccupied sites (6.1%), although the biological significance of this difference is open to question.

The odds ratio (Table 6) represents how much more likely it is for Washington ground squirrels to be present when the percent clay content of the soil changes from its mean value at colony sites to its mean value at unoccupied sites. For example, the odds of Washington ground squirrels being present at locations with a clay content of 4.97% were 1.3 times higher than sites whose clay content is 6.08% (95% CI; 1.6 to 1.007). Note that the paired analysis does not produce an intercept term for the regression.

Table 8. Mean, standard error, and univariate significance of variables in micro-habitat analysis, Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

| | **Colony Site** | | **Unoccupied** | | **P-value** |
|---|---|---|---|---|---|
| **Variable** | Mean | SE | Mean | SE | |
| Vegetation Category | 0.64 | 0.07 | 0.64 | 0.07 | 0.63 |
| Vertical Density < 30cm | 0.91 | 0.01 | 0.90 | 0.01 | 0.63 |
| Vertical Density > 30cm | 0.09 | 0.01 | 0.10 | 0.01 | 0.35 |
| Diversity Index of Vertical Density | 0.48 | 0.02 | 0.47 | 0.02 | 0.59 |
| Mean Effective Height | 8.68 | 0.84 | 8.64 | 1.18 | 0.96 |
| Coeff of Variation; Effective Height | 1.38 | 0.07 | 1.27 | 0.09 | 0.39 |
| Annual Grass Cover (%) | 24.04 | 2.38 | 26.84 | 2.56 | 0.31 |
| Perennial Grass Cover (%) | 15.95 | 2.05 | 13.88 | 2.02 | 0.19 |
| Forb Cover (%) | 5.57 | 0.79 | 5.27 | 0.94 | 0.78 |
| Shrub Cover (%) | 13.07 | 1.88 | 11.39 | 1.77 | 0.35 |
| Litter Cover (%) | 26.03 | 1.04 | 27.17 | 1.03 | 0.32 |
| Bare Ground Cover (%) | 8.66 | 1.41 | 7.60 | 1.37 | 0.59 |
| Microbiotic Crust Cover (%) | 10.99 | 1.47 | 10.92 | 1.52 | 0.97 |
| **Soil Texture** | | | | | |
| Clay (%) | 4.97 | 0.35 | 6.08 | 0.46 | 0.04 |
| Silt (%) | 45.01 | 3.14 | 47.98 | 2.38 | 0.30 |
| Sand (%) | 50.00 | 3.35 | 45.95 | 2.65 | 0.21 |
| Coarse Material (%) | 0.83 | 0.36 | 3.76 | 1.84 | 0.28 |
| **Interactions** | | | | | |
| Clay x Perennial Grass | | | | | 0.61 |
| Sand x Perennial Grass | | | | | 0.13 |

# DISCUSSION

## Abundance Measures

Density estimates from transect surveys indicate that there were more Washington ground squirrels in sagebrush habitat than other habitats surveyed. Estimates from live-trapping supported those results with higher densities in colonies that were located in sagebrush habitat. Both methods agree that Washington ground squirrels were more abundant in sagebrush habitat, however, the estimates obtained from the different methods are dissimilar. Density estimates from live-trapping are considerably higher than those obtained from transect. Because live-trapping was performed within known colonies results from this method reflect abundance of Washington ground squirrels within colonies. Alternatively, transect surveys were performed over large areas that may or may not have contained colonies of Washington ground squirrels. Density estimates obtained from the transect method reflect the level abundance over the study area and the scarcity of colonies even in habitats that appeared to be selected by Washington ground squirrels.

Transect surveys typically provide a relatively simple way to obtain abundance measures for many species; however, Washington ground squirrels occur in such low frequency that this method may be impractical. There was difficulty obtaining a large enough sample size. Washington ground squirrel colonies were widely spaced and not abundant; therefore a very large area would have to be surveyed in order to obtain a large enough sample size. Line transects, however, did prove to be an effective means of determining presence of the species. Washington ground squirrels can be depended upon to elicit alarm calls in the presence of observers, particularly during the period of juvenile emergence (Mid-April to early May) when they were easily detected.

Recognizing their burrow proved to be useful during transects, as we were able to identify probable colonies. Washington ground squirrel burrows, particularly natal burrows, had a characteristic shape. The entrance was worn into a cup-shape and frequently, an additional portion of soil removed from one of the sides and present next to the entrance. Vegetation within an approximately 30 cm radius around the entrance was typically removed, and vegetation that remained was often clipped (presumably from squirrels grazing). Scat, approximately 10 to 12 mm long and tapered at both ends, was also often present. Information gathered on burrows was used to determine presence or absence of Washington ground squirrels but not for estimating density. Density estimations obtained from burrow counts can be misleading because burrows may persist over years and can often be difficult to distinguish from those of other species (Van Horne et al. 1983, 1997a, Quade 1994).

Live-trapping Washington ground squirrels proved to be difficult. The sparse distribution of colonies and low abundance of individuals within colonies was complicated by the species varied reaction to trapping. Individuals exhibited combinations of behavior responses to trapping (trap-happy and trap-shy), heterogeneity (territoriality), and temporal affects of weather conditions. Subsequently, density estimates for each trapping grid were calculated in program CAPTURE using capture-recapture models that attempted to account for those behaviors. This approach did provide precise estimates of abundance of the larger colonies.

Density estimates from capture-recapture methods supported the transect survey findings of higher abundance in sagebrush habitat. These estimates are not statistically significant because of small sample sizes and few replicates, but investigations of related species had similar results. Sagebrush habitat was found to be more suiTable for Townsend's ground squirrels (*S. townsendii*), particularly in drought-prone environments and drought years (Van Horne et al. 1997b). During a drought period in southwestern Idaho, adult Townsend's ground squirrels maintained higher masses and rates of persistence in sagebrush than in grassland habitats where rates of persistence dropped. Adults also had higher rates of capture in sagebrush than in grassland habitats in following years suggesting higher winter survivorship in sagebrush. Animals captured as juveniles were not recaptured in subsequent years in grassland habitats whereas they were recaptured in sagebrush habitats suggesting a higher mortality during the intervening inactive season in grassland habitats (Van Horne et al. 1998). Survival of the winter hibernation period is related to pre-hibernation weight (Murie 1984) and reaching a mass that will sustain each animal until the next active season is highly dependent upon the quality of forage (Bintz 1984). Ground squirrels existing in grassland habitats may not have enough forage available to reach the necessary pre-hibernation weight during drought years. However, weights in this study were higher in grassland habitats, but this may be a result of the higher than average rainfall during the years of this study. Van Horne et al. (1997b) suggests that grasslands support higher quality forage but may be least useful in maintaining populations in drought-prone environments.

Sagebrush habitats may maintain ground squirrel populations because it supports a more sTable food source, especially during drought periods (Van Horne et al. 1998). Sagebrush may provide an alternate food and water source (Van Horne et al. 1998), and its shade may maintain succulence of other forage while maintaining lower soil temperatures which would decrease evaporative water loss (Van Horne et al. 1997b, Bintz 1984).

The higher abundance and density of squirrels in sagebrush should not, however, under-estimate the importance of bunchgrass habitats to the species. While abundance and density were lower, those results were not conclusive. In addition, average weights of squirrels were higher in bunchgrass, suggesting some benefit to selecting that habitat.

Movement data from this study concurs with studies on similar species that indicate dispersal is male biased. Sex ratios within colonies favored females, while movement data recognized that males were more likely to travel further distances (Figure 6, Table 3). There were almost half as many adult male Washington ground squirrels within colonies (0.53:1) while males were also observed to move

66 percent farther than females (85.6 m versus 51.7 m). Similar results were obtained in a study of Townsend's ground squirrels in southwestern Idaho (Smith and Johnson 1985) and in thirteen-lined ground squirrels (*S. tridecemlineatus*) in Wisconsin (Rongstad 1965). In two Belding's ground squirrel (*S. beldingi*) colonies in the Sierra Nevada range, all juvenile males were observed to disperse while most females remained within their mother's home range (Holekamp 1984). In a study of Columbian ground squirrels (*S. columbianus*), mothers and neighboring adult females were observed to display agonistic behavior toward juvenile males which may explain male biased dispersal (Wiggett and Boag 1993). The evolutionary advantages to male-biased emigration may be (1) to reduce competition for resources, (2) reduce competition for mates, and/or (3) to avoid inbreeding (Wiggett and Boag 1993).

Low shrub habitat appears to be the least preferred of the habitats examined. While density estimates from capture-recapture were comparable, recruitment and weight in low shrub were the lowest of the three habitats trapped, and no detections of squirrels were made during transect surveys in low shrub habitat. These results may reflect that low shrub habitat is least preferred, however, all of the low shrub habitat is located in the sandier soils in the northern half of the study area. The same is true for bitterbrush habitat. The low abundance of squirrels in these habitats may be related to soil type than the vegetation supported by these soils.

**Habitat Associations**

Perhaps the most compelling results of this study are those of the macro-habitat analysis. The most significant variable of that model was the percent silt content of the soil (P = 0.0044). These results suggest that Washington ground squirrels select sites based on the characteristics of the soil more than any other variable we measured, as they selected sites with relatively higher silt content than unoccupied sites. Silt content may have significant effects on the integrity of the soil and would affect how well these burrowing animals could construct and maintain their burrows.

Other species which have been observed to select sites based on soil characteristics are the pocket gophers (*Geomys sp.*) in East Texas which were observed to occur regularly in soils that were easily worked and considered (by the authors ) to be ideal for burrowing activities. They were not found in adjacent soils considered not conducive to burrowing activities because they were plastic, sticky, and compact (Davis et al. 1938). Pine voles (*Microtus pinetorum*), a semi-fossorial rodent, were observed to respond to soil texture in a study conducted in Pennsylvania orchards. They were present at sites where gravel and clay were significantly higher while fine material and sand were significantly lower than where pine voles were absent (Fisher and Anthony 1980). In a micro-habitat study of pygmy rabbits (*Sylvilagus idahoensis*) in Oregon, soil in occupied sites had significantly lower clay content than at unoccupied sites (Weiss and Verts 1984). Similar results were found in a micro-habitat study of Washington ground squirrels

(Betts 1990) where soil at occupied sites was significantly lower in clay content. A factor that may be affecting habitat selection is the energetic costs of burrowing. Physiological testing on pocket gophers (*Thomomys bottae*) found that energetic costs of digging in soils high in clay were five to ten times higher than in other soil types tested (Vleck 1979). While collecting soil samples, I found that pits dug in sandier soils tended to collapse while pits dug in soils with a relatively higher silt content did not.

These findings support our observations in the field and explain the distribution of most colonies within the study area. The majority of the colonies were located in the southern portion of the study area which is underlain by Warden type soils (Figure 8). Warden soils are a loamy soil characterized by having a high silt content. A disproportionate distribution of colonies over the study area was also evident from the plot surveys. There were a total of nine plots surveyed in the region underlain by Warden soils; eight of those plots contained Washington ground squirrels. Conversely, twelve plots were surveyed outside of the region underlain by Warden soils and Washington ground squirrels were detected in only one. In addition to having relatively high silt content, Warden soils are also characterized as being very deep. Reynolds and Wakkinen (1987) found that Townsend's ground squirrel dig deeper burrow systems, averaging 128 cm deep, than other burrowing species examined (*Peromyicus*, *Microtus*, and *Dipodomys* species). They suggest that deeper burrow systems likely provide insulative properties during the regions climatic extremes.

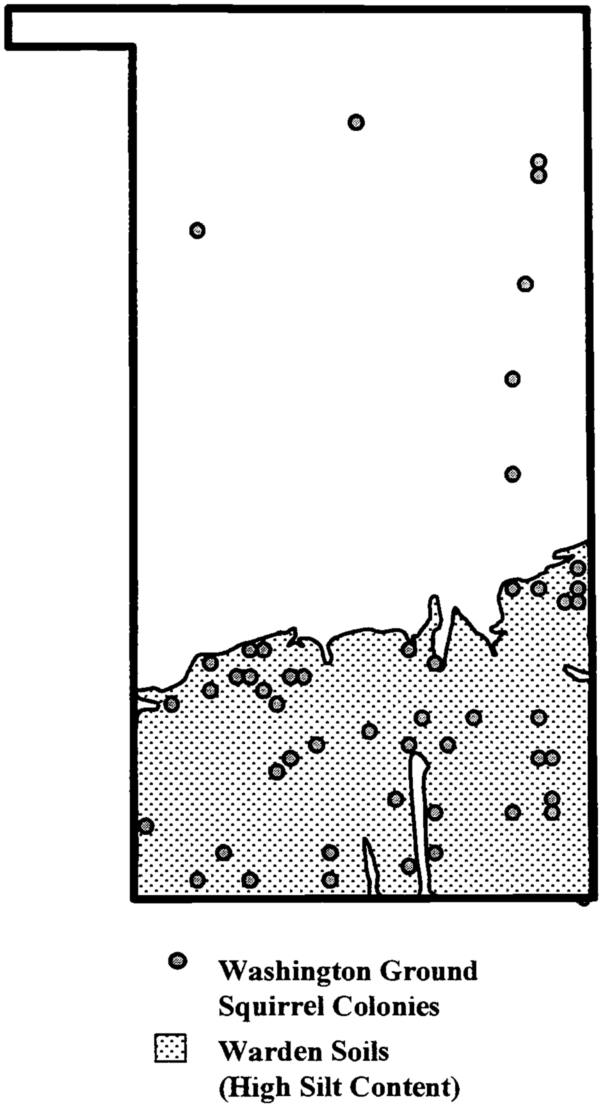


Figure 8. Distribution of Warden soils and Washington ground squirrel colonies on Boardman Bombing Range, Morrow County, Oregon, 1996 - 1997

Distribution of Warden soils may be partially explained by the actions of the historic Bretz floods. Flood waters scoured lower elevations that were close to the Columbia River, removing topsoil and exposing layers more resistant to erosion. Flood waters may have had less of an impact on areas of the bombing range above 225 meters elevation and their soils remained intact. Such is the case with Warden soils at approximately 11 km south of the northern boundary of the Bombing Range (Figure 9).

While silt content of the soil has been recognized as significant in the macro-habitat analysis in this study, it is correlated to percent sand and clay content of the soil (r = -0.99 and 0.71 respectively). This correlation suggests that perhaps sand and clay content of the soil may also be important for the identification of suiTable habitat for Washington ground squirrels. However, sand was negatively correlated to silt mostly because of the way it was calculated. The percent content of sand and clay were determined using laboratory techniques. Whereas percent silt content is then calculated by subtracting percent sand and clay from 100%. The results of this analysis could alternatively be interpreted as avoidance of sandy soils.

Percent clay content was positively correlated with silt at the macro-habitat level (r = 0.71) indicating that clay content increases with silt content. From this information, it could be interpreted that Washington ground squirrels select soils relatively high in clay as well as silt. However, the micro-habitat analysis indicated that squirrels selected for sites with a relatively lower clay content (P = 0.043). A

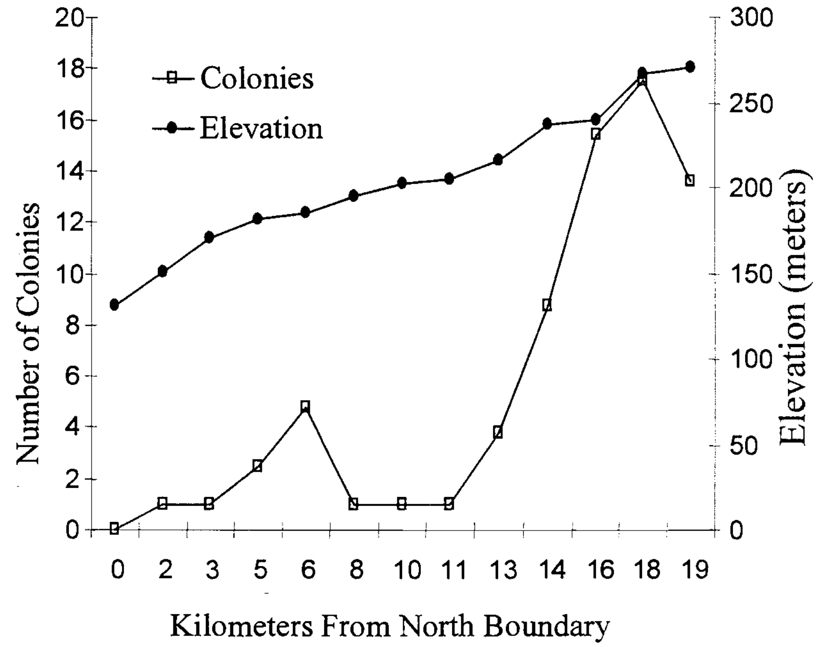


Figure 9. Relationship of elevation and occurrence of Washington ground squirrel colonies on Boardman Bombing Range, Morrow County, Oregon, 1996-1997.

closer look at the clay content at the macro- versus micro-habitat levels reveals a potential narrow tolerance for clay; both analysis revealed similar ranges for clay at occupied sites (4.3 to 6.3%). Interestingly, the ranges for clay content at unoccupied sites are quite different for the two analyses and 'sandwich' the range for occupied sites. Unoccupied sites at the macro-habitat level have a range of values that is on the low end of the occupied sites (3.2 to 4.4 % clay) while unoccupied sites at the micro-habitat level have a range of values on the high end (5.2 to 7.0 % clay). Low levels of clay in soil produce a soil that is more friable, while high levels of clay create a dense soil which may present a formidable barrier to digging. Washington ground squirrels may be selecting for sites that were intermediate in clay content.

Another significant variable at the macro-habitat scale was percent cover of bare ground ($P = 0.032$). While my analysis did not detect significant differences in the type of vegetation present at occupied versus unoccupied sites, it did reveal that the amount of vegetative cover might be an important factor. The lack of significance of the type of vegetation is not surprising when one considers the diet of this species. Ground squirrels are hindgut fermenters which allows them to eat a wide variety of succulent foods (Robbins 1993). They have been observed to use a broad range of forbs and grasses, and will eat the stems, buds, leaves, flowers, roots, bulbs, and seeds of plants (Scheffer 1941). Washington ground squirrels may benefit from increased vegetative cover since it may provide more available forage resources which has been shown to be an important determinant for survival through the inactive season (Bintz 1984). Increased vegetative cover may also reduce vulnerability of squirrels to raptorial birds. Swainson's hawks have been observed to spend less time foraging over areas with relatively higher vegetation cover, even though those areas contained a higher density of prey (Bechard 1982).

The importance of vegetated cover has distinct implications on the species' compatibility with farming practices such as dry-land wheat farming, a major crop within the squirrel's range. Dry-land wheat fields are left fallow every other year, leaving 100% bare ground, which is well outside of the range for bare ground as determined by this study. Other investigators have observed dry-land wheat fields to be an effective barrier for movements of Washington ground squirrels (Carlson et al. 1980).

A factor that may be affecting the amount of bare ground is livestock grazing. Results from the comparison of the grazed versus ungrazed sagebrush and bunchgrass habitats indicate that the cover of bare ground was higher in grazed habitats ($P = 0.022$). Areas subject to grazing typically had much more exposed earth due to the breaking up of the microbiotic crust and the crushing of plants. In other studies, reduction of microbiotic crust cover had also been correlated to grazing which resulted in increased erosion, and decreased water infiltration (Fleischner 1994). Microbiotic crust also functions in the ecosystem to increase available soil nutrients such as nitrogen and phosphorus, increase soil stability, and contribute to ecological succession (Mayfield and Khelmer 1984). Replacing microbiotic crust with bare ground results in a loss of these important functions.

Other impacts associated with grazing are decreased species richness, soil compaction, and altered physical structure of the habitat (Fleischner 1994).

While these results suggest livestock grazing may reduce the suitability of habitat for Washington ground squirrels, this study did not take the intensity of grazing into consideration. Intensities were extremely variable within the grazed habitats and further studies should examine grazing levels and their effects on abundance before conclusions can be made.

Rainfall may affect the overall abundance of Washington ground squirrels. Prior to Quade's (1994) study on the bombing range, the region experienced six consecutive drought years which may be the reason she found only a few small populations. Conversely, this study was conducted following two years of above average rainfall and we observed comparatively high abundance. Eric Yensen (pers. comm.) has noticed a similar phenomenon with Idaho ground squirrels in Western Idaho. These high fluctuations in population may be problematic for the species. Studies using mathematical modeling found that populations which undergo large variations through time may be more susceptible to local extinction (Pimm et al. 1988).

The apparent higher abundance of Washington ground squirrels during this study is likely related to increases in forage quality and quantity, which in turn is due to the higher than normal rainfall during the period and previous years. Average litter sizes in round-tailed ground squirrels (*S. tereticaudus*) in southern Arizona were observed to be larger during years of increased rainfall during a study conducted between 1956 and 1970 (Reynolds and Turkowski 1972). Beginning of breeding season was also observed to change with rainfall and started earlier after increased rains in December and January. Food supplementation studies (Dobson and Kjelgaard 1985a, 1985b) have found that density, litter size, and body weight of Columbian ground squirrels (*S. columbianus*) increased with food availability. Evidence on the effect of moisture and forage availability becomes more obvious when one considers the biology of this species. Estivation begins in early summer when the vegetation has become desiccated by the lack of rainfall and extreme daily temperatures that often exceed $100^0$ F ($37.8^0$ C). Bintz (1984) observed changes in behavior on ground squirrels late in the plant growing season when the forage value of the vegetation became poor due to desiccation.

**Management Recommendations**

Washington ground squirrels are a Federal Species of Concern, candidate for listing in Washington, and proposed for listing in Oregon. In an effort to maintain the continued existence of the species, I suggest the following management practices:

Maintain remaining areas of suiTable habitat for Washington ground squirrels, particularly those areas where they are currently or were historically present. It is especially important to maintain all habitat on the few remaining large undeveloped tracts as these areas may serve as source populations for surrounding fragmented areas of habitat in Oregon. SuiTable habitat consists of areas with a relatively high coverage of vegetation and are underlain by Warden soils, which are deep and have a characteristically high silt content.

Moderate grazing does not appear to be directly incompatible with maintaining ground squirrel populations. However, intense livestock grazing appears to be associated with a decrease in vegetative cover and may adversely affect squirrels, though results are not conclusive. Levels of grazing intensity may play a role in determining the severity of its affect and further studies should address this question.

Wherever development within suiTable habitat is to occur, the area should be surveyed, and buffers should be established around ground squirrel colonies. Minimum buffer size should be approximately 300 meters based on recaptures of marked individuals. Additionally, maintaining connectivity among undisturbed patches may be essential for the continued existence of the species. Isolated colonies are more susceptible to disease, predation, and problems associated with inbreeding. Corridors for dispersion will enable the colonization of suiTable unoccupied habitat and genetic exchange among subpopulations. Corridors should be such that they do not increase predation or other means of mortality.

Finally, preserves should be established for this species. Washington ground squirrels are unique and ecologically important in the region. Their diurnal behavior, annual cycle, and size make them well suited as a prey species for raptorial birds that occur there. Establishing large preserves in the few remaining shrub-steppe habitats will not only benefit the ground squirrel, but will also benefit many other species that occur and depend on undisturbed habitat in the Columbia River Basin. The Boardman Bombing Range is particularly suited for this role. It contains a large expanse of suiTable habitat for Washington ground squirrels and appears to be a stronghold for other sensitive species in Oregon (Table 9).

Table 9. Oregon Status of sensitive species that occur on Boardman Bombing Range

| **Species** | **Scientific Name** | **Status** |
|---|---|---|
| Ferruginous Hawk | *Buteo regalis* | Critical |
| Swainson's Hawk | *Buteo Swainsoni* | Vulnerable |
| Burrowing Owl | *Speotyto cunicularia* | Critical |
| Long-billed Curlew | *Numenius americanus* | Vulnerable |
| Sage Sparrow | *Amphispiza belli* | Critical |
| Grasshopper Sparrow | *Ammodramus savannarum* | Vulnerable |
| Black-throated Sparrow | *Amphispiza bilineata* | Naturally Rare |
| Loggerhead Shrike | *Lanius ludovicianus* | Vulnerable |
| Washington Ground Squirrel | *Spermophilus washingtoni* | Critical |
| Pygmy Rabbit | *Brachylagus idahoensis* | Critical |
| White-tailed Jackrabbit | *Lepus townsendii* | Undetermined |
| Sagebrush Lizard | *Sceloporus graciosus* | Vulnerable |
| Desert Horned Lizard | *Phrynosoma platyrhinos* | Vulnerable |

Adjacent to the bombing range is a large tract of equally suiTable shrub-steppe habitat which is owned by the State of Oregon and leased to private interests. Soil maps indicate that Warden soils extend west of the bombing range into this tract, and land use practices on the majority of the tract have been very similar to that of the bombing range (never plowed and used for livestock grazing).

Combined with the adjacent Bombing Range, this area would undoubtedly be the largest remaining block of Washington ground squirrel habitat in the Oregon portion of the Columbia basin. Little information is currently available about the distribution of Washington ground squirrels on that tract, but based on its proximity to the population of squirrels on the bombing range and the apparent suitability of the habitat, it is suspected that they are present in densities similar to the bombing range. This area should be surveyed and populations of squirrels managed appropriately.

The conclusions obtained from this study are from data gathered on the Boardman Bombing Range in Morrow County, Oregon and may not apply to other areas where squirrels occur. Differences in soil, vegetation, climate, and other variables may affect what constitutes suiTable habitat and period of activity. However, I believe that differences in these variables throughout the range of Washington ground squirrels will be slight and these recommendations may be applicable elsewhere.

**Future Studies**

Further studies that conduct trapping should use the following guidelines;
(1) Open traps in the early morning so as to not capture non-target species.
(2) Observe temperature extremes and check traps more frequently as temperatures increase. Close traps during very hot days.

(3) Cover the traps by placing under vegetation, or covering with cardboard, scrape wood, cowpies, etc. Gallon-size milk containers made of waxed cardboard fit well over the tomahawk live traps and can be obtained at a reasonable price.

(4) Some captured squirrels tended to injure their nose while in the traps. Minimizing the time spend in the traps would help this. We applied antibiotic to some, though the benefit may be purely to the researcher.

(5) Bait with apple, and use large chunks as the temperature increase (for water content).

Studies that conduct transect surveys should use the following guidelines:

(1) Be certain the observers can hear and are familiar with ground squirrel alarm call. Alarm calls have a very high frequency and may be out of the hearing range for some people. Researchers can become familiar with their calls at an easily accessed site near the cemetery located on the south end of the Boardman Bombing Range.

(2) Conduct surveys in the morning when squirrels are more likely to be active.

(3) Conduct surveys within a week of juvenile emergence. Ideal dates in 1996 and 1997 were from April 15 until May 13. These dates may vary depending on climatic conditions.

(4) Space transect lines approximately 60 m apart.

(5) Discontinue surveys when the weather conditions, particularly the wind, limit hearing distance.

(6) Use these surveys to determine presence and absence only. It is difficult to meet the assumptions of the model for density estimation for reasons discussed in the text (See Abundance Measures section in the Discussion).

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# Appendices

Appendix 1. Plant Species Encountered on Boardman Bombing Range, 1996-1997

| **SpeciesName** | **CommonName** | **Family** |
|---|---|---|
| *Achillea millefolium* | Western Yarrow | Compositae |
| *Agropyron smithii* | Rhyzomatous Wheatgrass | Poaceae |
| *Agropyrum spicatum* | Bluebunch Wheatgrass | Poaceae |
| *Amsinkia lycopsoides* | Tarweed Fiddleneck | Boraginaceae |
| *Antennaria dimorpha* | Low Pussytoes | Compositae |
| *Artemesia tridentata* | Big Sage | Compositae |
| *Aster sp.* | Aster | Compositae |
| *Astragalus spp.* | Astragulus species | Leguminosae |
| *Balsamorhiza sp.* | Balsamorhiza species | Compositae |
| *Brodiaea douglasii* | Douglas' Brodiaea | Liliaceae |
| *Bromus mollis* | Soft Brome | Poaceae |
| *Bromus tectorum* | Cheatgrass/Downy Brome | Poaceae |
| *Calochortus macrocarpus* | Sagebrush Mariposa | Liliaceae |
| *Cardaria draba* | Hoary Cress | Cruciferaceae |
| *Centarea sp.* | Knapweed | Compositae |
| *Cerastium arvense* | Meadow Chickweed | Caryophyllaceae |
| *Chaenactis douglasii* | Dusty Maiden | Compositae |
| *Chondrilla juncea* | Rush Skeletonweed | Compositae |
| *Chrysothamnus nauseous* | Grey Rabbitbrush | Compositae |
| *Chrysothamnus viscidiflorus* | Green Rabbitbrush | Compositae |
| *Crocidium multicaule* | Spring Gold | Compositae |
| *Cryptantha sp.* | Cryptantha | Boraginaceae |
| *Distichis spicata* | Saltgrass | Poaceae |
| *Draba verna* | Spring Whit-low Grass | Compositae |
| *Epilobium paniculatum* | Parched Fireweed | Onagraceae |
| *Erigeron sp.* | Erigeron species | Compositae |
| *Eriogonum sp.* | Buckwheat | Polygonaceae |
| *Erodium cicutarium* | Redstem Storksbill | Geraminaceae |
| *Erysimum occidentale* | Western Wallflower | Compositae |
| *Euphorbia sp.* | Spurge | Euphorbiaceae |
| *Festuca idahoensis* | Idaho Fescue | Poaceae |
| *Frittilaria pudica* | Yellow Bells | Liliaceae |
| *Gilia minutiflora* | Small-Flowered Gilia | Polemoniaceae |
| *Gutierrezia sarothrae* | Broom Snakeweed | Compositae |
| *Heterotheca villosa* | Hairy Golden Aster | Compositae |

Appendix 1 (Continued).

| SpeciesName | CommonName | Family |
|---|---|---|
| *Hordeum jubatum* | Foxtail Barley | Poaceae |
| *Juniperus occidentalis* | Western Juniper | Cupressaceae |
| *Kochia scoparia* | Kochia | Chenopodiaceae |
| *Koeleria pyramidata* | Prairie June Grass | Poaceae |
| *Lactuca serriola* | Prickley Lettuce | Compositae |
| *Lepidium sp.* | Pepper grass | Compositae |
| *Linum perenne* | Blue Flax | Linaceae |
| *Lomatium sp.* | Desert Parsley | Umbrellifera |
| *Madia glomerata* | Cluster Tarweed | Compositae |
| *Microsteris gracilis* | Slender Phlox | Polemoniaceae |
| *Oenothera pallida* | Pale Evening Primrose | Onagraceae |
| *Opuntia polyacantha* | Plains Prickleypear Cactus | Cactaceae |
| *Oryzopsis hymenoides* | Indian Ricegrass | Poaceae |
| *Penstemon acuminatus* | Sand Dune Penstemin | Scrophulariaceae |
| *Phacelia sp.* | Silverleaf Phacelia | Hydrophyllaceae |
| *Phlox sp.* | Phlox | Polemoniaceae |
| *Plantago patagonica* | Indian-Wheat | Plantaginaceae |
| *Poa bulbosa* | Bulbous Bluegrass | Poaceae |
| *Poa secundo* | Sandbergs Bluegrass | Poaceae |
| *Poa sp.* | Poa species | Poaceae |
| *Psoralea lanceolata* | Lance-leaf Scurf-Pea | Leguminosae |
| *Purshia tridentata* | Antelope Bitterbrush | Rosaceae |
| *Ranunculus testiculatas* | Bur Buttercup | Ranunculacea |
| *Rumex sp.* | Dock | Polygonaceae |
| *Salsola kali* | Russian Thistle | Chanopodiaceae |
| *Sisymbrium altissimum* | Tumbling/Jim Hill Mustard | Cruciferaceae |
| *Sitanion hystrix* | Bottlebrush Squirreltail | Poaceae |
| *Stephanomeria virgata* | Wreath Plant | Compositae |
| *Stipa comata* | Needle and Thread Grass | Poaceae |
| *Taeniatherum caput-medus* | Medusa Head | Poaceae |
| *Tragopogan dubius* | Yellow Salsify | Compositae |
| *Vulpia octoflora* | Sixweeks Fescue | Poaceae |
| *Wyethia amplexicaulis* | Northern Mules Ear | Compositae |

Appendix 2. UTM coordinates, habitat type, and size/activity rating for Washington ground squirrel colonies on Boardman Bombing Range, 1996-1997.

| | UTMs | | | Land | | | |
|---|---|---|---|---|---|---|---|
| Site | E | N | VegType | Use | Soil Type | Size[a] | Activity[a] |
| 1 | 295190 | 5062390 | Sagebrush | Grazed | Warden | 3 | 4 |
| 2 | 295725 | 5063000 | Bunchgrass | UnGrazed | Warden | 1 | 2 |
| 3 | 295600 | 5063200 | Bunchgrass | UnGrazed | Warden | 3 | 3 |
| 4 | 294860 | 5063190 | Sagebrush | Grazed | Warden | 2 | 3 |
| 5 | 295230 | 5062860 | Sagebrush | Grazed | Warden | 1 | 1 |
| 6 | 294700 | 5063070 | Sagebrush | Grazed | Warden | 3 | 4 |
| 7 | 295400 | 5062820 | Sagebrush | UnGrazed | Warden | 1 | 1 |
| 8 | 288420 | 5057810 | Sagebrush | Grazed | Warden | 5 | 5 |
| 9 | 285950 | 5058080 | Sagebrush | Grazed | Warden | 3 | 3 |
| 10 | 288890 | 5060700 | Sagebrush | UnGrazed | Warden | 2 | 2 |
| 11 | 288400 | 5061700 | Bunchgrass | UnGrazed | Warden | 2 | 3 |
| 12 | 288090 | 5061410 | Bunchgrass | Grazed | Sagehill | 3 | 2 |
| 13 | 287300 | 5056960 | Sagebrush | Grazed | Warden | 2 | 1 |
| 14 | 287908 | 5057013 | Sagebrush | Grazed | Warden | 3 | 3 |
| 15 | 286483 | 5060905 | Sagebrush | Grazed | Warden | 3 | 3 |
| 16 | 288460 | 5061780 | Bunchgrass | UnGrazed | Warden | 2 | 2 |
| 17 | 289180 | 5061530 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| 18 | 288470 | 5061510 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| 19 | 288215 | 5061220 | Bunchgrass | UnGrazed | Warden | 4 | 4 |
| 20 | 288840 | 5062020 | Sagebrush | UnGrazed | Warden | 3 | 3 |
| 21 | 291540 | 5057220 | Annual Grass | Grazed | Royal | 5 | 5 |
| 22 | 291700 | 5058730 | Annual Grass | Grazed | Royal | 5 | 5 |
| 23 | 292634 | 5059710 | Sagebrush | Grazed | Warden | 2 | 2 |
| 24 | 292210 | 5061450 | Sagebrush | Grazed | Royal | 3 | 5 |
| 25 | 294280 | 5067800 | Low Shrub | Grazed | Koehler | 2 | 2 |
| 26 | 295120 | 5072150 | Low Shrub | Grazed | Quincey | 2 | 3 |
| 27 | 294980 | 5072430 | Low Shrub | Grazed | Quincey | 4 | 3 |
| 28 | 292080 | 5059985 | Sagebrush | Grazed | Warden | 3 | 3 |
| 29 | 290840 | 5060100 | Sagebrush | Grazed | Warden | 3 | 3 |
| 30 | 294670 | 5069700 | Sagebrush | Grazed | Koehler | 3 | 2 |
| 31 | 294130 | 5058090 | Sagebrush | Grazed | Warden | 1 | 3 |
| 32 | 295000 | 5058180 | Low Shrub | Grazed | Warden | 3 | 4 |
| 33 | 294920 | 5058630 | Low Shrub | Grazed | Warden | 2 | 2 |
| 34 | 292190 | 5057530 | Sagebrush | Grazed | Warden | 1 | 2 |
| 35 | 292300 | 5058340 | Sagebrush | Grazed | Warden | 3 | 4 |
| 36 | 294420 | 5059500 | Sagebrush | Grazed | Warden | 5 | 5 |
| 37 | 294820 | 5059410 | Sagebrush | Grazed | Warden | 5 | 5 |
| 38 | 287740 | 5071100 | Bunchgrass | Grazed | Quincey | 2 | 2 |
| 39 | 291100 | 5073360 | Low Shrub | Grazed | Quincey | 3 | 2 |
| 40 | 294700 | 5060200 | Annual Grass | Grazed | Warden | 3 | 3 |
| 41 | 293180 | 5060360 | Sagebrush | Grazed | Warden | 2 | 2 |
| 42 | 289020 | 5058060 | Sagebrush | Grazed | Warden | 4 | 4 |

Appendix 2 (Continued)

| Site | UTMs E | N | VegType | Land Use | Soil Type | Size[a] | Activity[a] |
|---|---|---|---|---|---|---|---|
| 43 | 289385 | 5059445 | Sagebrush | Grazed | Warden | 3 | 3 |
| 44 | 289740 | 5059457 | Sagebrush | Grazed | Warden | 3 | 3 |
| 45 | 290020 | 5056960 | Sagebrush | Grazed | Warden | 2 | 4 |
| 46 | 290020 | 5057500 | Sagebrush | Grazed | Warden | 2 | 3 |
| 47 | 288950 | 5061100 | Sagebrush | UnGrazed | Warden | 2 | 3 |
| 48 | 287660 | 5061290 | Bunchgrass | Grazed | Warden | 3 | 2 |
| 49 | 291815 | 5059700 | Sagebrush | Grazed | Warden | 1 | 3 |
| 50 | 292030 | 5060260 | Sagebrush | Grazed | Warden | 1 | 3 |
| 51 | 291480 | 5061810 | Sagebrush | UnGrazed | Warden | 3 | 2 |
| 52 | 294270 | 5065650 | Annual Grass | Grazed | Royal | 4 | 4 |

a - Size/Activity Rating: 5 = large/most active; 1 = small/least active

**Incedental Sightings**

| | | | | | |
|---|---|---|---|---|---|
| 53 | 295130 | 5063135 | Sagebrush | Grazed | Warden |
| 54 | 292180 | 5060835 | Sagebrush | Grazed | Warden |
| 55 | 291020 | 5060865 | Sagebrush | Grazed | Warden |
| 56 | 292175 | 5060170 | Sagebrush | Grazed | Warden |
| 57 | 289510 | 5060500 | Sagebrush | Grazed | Warden |
| 58 | 291395 | 5061470 | Sagebrush | Grazed | Warden |
| 59 | 288520 | 5071730 | Bunchgrass | Grazed | Quincey |
| 60 | 288510 | 5069170 | Bunchgrass | Grazed | Koehler |
| 61 | 289555 | 5070300 | Bunchgrass | Grazed | Koehler |
| 62 | 286835 | 5070190 | Bunchgrass | Grazed | Koehler |
| 63 | 288150 | 5056125 | Bunchgrass | UnGrazed | Warden |
| 64 | Not Available | | Bunchgrass | UnGrazed | Warden |
| 65 | 290500 | 5059710 | Annual Grass | Grazed | Warden |
| 66 | 289820 | 5059550 | Annual Grass | Grazed | Warden |
| 67 | 294600 | 5074270 | Annual Grass | Grazed | Quincey |
| 68 | 287860 | 5063965 | Low Shrub | Grazed | Warden |
| 69 | 287860 | 5068332 | Low Shrub | Grazed | Koehler |

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# Abundance and Habitat Associations of Washington Ground Squirrels in the Columbian Basin, Oregon

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Abstract.—The Washington ground squirrel (*Urocitellus washingtoni*) is listed as threatened in Oregon and is a species of special concern in Washington. We investigated abundance and habitat selection of the species on the Boardman Bombing Range, Morrow County, Oregon during 1996–1997. Transect surveys were used to determine relative abundance among seven vegetative types, and mark-recapture methods were used to compare density of squirrels among habitats where they were present. Transect surveys indicated highest abundance in sagebrush, followed by perennial grassland then annual grassland; and no squirrels were detected in bitterbrush or low-shrub habitats. Results from live-trapping and capture-recapture methods also indicated higher densities in sagebrush habitat. Mean maximum distance moved on trapping grids was greater for males than females for adults and juveniles alike. Macro-habitat analyses revealed a selection for areas with higher silt content (Warden soils) in soils and higher vegetative cover. Micro-habitat associations indicated a selection for areas with lower clay content in soils. The continued existence of Washington ground squirrels depends upon maintenance of the remaining suitable habitat, particularly large tracts of sagebrush and perennial bunchgrass on Warden soils.

## Introduction

The Washington ground squirrel (*Urocitellus washingtoni*) inhabits the shrub-steppe communities of the Columbia Basin in northcentral Oregon and southcentral Washington. It is a member of the family Sciuridae that includes 20 congeners in Western North America, nine of which occur in Oregon and Washington (Verts and Carraway, 1998:181–203). It is a semi-fossorial species that hibernates 7–8 mo of the year and is active from about Feb. until mid-Jun., depending on weather conditions. Historically its range was on the south and east side of the Columbia River from the mouth of the John Day River, east to Walla Walla, Washington, and north to Spokane, Washington (Bailey, 1936). Conversion of the native shrub-steppe habitat to cultivated agriculture has reduced and fragmented the remaining habitat causing a significant decline in the range of the species (Betts, 1990).

There have been relatively few studies on Washington ground squirrels, and most early information was on their natural history (Bailey, 1936; Howell, 1938; Scheffer, 1941). Bailey (1936) characterized the squirrel as an agriculture nuisance with populations estimated at 100– 250/ha. After years of control and conversion of their habitat, a 1971 search for the species in Oregon was unsuccessful (Olterman, 1972); however, Rohweder *et al.* (1979) found scattered and small populations on the Naval Weapons System Training Facility (hereafter Bombing Range) in northcentral Oregon. Of the 179 sites in Oregon and Washington historically occupied by Washington ground squirrels, 68 were unoccupied in

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1989 (Betts, 1990). In 1998, Betts (1999) revisited the sites known to be active during 1989 and found that 25 of the 36 colonies in Oregon were no longer occupied. Reasons for these apparent declines were not clear. Currently, the Washington ground squirrel is listed as a species of special concern in Washington and as threatened in Oregon.

The purpose of our study was to investigate relative abundance and habitat associations of Washington ground squirrels in the Columbia Basin of northcentral Oregon. The specific objectives of our study were: (1) compare densities of Washington ground squirrels among the dominant vegetative types and (2) describe soil and vegetative characteristics of areas occupied by Washington squirrels at the micro- and macro-habitat scales. Our goal was to provide information on the habitat associations of the species, which may be used for future conservation strategies.

## METHODS

### STUDY AREA

The study was conducted in the spring and summer of 1996 and 1997 on the 19,070 ha Boardman Bombing Range near Boardman, Oregon. The bombing range is approximately 275 km east of Portland, Oregon in shrub-steppe communities of the Columbia River Basin. Elevation ranges from 125 m on the north end of the bombing range to 275 m elevation at the south end. Mean annual rainfall was approximately 22 cm, most of which falls in winter and early spring. There was higher than average rainfall during winter and spring of the years in our study, and the springs were earlier than during usual years. Summers were very hot and dry by Jul., typical of most summers in the area. High winds were common during spring, often exceeding 45 k/h.

The area is a mosaic of vegetative types, ranging from antelope bitterbrush (*Purshia tridentata*) on sandy soils in the north to bunchgrass and sagebrush (*Artemesia* spp.) communities on the loamy soils in the southern portion. Five broadly defined vegetative communities were identified on the Bombing Range, including annual grassland, perennial grassland, low shrubland, sagebrush and bitterbrush. Annual grass communities consisted primarily of cheatgrass (*Bromus tectorum*), an exotic species introduced from Europe. Cheatgrass grows in a dense carpet that excludes other species, and it has been described as a zootic climax as a result of heavy grazing in the bunchgrass habitat (Poulton, 1955; Daubenmire, 1970). Perennial bunchgrass communities were a mixture of needle-and-thread grass (*Hesperostipa comata*) and bluebunch wheatgrass (*Pseudorogneria spicatum*), both natives to the region. The largest intact stands of this habitat remaining in the Oregon portion of the Columbia basin are believed to occur on the Bombing Range where they have been protected from livestock grazing. In stands of better condition, open spaces between the bunchgrass plants were dominated by microbiotic crust, which helps prevent wind erosion and establishment of exotic plant species. Within the bunchgrass community, needle-and-thread was typically dominant on sandier soils while bluebunch wheatgrass was the dominant grass species on loamy soils. Other common native bunchgrass species that occurred in the region were Indian ricegrass (*Actinatherum hymenoides*), Idaho fescue (*Festuca idahoensis*) and squirreltail bottlebrush (*Elymus elymoides*).

Low shrub communities primarily consisted of two species of rabbitbrush (*Chrysothamnos* spp.) and snakeweed (*Gutierrezia sarothrae*). These species occurred on the sandier soils of the study area and were indicative of heavy grazing and fire in sagebrush and bunchgrass habitats. Many native forbs like mariposa lily (*Calochortus macrocarpus*) and Douglas' brodiaea (*Tritelia douglasii*) occurred in the open spaces between shrubs; however, cheatgrass often dominated these spaces. Sagebrush communities occurred throughout the study area and were dominated by big sagebrush (*Artemisia tridentata*). Understory vegetation within sagebrush habitats varied from microbiotic crust in areas of low grazing intensity to various mixtures of cheatgrass, bunchgrass and annual forbs with cheatgrass dominating the spaces between shrubs in heavily grazed areas. Bitterbrush communities occurred on the sandy soils of the northern portion of the study area and were dominated by antelope bitterbrush with an understory of annual grasses (primarily cheatgrass) and forbs including western wallflower (*Erysimum occidentale*) and cluster tarweed (*Madia glomerata*). For more information on the vegetation of the study area, *see* Greene (2000).

### STUDY DESIGN

Three study plots were established in each of the vegetative types. In sagebrush and bunchgrass habitats, three plots were established in one grazed and one un-grazed plot. Thus a total of seven habitats were sampled. First, we randomly selected coordinates for the southwest corner of a 40 ha, square-shaped area (633 m on a side). If the habitat could not be classified into one of the seven types, the plot was rotated so that the random coordinates became the northeast corner of the plot. If the habitat still could not be classified, new random coordinates were generated. These plots were used to compare densities of Washington ground squirrels among the seven vegetative types. Habitat associations were investigated at two scales. The 40-ha plots were used for the macro-habitat comparisons, which measured site selectivity among the vegetative types. A smaller scale of micro-habitat associations was investigated by collecting data at sites occupied by Washington ground squirrels. We refer to sampling locations found on the 40 ha plots and used in the macro-habitat analysis as ‘plot-points,’’ and the points where ground squirrels were found as occupied sites, which ranged from one to many squirrels in number. We also found a few major concentrations of ground squirrels in relatively small areas (<1 ha) that consisted of several adult males and females with numerous juveniles. We refer to these major concentrations as colonies for convenience following Betts (1990), even though it may not fit the strict definition Taxonomy of ground squirrels follows Helgen *et al.* (2009).

### ABUNDANCE MEASURES

*Line transects.*—Line transect surveys were established in each of the vegetative types to compare abundance of Washington ground squirrels at the study area level. Transects were traversed by the first and third authors during mid-morning shortly after squirrels emerged from their burrows and before the high temperatures occurred. We also avoided days with poor weather or high winds. We sampled on each plot once in 1996 ($n = 21$). In 1997, transects were sampled on each plot plus one additional plot per vegetative type ($n = 28$) to increase sample sizes. Detections were counted when a squirrel was either seen or heard. We conducted the surveys during the period of increased alarm calling that corresponded with juvenile emergence from natal burrows, which was a 3–4 wk period from Apr. 15 to May 13th.

Transect lines were parallel, 60 m apart, and extended to the boundaries of the plot. We chose this distance because alarm calls could be heard dependably at distances of up to 30 m, so the distance was doubled to eliminate overlap among transects. Consequently, there were 11 transects of 633 m in length on each plot. Two assumptions of this method are that the observer detects all squirrels on the transect line, and that the distances from the line to a ground squirrel are measured accurately. To meet the latter assumption, we placed a wire flag in the ground at the position where the detection was made then resumed the survey. Upon completion of the survey, we returned to the flag to confirm the presence of squirrels and make accurate measurements of distance of the observation to the transect line.

*Capture-recapture methods.*—Trapping grids were superimposed on ground squirrel colonies in sagebrush, low shrub and bunchgrass habitats to estimate abundance within colonies. Three replicate grids were trapped in each of these habitats between 28 Mar. and 6 Jun., 1997. The grids were oriented with their centers at the estimated center of the colony and consisted of 100 Tomahawk (No. 201) live traps arranged in a grid with 20-m intervals between traps. We used a 10 × 10 configuration for all grids except for a 5 × 20 grid, which was established to conform to the shape of one colony, and a 9 × 11 grid modified to avoid a fence. Traps were opened and baited with apples in the morning and checked during the middle of the day (11:00–2:00) to avoid heat stress and mortality of captured animals. We placed traps under vegetation when possible or covered them with wood, cow dung, or cardboard to minimize exposure to the sun. Captured animals were aged, weighed, sexed and individually marked by toe clips with age determined by pelage and weight. All field work for the project was conducted under Oregon State University's Institutional Animal Care and Use Committee (permit no. 2691).

## HABITAT ASSOCIATIONS

Vegetative and soil characteristics were measured in 1997 at the macro-habitat scale on 28 plots by collecting data at five points systematically distributed in an 'X' shape covering each plot for a total of 105 points. Of the 105 points, those where ground squirrels were present were compared to those where ground squirrels were not detected. Presence and absence was determined around the plot-point in a 50 m radius, a distance that the species readily travels (*see* below). Vegetative and soil characteristics at the micro-habitat scale were measured within Washington ground squirrel colonies. For each colony, we located a paired ''unoccupied site'' within the same vegetative type. Unoccupied sites were located by moving 250 m from the colony site in a randomly chosen direction. We determined that 250 m was an appropriate distance after observing movements of squirrels within colonies and because Carlson *et al.* (1980) observed 239 m as the longest distance moved. Each prospective unoccupied site was surveyed for presence of Washington ground squirrels within a 50-m radius. We did this by listening for alarm calls and looking for squirrels on the plot for a period of time and by systematically walking the plot and looking for burrows or scat. If evidence of squirrels was present on the prospective site, another site was chosen in the same manner starting from the rejected site.

## HABITAT VARIABLES

For each plot-point, colony site, and unoccupied site we measured percent vegetative cover by species, vertical density by life form, effective height of the vegetation, percent shrub cover, and collected soil samples for texture analysis. To obtain these measurements and samples, we established 2, 50 m transect lines set perpendicular to each other, oriented in the cardinal directions, and crossing at their midpoints. Percent cover by plant species, litter, bareground and microbiotic crust were determined by taking 10 measurements at each 5 m intervals (n = 20) along the transect lines. We used a modification of the point intercept method for these measurements with a sighting scope instead of a rod lowered into the vegetation (Pieper, 1973). The vegetation at the cross hair intersection was recorded by species. For analysis, the species were pooled into percent cover for each of five life forms (annual grass, perennial grass, forbs, low shrubs and tall shrubs). Vertical density was measured four times at each 5 m interval (n = 88) with a 6 mm-diameter rod (Wiens 1973). The rod, marked in 10-cm increments, was lowered through the vegetation vertically until it rested on the ground. We recorded the number of times the rod was touched by vegetation in each 10 cm interval. The vegetation was recorded in life form categories similar to those used in the percent cover. Three variables were created from these data for the analysis: (1) the proportion of all contacts that were below 30 cm, (2) the proportion above 30 cm and (3) Shannon-Wiener index of diversity (Zar, 1984) for the number of contacts among the 10 cm increments. Effective height was measured once at each 5 m interval ($n = 22$) using a red and white 30-cm wide plank with a 3 cm square checkerboard pattern. We recorded the height at which ≥90% of the board was obscured by vegetation when it was viewed at eye level from 10 m (Wiens 1973). Average effective height and coefficient of variation for this variable were calculated for these comparisons. Shrub intercept was measured along the transect lines (total of 100 m) at each site. Distance along the transect line that was intercepted by shrubs was recorded by species and whether the plant was live or dead. Percent shrub cover was computed as the intercept distance divided by the total length of the transect line (Pieper, 1973).

A soil sample was collected from a depth of 30 cm at each end of the transect lines and at their intersection for a total of five samples/plot. For laboratory analysis, we combined the five samples from each location to make a composite sample. Soil texture (*i.e.*, percent coarse material, sand, silt, and clay) was determined using the hydrometer method according to the American Society for Testing Material procedures (Day, 1965).

### STATISTICAL ANALYSES

*Abundance estimates.*—Estimates of density, effective sampling width, and a probability of detection were estimated with program DISTANCE using the perpendicular distance of the squirrels from the transect lines and the total length of transect line sampled (Laake *et al.*, 1993; Buckland *et al.*, 1993). Because vegetative structure may affect detectability of squirrels, estimates were obtained for each vegetative type. Distances were pooled into 20 m intervals to compensate for movements of animals in response to the observer. To obtain a sufficient sample size to estimate detection functions for each vegetative type, we pooled detections for both years.

Abundance of squirrels in colonies was estimated from capture-recapture methods for closed populations using program CAPTURE (Otis *et al.*, 1978). Model selection for abundance estimation was based on $X^2$ goodness of fit tests and the model selection procedures in CAPTURE (White *et al.*, 1982). Models considered for estimates accounted for any heterogeneity of behavior (model $M_h$) among animals (dominance, territoriality), response to being trapped (trap-shy or trap-happy animals, model $M_b$) and/or evidence of time effects (model $M_t$) such as weather, which may have affected capture probabilities of squirrels (White *et al.*, 1982). The robustness of the different estimators in CAPTURE was evaluated using the simulation capabilities in program CAPTURE based on varying levels of heterogeneity, behavioral response and time effects. We used model $M_{th}$ and the Chao estimator (Chao *et al.*, 1992) to estimate abundance and capture probabilities. Density was estimated by dividing the population estimate by the effective trapping area of the grid, which is calculated by adding one-half of the mean maximum distance moved (MMDM) to each side of the grid (Wilson and Anderson, 1985). Analysis of variance was used to compare MMDM among each sex and age group and also among habitats.

*Habitat associations.*—At the macro-habitat level, vegetative and soil characteristics were compared based on the presence or absence of Washington ground squirrels using logistic regression. Univariate analysis and correlation were used to determine insignificant or redundant variables with SAS (1989). Variables with a $P > 0.25$ in the univariate analysis or those correlated with another variable at $r > 0.7$ were not included in the multivariate

TABLE 1.—Transect distances, number of detections and results of DISTANCE analysis from transect surveys of Washington ground squirrels in seven vegetative types on the Boardman Bombing Range, Morrow County, Oregon, 1996–1997

| Pooled habitats | Number of detections | Kilometers surveyed | Detections/10 km |
|---|---|---|---|
| Sagebrush | 15 | 113.1 | 1.3 |
| Bunchgrass | 9 | 149.0 | 0.6 |
| **Habitat** | | | |
| Grazed sagebrush | 12 | 67.2 | 1.8 |
| Ungrazed sagebrush | 3 | 45.9 | 0.7 |
| Grazed bunchgrass | 2 | 109.6 | 0.2 |
| Ungrazed bunchgrass | 7 | 39.7 | 1.8 |
| Annual grass | 2 | 43.1 | 0.5 |
| Low shrub | 0 | 53.7 | 0.0 |
| Bitterbrush | 0 | 56.4 | 0.0 |

analysis (Hosmer and Lemeshow, 1989:83). In the case of high ($r > 0.7$) correlations between variables, biological significance and ease of interpretation determined which variable was retained in the model. We also expanded the model to include interactions between the soil and vegetative variables that remained in the multivariate model. Interactions were critiqued at a more critical level and considered significant if $P < 0.10$ (Hosmer and Lemeshow, 1989:89). Number of variables in the model was reduced using Wald's test, and succeeding models were evaluated using drop in deviance and Akaike's Information Criteria (Hosmer and Lemeshow, 1989:90).

At the micro-habitat scale, vegetative and soil characteristics of ground squirrel colonies were compared to unoccupied sites using matched-pair logistic regression. With this analysis, the explanatory variable is the arithmetic difference between the variables measured at the paired sites. After obtaining the difference, variable reduction and model selection was conducted identically to the macro-habitat analysis described above.

## RESULTS

### ABUNDANCE

Washington ground squirrels were not abundant on the study area during 1996–97; therefore, we detected few squirrels along transects. We found ground squirrels at 15 sites in sagebrush, nine in bunchgrass and two in annual grass. Sagebrush with a taller, more concealing structure had a lower probability of detection (0.31 vs 0.67) and a smaller effective sampling width (18.9 vs 40.0 m) along transects than bunchgrass (Table 1). No detections were recorded in low shrub or bitterbrush vegetative types during transect surveys. Squirrels were more abundant in sagebrush ($\hat{D} = 0.35$ squirrels/km$^2$, 95% CI = 25.0 to 45.9) than bunchgrass ($\hat{D} = 0.08$ squirrels/km$^2$, 95% CI = 0.0 to 0.24).

Estimates of density of squirrels in colonies were highest for two sagebrush sites with 15.7 (95% CI; 15.4 to 17.3) and 3.9 (95% CI; 3.7 to 6.5) squirrels/ha (Fig. 1). The highest density estimate for the other vegetative types was 2.6 (95% CI; 2.1 to 5.5) squirrels/ha in low shrub. Differences among vegetative types were not statistically significant because of high variation and a small number of replicates ($F = 1.64$; $P = 0.26$). The third trapping grid in sagebrush was lower possibly because it was trapped (28 Mar.–8 Apr.) before most juvenile emergence had occurred. The earliest young of the year were captured was 29 Mar., 1997.

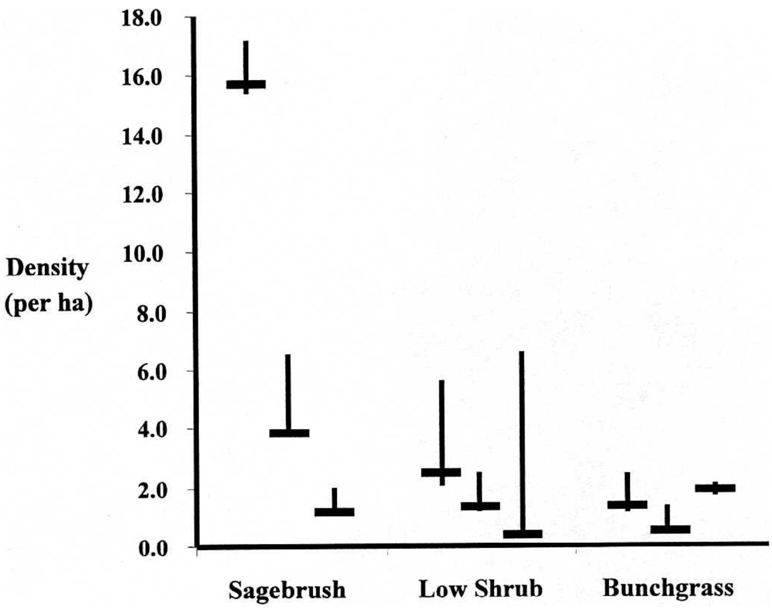


FIG. 1.—Density and 95% confidence intervals of Washington ground squirrels at three replicate sites in sagebrush, low shrub, and bunchgrass habitats on Boardman Bombing Range, Morrow County, Oregon, 1997

MOVEMENTS

Mean maximum distance moved (MMDM) between trapping occasions was significantly greater for males than females ($F = 12.78$, $P = 0.0006$, Fig. 2). Males moved an average maximum distance of 85.6 m (95% CI = 69.1 to 101.5, $n = 30$) within colonies, while females moved an average maximum distance of 51.7 m (95% CI = 40.4 to 62.0, $n = 51$). There was no significant difference in MMDM between the age classes ($F = 0.15$, $P = 0.15$). Movement within colonies was not significantly different among vegetative types and averaged 63.6 and 68.4 m in sagebrush and low shrub, respectively ($F = 0.05$; $P = 0.95$). The longest observed distance moved within a colony was by an adult male who traveled 182 m in the low shrub type.

HABITAT ASSOCIATIONS

*Macro-habitat selection.*—The 100 plot-points were placed in seven vegetative types including annual grasses, grazed and ungrazed perennial grasses, low shrub habitats, grazed and ungrazed sagebrush and bitterbrush. We observed Washington ground squirrels at 20 of the 100 points on 21 plots. Significant variables ($P < 0.05$) retained in the modeling after univariate analysis and correlation analyses were percent coarse material and silt content of the soil, coefficient of variation for the effective height, and percent cover of perennial grass, forbs, litter, bare ground and microbiotic crust (Table 2). Percent silt content of the soil was correlated with percent sand and clay ($r = -0.997$ and 0.713, respectively); therefore it was retained in the analysis while sand and clay were removed. Interactions between percent silt and the vegetation variables were not significant ($P >$ 0.10). Further variable reduction using Wald's test produced a model with percent silt

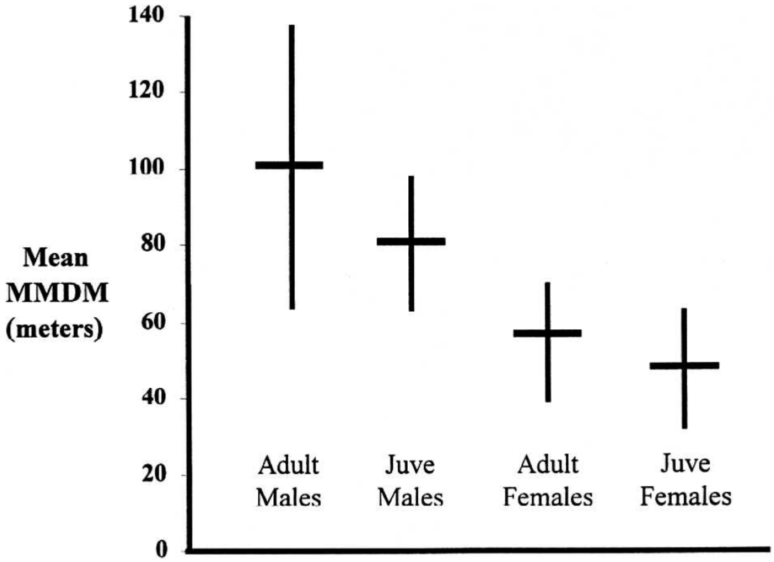


FIG. 2.—Mean maximum distance moved (MMDM) on trapping grids by Washington ground squirrels by age and sex on Boardman Bombing Range, Morrow County, Oregon, 1997

content of the soil (P = 0.004) and percent cover of bare ground (P = 0.032) as significant explanatory variables. The mean silt content was higher at occupied points (50 vs. 22%), and mean percent cover of bare ground was lower at occupied points (3 vs. 13%) (Table 2). The odds of Washington ground squirrels being present at locations with a silt content of 50.2%

TABLE 2.—Vegetative characteristics (mean, standard error) of occupied and unoccupied plots by Washington ground squirrels from the macro-habitat analysis, Boardman Bombing Range, Morrow County, Oregon, 1996–1997

| Variable | Occupied | | Unoccupied | | P-value |
|---|---|---|---|---|---|
| | Mean | SE | Mean | SE | |
| Vertical density < 30 cm | 0.9 | 0.0 | 0.9 | 0.0 | 0.57 |
| Diversity Index of vertical density | 0.5 | 0.0 | 0.5 | 0.0 | 0.58 |
| Mean effective height | 9.0 | 1.6 | 9.2 | 0.7 | 0.89 |
| Coeff of Variation; effective height | 1.1 | 0.1 | 1.3 | 0.1 | 0.20 |
| Annual grass cover (%) | 25.5 | 4.9 | 23.1 | 1.4 | 0.52 |
| Perennial Grass Cover[a] (%) | 22.6 | 4.2 | 9.6 | 1.4 | 0.001 |
| Forb cover (%) | 4.8 | 0.8 | 8.9 | 0.8 | 0.02 |
| Shrub cover (%) | 9.4 | 2.6 | 11.2 | 1.4 | 0.55 |
| Litter cover (%) | 24.0 | 1.5 | 31.6 | 0.9 | 0.001 |
| Bare ground cover (%) | 3.1 | 0.5 | 12.9 | 1.1 | 0.0001 |
| Microbiotic crust cover[a] (%) | 13.4 | 2.1 | 6.1 | 0.8 | 0.001 |
| **Soil texture** | | | | | |
| Clay (%) | 5.4 | 0.5 | 3.8 | 0.3 | 0.017 |
| Silt[b] (%) | 50.2 | 1.8 | 22.3 | 2.1 | 0.0001 |
| Sand[b] (%) | 44.4 | 2.1 | 74.0 | 2.3 | 0.0001 |
| Coarse material (%) | 0.1 | 0.1 | 0.9 | 0.2 | 0.11 |

TABLE 3.—Results of logistic regression analysis of habitat selection of Washington ground squirrels at the macro- and micro habitat levels, Boardman Bombing Range, Morrow County, Oregon, 1996–1997

| Variable | Regression coefficient | SE | P-value | Odds ratio |
|---|---|---|---|---|
| **Macro-habitat analysis:** | | | | |
| Intercept | 3.4498 | 1.444 | 0.0169 | |
| %Silt | 0.0808 | 0.0284 | 0.0044 | 1.084 |
| %Bare ground | −0.1829 | 0.0854 | 0.0321 | 0.833 |
| **Micro-habitat analysis:** | | | | |
| %Clay | −0.2045 | 0.1011 | 0.0431 | 0.815 |

was 9.5 times higher than were locations whose silt content was 22.3% (95% CI: 2 to 45) (Table 3). Likewise, the odds of Washington ground squirrels being present at locations with 3.12% bare ground cover was 5.9 times higher than them being present at locations whose percent bare ground cover was 12.9% (95% CI; 1.2 to 29.7).

*Micro-habitat selection.*—The majority (64%) of the 44 occupied sites were located in habitats dominated by sagebrush. The remaining occupied sites were found in bunchgrass or low shrub vegetation; no squirrels or sign thereof were found in bitterbrush or annual grass vegetation. Significant variables retained in the modeling after correlation and univariate analyses were percent cover of perennial grass, percent clay and percent sand (Table 4). Interactions between soil variables and perennial grass were not significant ($P > 0.10$). Further variable reduction using Wald's test produced a model with percent clay content of soil ($P = 0.043$) as the only significant variable. The mean value for percent clay content of the soil was lower at occupied sites (5.0%) than unoccupied sites (6.1%). The odds of Washington ground squirrels being present at locations with a clay content of 5.0% were 1.3 times higher than sites whose clay content is 6.1% (95% CI; 1.6 to 1.007) (Table 3).

TABLE 4.—Vegetative characteristics (mean, standard error and univariate significance) of colonies occupied by Washington ground squirrels and unoccupied sites from the micro-habitat analysis, Boardman Bombing Range, Morrow County, Oregon, 1996–1997

| | Colony site | | Unoccupied | | |
|---|---|---|---|---|---|
| Variable | Mean | SE | Mean | SE | P-value |
| Vertical density < 30 cm | 0.91 | 0.01 | 0.90 | 0.01 | 0.63 |
| Vertical density > 30 cm | 0.09 | 0.01 | 0.10 | 0.01 | 0.35 |
| Diversity index of vertical density | 0.48 | 0.02 | 0.47 | 0.02 | 0.59 |
| Mean effective height | 8.68 | 0.84 | 8.64 | 1.18 | 0.96 |
| Coeff of variation; effective height | 1.38 | 0.07 | 1.27 | 0.09 | 0.39 |
| Annual grass cover (%) | 24.04 | 2.38 | 26.84 | 2.56 | 0.31 |
| Perennial grass cover (%) | 15.95 | 2.05 | 13.88 | 2.02 | 0.19 |
| Forb cover (%) | 5.57 | 0.79 | 5.27 | 0.94 | 0.78 |
| Shrub cover (%) | 13.07 | 1.88 | 11.39 | 1.77 | 0.35 |
| Litter cover (%) | 26.03 | 1.04 | 27.17 | 1.03 | 0.32 |
| Bare ground cover (%) | 8.66 | 1.41 | 7.60 | 1.37 | 0.59 |
| Microbiotic grust cover[a] (%) | 10.99 | 1.47 | 10.92 | 1.52 | 0.97 |
| **Soil Texture** | | | | | |
| Clay (%) | 4.97 | 0.35 | 6.08 | 0.46 | 0.04 |
| Silt (%) | 45.01 | 3.14 | 47.98 | 2.38 | 0.30 |
| Sand (%) | 50.00 | 3.35 | 45.95 | 2.65 | 0.21 |
| Coarse material (%) | 0.83 | 0.36 | 3.76 | 1.84 | 0.28 |

## Discussion

### abundance

Abundance estimates from transect surveys in our study indicated that there were more Washington ground squirrels in sagebrush than the other vegetative types during 1996–1997. Estimates from live-trapping supported these results with higher abundance in colonies that were located in sagebrush. However, density estimates from live-trapping were considerably higher than those obtained from transects because live-trapping was performed within known colonies and reflected densities within colonies. In contrast, transect surveys were performed over larger areas that had a few scattered groups and individuals squirrels. Density estimates from transect surveys was a better indication of abundance on the study area and the scarcity of the species at a larger scale. In fact, Washington ground squirrels occurred with such low frequency in our study that it was difficult to obtain a large enough sample size for precise density estimates from transect surveys. Line transects, however, did prove to be an effective means of determining presence of the species. Washington ground squirrels elicit alarm calls in the presence of observers, particularly during the period of juvenile emergence (mid-Apr. to early May), which can be used as a good cue for presence in addition to direct observations.

Density estimates from capture-recapture methods suggested higher abundance within colonies in sagebrush. Estimated densities in this study (range = 1.0–16.0 squirrels/ ha) were much lower than the rough estimates (100–250 squirrels/ha) of Bailey (1936) and estimates of Klein (2005), who reported a range of densities of 11.0–90.0 squirrels/ha on seven study sites from 2002–2003. This study and that of Klein (2005) were conducted on some of the same study sites with similar methods, and results indicate that populations of Washington ground squirrels fluctuated considerably and were lower during 1996–1997 (this study) compared to 2002–2003 (Klein, 2005). The recent increase in squirrel abundance on the Bombing Range (Klein, 2005) was likely due to the increased rainfall around the turn of the century as it has been shown that other ground squirrel populations decline after periods of drought (Van Horne *et al.*, 1997a). Sagebrush habitat was found to be more suitable for Townsend's ground squirrels (*U. townsendii*), particularly in drought-prone environments and drought years (Van Horne *et al.*, 1997a). During a drought period in southwestern Idaho, adult Townsend's ground squirrels maintained higher masses and rates of persistence from one year to the next in sagebrush than in grassland habitats where rates of persistence dropped (Van Horne *et al.*, 1997a). Survival during the winter hibernation period was related to pre-hibernation weight of Columbian ground squirrels (*U. columbianus*) (Murie and Boag, 1984), so attainment of a mass that will sustain each individual squirrel until the next active season was highly dependent upon the precipitation and quality of forage (Bintz, 1984).

Low shrub vegetation was used less than sagebrush and perennial grasslands in our study. While density estimates of colonies from capture-recapture methods were comparable among sagebrush, perennial grasslands and low shrub vegetation, no detections of squirrels were made with transect surveys in low shrub habitats. These results suggest that low shrub habitat was not selected; however, all low shrub habitats and bitterbrush habitats were located in the sandier soils in the northern half of the study area. The low abundance of squirrels in these habitats may be related to soil type rather than vegetation (*see* below).

### habitat associations

One of the important results of this study was that Washington ground squirrels selected sites based on soil characteristics as much as on vegetative characteristics. At the macro-habitat scale, they selected sites with higher silt content, which may have significant effects on the integrity of the soil and the species' ability to construct and maintain burrows. Similarly, Betts (1990) compared vegetation and soils at sites occupied and unoccupied by Washington ground squirrels and concluded that food availability and soil characteristics were most important in determining distribution of the species. Pocket gophers (*Geomys* spp.), a highly fossorial genera in Texas, have been observed to select sites based on soil characteristics and occur regularly in soils that were easily worked and ideal for burrowing (Davis *et al.*, 1938). They were not found in soils considered not conducive to burrowing activities because they were plastic, sticky and compact, suggesting high clay content. Conversely, pine voles (*Microtus pinetorum*), a semi-fossorial rodent in southern Pennsylvania orchards, selected sites with higher gravel and clay content, while fine material and sand were significantly lower than where pine voles were absent (Fisher and Anthony, 1980). Pygmy rabbits (*Brachylagus idahoensis*), one of the few burrowing lagomorphs, selected sites with significantly deeper soils and lower clay content than unoccupied sites in Oregon (Weiss and Verts, 1984).

Most of the sites occupied by Washington ground squirrels in our study were located in the southern portion of the study area, which is underlain by Warden soils. Warden soils are loamy and characterized by high silt content. In addition to having relatively high silt content, Warden soils are also deep. Reynolds and Wakkinen (1987) found that Townsend's ground squirrel dug deeper burrows than other burrowing species (*Peromyscus*, *Microtus* and *Dipodomys* spp.) and suggested that deeper burrow systems likely provided insulation from extreme temperatures and low precipitation.

While silt content of the soil was significant in the macro-habitat analysis in this study, it also was correlated highly with percent sand and clay content ($r = -0.99$ and $0.71$ respectively). This correlation suggests that sand and clay content of the soil also are important for the identification of suitable habitat for Washington ground squirrels. Sand was negatively correlated to silt suggesting an avoidance of sandy soils by the species, which likely explains their absence from the northern part of the Bombing Range. In addition, the micro-habitat analysis indicated that squirrels selected sites with low clay content in our study. The low clay content at occupied sites at both the macro- and micro-habitat scales (4.3 and 6.3%) suggested a low tolerance for clay content in soils. Low levels of clay provide a soil that is more friable, while high levels of clay create a dense soil, which may prohibit burrowing.

While our analysis did not detect significant differences in the type of vegetation present at occupied versus unoccupied sites in sagebrush and bunchgrass communities, it did reveal that the amount of vegetative cover might be an important factor. The lack of significance in the type of vegetation is not surprising when one considers the diet of this species. Ground squirrels are hindgut fermenters, and they eat a wide variety of succulent foods (Robbins, 1993) including stems, buds, leaves, flowers, roots, bulbs and seeds of plants (Scheffer, 1941). However, Washington ground squirrels appear to benefit from higher sagebrush cover because it may provide more available forage and protect them from aerial predators. Sagebrush may provide an alternate source of food and water (Van Horne *et al.*, 1998), and its shading properties may maintain succulence of other forage while maintaining lower soil temperatures (Bintz, 1984; Van Horne *et al.*, 1997a). Forage has been shown to be an important determinant for survival through the inactive season for Townsend's ground squirrels (Bintz, 1984). Increased vegetative cover may also reduce vulnerability of squirrels to the suite of raptorial birds, which prey on Washington ground squirrels (Klein, 2005). Swainson's hawks, ferruginous hawks, northern harriers and prairie falcons frequent the study area, and predation on dispersing juveniles was high in another study due to these predators (Klein, 2005). Swainson's hawks have been observed to spend less time foraging over areas with higher vegetative cover, even though those areas contained a higher density of prey (Bechard, 1982).

Another significant variable at the macro-habitat scale in this study was percent cover of bare ground. A factor that may have affected the amount of bare ground on our study area was livestock grazing. Results from the comparison of the grazed versus ungrazed sagebrush and bunchgrass habitats indicated that the cover of bare ground was higher in grazed habitats (Greene, 2000). In other studies, reduction of microbiotic crust cover has also been correlated to grazing, which resulted in increased erosion, and decreased water infiltration (Fleischner, 1994). Microbiotic crust also increases the available soil nutrients such as nitrogen and phosphorus, increases soil stability and contributes to ecological succession (Mayfield and Khelmer, 1984). The replacement of microbiotic crust by bare ground results in a loss of these important functions, and Washington ground squirrels selected sites with low amounts of bare ground in our study.

Washington ground squirrels are ecologically important in the Columbia Basin of Oregon. Their diurnal behavior, annual cycle and size make them well suited as prey for several species of predatory birds and mammals (Klein, 2005). Conservation of the few remaining shrub-steppe habitats in the Columbia Basin will be important for Washington ground squirrels and the many other species that depend on this plant community. The Boardman Bombing Range contains a large expanse of suitable habitat for this species, and it is a stronghold for other sensitive species including the American badger (*Taxidea taxus*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*B. swainsoni*), burrowing owl (*Speotyto cunicularia*) long-billed curlew (*Numenius americanus*), sage sparrow (*Amphispiza belli*), grasshopper sparrow (*Ammodramus savannarum*), black-throated sparrow (*Amphispiza bilineata*) and longerhead shrike (*Lanius ludovicianus*).

Washington ground squirrels are a candidate for federal listing, candidate for listing in Washington and listed as threatened in Oregon. Continued existence of the species will depend on conservation of remaining areas of suitable habitat, particularly those areas where they are currently or were historically present. It is especially important to maintain all habitat on the few remaining large undeveloped tracts as these areas likely serve as source populations for surrounding fragmented areas of habitat in Oregon. Suitable habitat consists of areas with a relatively high coverage of sagebrush, rabbitbrush, or perennial bunchgrass on Warden soils.

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# Status of Washington Ground Squirrels on the Boardman Naval Weapons Systems Training Facility:

## Evaluation of Monitoring Methods, Distribution, Abundance, and Seasonal Activity Patterns

Submitted to:
U.S. Dept. of the Navy
Natural Resources Section

Submitted by:
Cheryl Quade
The Nature Conservancy

4 November 1994

(photo courtesy of Gary Clowers, Raven Research West, Inc. 1993)

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I. INTRODUCTION

The little-known Washington ground squirrel (*Spermophilus washingtoni*), a grayish-brown ground squirrel flecked with white spots, formerly occupied low elevation sagebrush and grassland habitats east and south of the Columbia River in Washington and Oregon on the Columbia Plateau (Bailey 1936, Howell 1938). By 1988, this once abundant ground squirrel occupied only 45% of historically active sites in both states, with colonies on another 25 (14%) sites degraded to "highly vulnerable to extinction" (Betts 1990). The Washington ground squirrel is currently classified as a "species of special concern" in Oregon and Washington.

Habitat fragmentation and degradation have likely contributed to the contraction of range and decline in overall abundance of the species (Betts 1990). Through overgrazing and agricultural conversion, the native landscape of the Columbia Basin has slowly been transformed. Non-indigenous species and crops are replacing indigenous grasses and other plant species throughout the region. The largest protected collection of Washington ground squirrel colonies in Oregon is found at the Boardman Naval Weapons Systems Training Facility (Fig. 1), approximately 5km south of Boardman and 72km west of Pendleton (Betts 1990). Nestled amidst agricultural fields in northern Morrow County, Boardman NWSTF offers the largest unfragmented tract of high quality native grassland in the range of the Washington ground squirrel (Carlson et al. 1980, Kagan 1987). Much of the area has been largely excluded from grazing since 1943 (Rappel 1978). Overall, the mixture of palouse grasslands and shrublands found there afford an unique setting to study the Washington ground squirrel in its native habitat.

Aside from early natural history accounts (Bailey 1936, Howell 1938, Dalquest 1948), an unpublished population study (Carlson et al. 1980), and a geographic range study (Betts 1990), little is known about the Washington ground squirrel. The Washington ground squirrel is ecologically important in its role as a major food source for raptors and other predators and for the potential aeration of soils associated with its fossorial habits. Swainson's hawks and ferruginous hawks (C2 candidate for threatened status by the U.S.F.W.S), in particular, are two Oregon "species of special concern" which prey upon the Washington ground squirrel. Other predators include badgers, gopher snakes, rattle snakes, and coyotes.

II. ENVIRONMENTAL CHARACTERISTICS

**A. General Habitat Characteristics**

1. General Land Use Patterns

Currently, the 19,070 ha of the Boardman Naval Weapons Systems Training Facility (hereafter, Boardman NWSTF) are used for military training, livestock production, agriculture, and wildlife habitat. Historical and cultural areas, Research Natural Areas, and landscape and maintenance areas are also located within the facility (McClelland and Bedell 1987).

Military activity involves training naval pilots (Naval Air Station Whidbey Island, 402 km to theIncluded as historical and cultural areas are the seven miles of Oregon Trail that crosses the NWSTF in the south, and its associated landmarks (Fig. 2). The stretch of uninterrupted wagon ruts within this section of trail is one of the most pristine in the state of Oregon. Upper and Lower Well Springs, the cemetery containing the marked grave of Colonel Gilliam and other unidentified pioneers, and remnants of the stagecoach station at Upper Well Springs are found along the trail and within Boardman NWSTF. Three Research Natural Areas (hereafter, RNA), managed through agreements with The Nature Conservancy, occupy 2,046 ha (including the 1,035 ha of central target mentioned above). They were selected for the regional and international significance of their plant communities and were designed to provide a baseline for

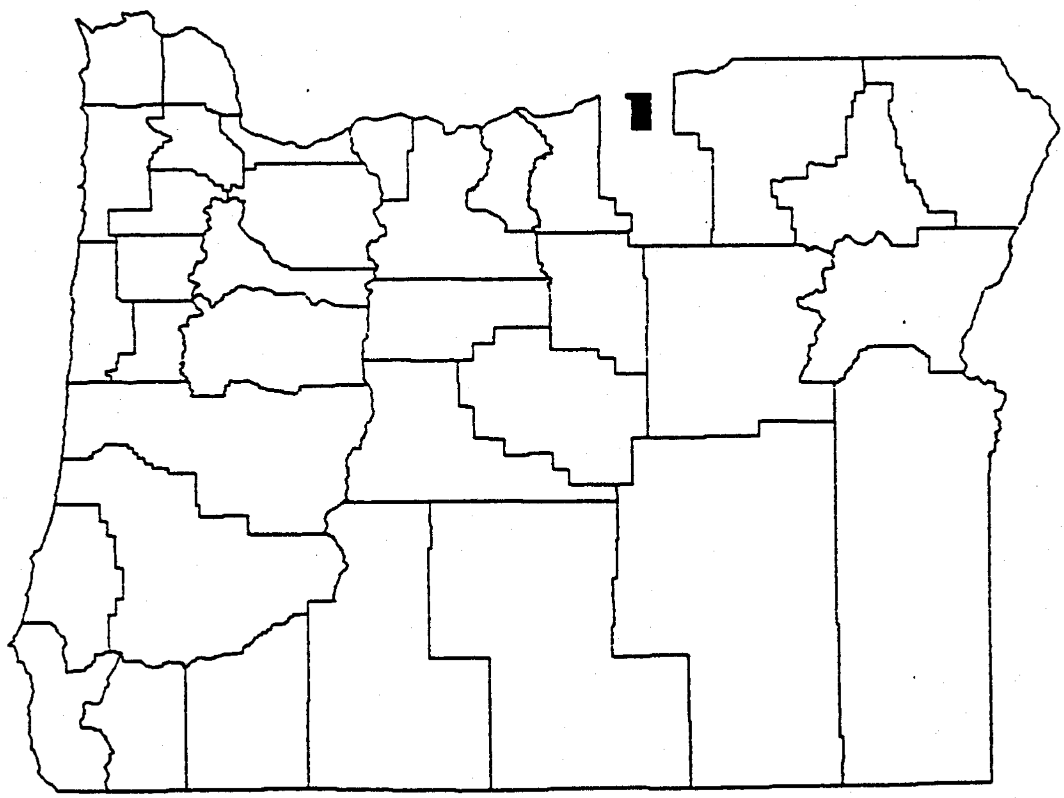

Figure 1: General location of the Boardman Naval Weapons Systems Training Facility in the state of Oregon.

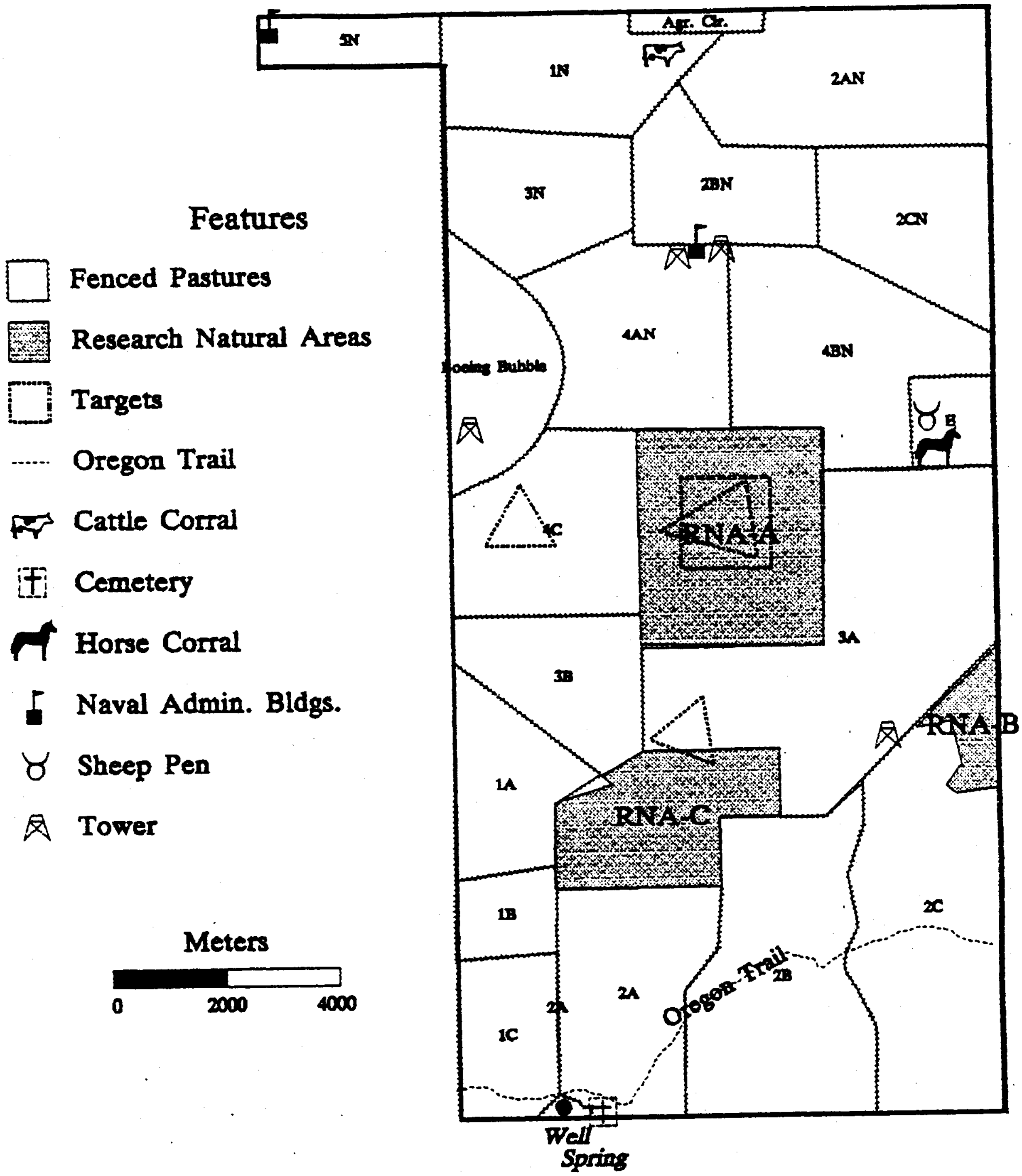


Figure 2: Central targets, fenced rangelands, agricultural land, administrative areas, historical and cultural landmarks, and Research Natural Areas within Boardman Naval Weapons Systems Training Facility.

comparison with other sites, protected habitat for indigenous species, and sites for general ecological research.

2. Climate

The windy, semi-arid climate of Boardman is characterized by low precipitation throughout the hot summers and relatively cold winters. With only 28 cm at the southern end of the NWSTF decreasing to 20 cm north to Boardman, the total annual precipitation is comparable to desert landscapes such as Phoenix, Arizona. November, December, and January are the wettest months, with minimal measurable precipitation during June-October. Additional, unmeasured precipitation comes in the form of winter fog (McClelland and Bedell 1987).

At Boardman, the mean monthly temperature is 13.3°C (mean min. 5°C, mean max. 19°C). The frost-free period extends 180-200 days. Winds from the southwest prevail most of the year, with velocities commonly exceeding 40 km per hour March through July. The percent of time winds exceed 4.8 km per hour is 60% in January, 80% in April, 86% in July, and 76% in October (PGE 1986).

3. Physiography

Topography on the Boardman NWSTF generally follows a north-south gradient, gradually rising from 125 to 275m (McClelland and Bedell 1987). The relatively flat (2 -10% slopes) northern landscape changes to variable terrain with moderately steep canyons and rounded hills (5 -20% slopes) in the south. The southern canyons are known as Juniper Canyon and Well Spring Canyon, to the east and west of the Boardman Naval Weapons Systems Training Facility, repectively.

4. Soils

Soils that now cover the Columbia River basalt beneath Boardman NWSTF were the result of Pleistocene geologic events (Allen et al. 1986). Each time the Cordilleran ice sheet advanced into the Clark Fork River Valley (Montana) between 15,000 and 12,800 years ago, it trapped huge quantities (2,000 $km^3$) of glacial melt water. The lakes formed behind the ice dam were collectively known as "Lake Missoula." Eventually, enough water would collect to move (float) the ice and cause some of the greatest floods recorded in North America. At least 40 such flooding events, called the Bretz floods, occurred over the 2,200 year time period. Near Boardman, the water repeatedly collected to form a lake that covered almost 3,900 $km^2$ and reached depths of 300m (Lake Condon). The flood waters scoured the area near Boardman, leaving behind closed (no outlets) depressions with southwestern orientation (direction of floods) that are still visible. Erratics (rocks not normally found in this area and presumably carried by the floods) are also still commonly seen. Lacustrine silts, sand, and gravel were deposited by these events and shaped by prevailing northern winds.

Reflecting the influence of Lake Condon and perhaps more recent flooding from the Columbia River, the northern soils on the NWSTF contain more sand than silt (Fig. 3). Southern soils contain more silt than sand, acquiring loamy characteristics. The 12 soil types identified on NWSTF by the Soil Conservation Service (1983) are presented in Table 1.

5. Wetlands

There are no perennial wetlands on Boardman NWSTF although cottonwood snags still stand at Well and Tub springs, indicating past occurrence. The shallow springs and streams once existing in the southern part of the range as indicated on topographic maps have diminished. perhaps due

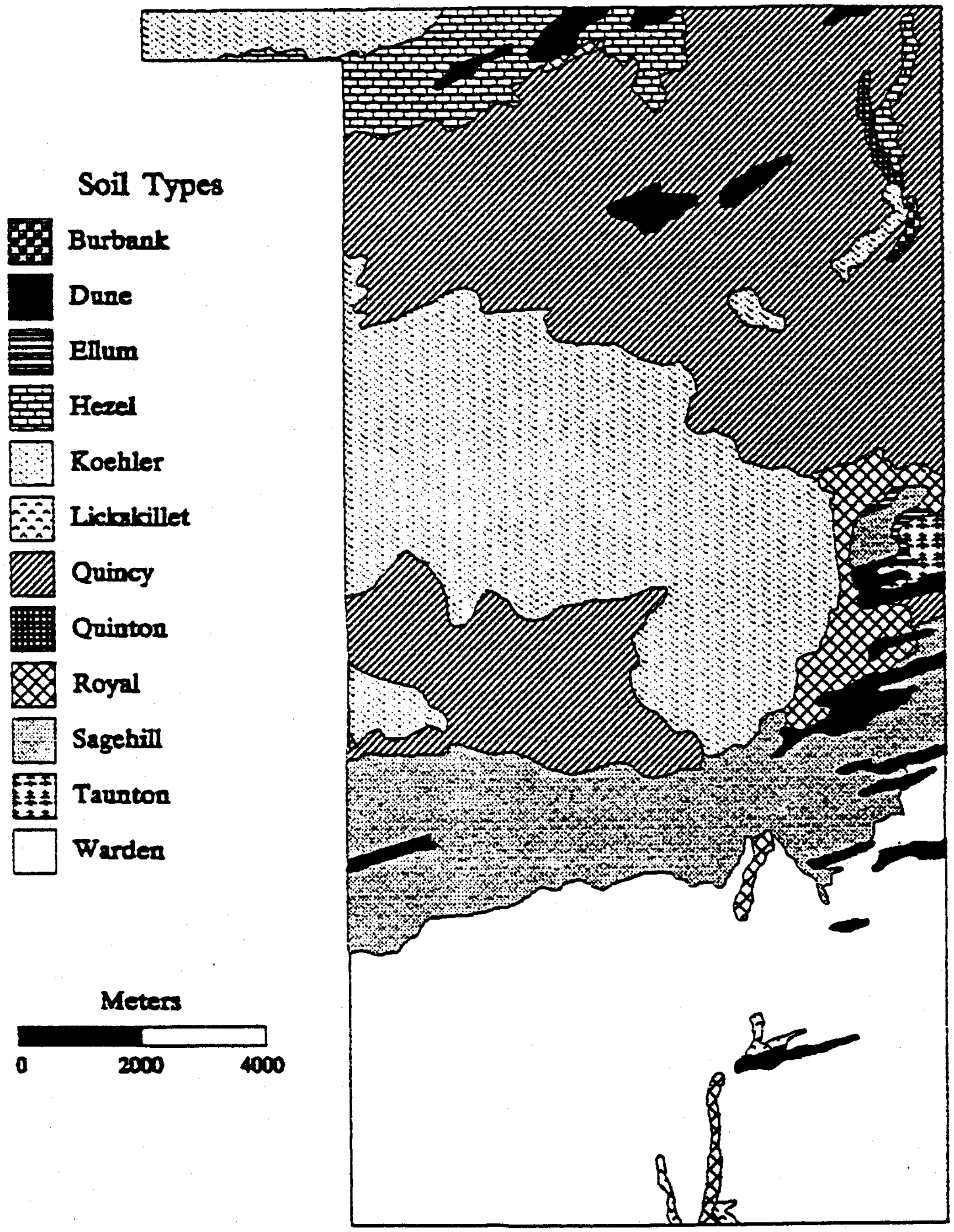


Figure 3: Soils map for Boardman Naval Weapons Systems Training Facility (Soil Conservation Service 1983, McClelland and Bedell 1987).

Table 1: Soils of Boardman Naval Weapons Systems Training Facility, adapted from the Soil Conservation Service (1983)

| Series Name | Description | Depth, to bedrock (other) | Drainage | Associated Physiography (% slope) | Formation |
|---|---|---|---|---|---|
| Burbank | loamy fine sand | very deep, >1.5m (0.5-1m to very gravelly and very cobbly sand) | excessive | terraces (2-12%) | gravelly alluvial deposits and wind worked material |
| Ellum | fine sandy loam | moderate, >1.5m (25-60cm to lime; 0.5-1m to calcareous, gravelly duripan, which can be weakly or strongly cemented) | well | terraces (2-12%) | water deposited sand and gravel |
| Hezel | loamy fine sand | very deep, >1.5m (40-90cm to lacustrine materials, 10-75cm to secondary lime) | somewhat excessive | terraces and uplands (2-12%) | water and wind lain materials |
| Koehler | loamy fine sand | moderate, >1.5m (0.5-1m to duripan) | excessive | terraces (2-12%) | mixed sand |
| Lickskillet | very stony loam | shallow, 30-50cm | well | west and south facing slopes of canyon and river breaks (7-70%) | shallow, stony colluvium from loess and in residuum from basalt |
| Quincy | loamy fine sand | very deep, >1.5m (>50cm to lime) | excessive | uplands and terraces with rigid, hummocky, or duny microrelief (2-12%) | mixed sand |
| Quinton | loamy fine sand | moderately deep, 0.5-1m | excessive | terraces (2-20%) | mixed sand over basalt bedrock |
| Royal | loamy fine sand | very deep, >1.5 m (25-60cm to lime) | well | foot slopes and terraces (0-20%) | wind lain material |
| Sagehill | fine sandy loam | very deep, >1.5 (40-75cm to lime) | well | terraces (2-20%) | wind lain material and calcareous lacustrine sediment |
| Taunton | fine sandy loam | moderate, >1.5m (0.5-1m to duripan) | well | high terraces (0-12%) | wind lain alluvium |
| Warden | silt loam | very deep, >1.5m (40-75cm to lime) | well | terraces and uplands (0-40%) | wind lain silt over calcareous lacustine silt |

to a lowering water table. After heavy rains, water sometimes collects on the surface of roads and in the canyons. Snowmelt from the Blue Mountains flows through Juniper Canyon during wet years, forming an ephemeral pond where the topography flattens in the northeast. The last flow occurred during 1993.

6. Flora and Fauna

Boardman NWSTF supports the largest remnants of needle and thread grass (*Stipa comata*)[1]/Sandberg's bluegrass (*Poa secunda*) grassland (hereafter, "*Stipa/Poa*"), bluebunch wheatgrass (*Agropyron spicatum*)/Sandberg's bluegrass grassland (hereafter, "*Agropyron/Poa*"), and big sagebrush (*Artemisia tridentata*)/bluebunch wheatgrass shrubland (hereafter, "*Artemisia/Agropyron*"). Such pristine, indigenous plant communities are no longer found elsewhere in the Columbia Plateau (Kagan 1987). Boardman NWSTF is also home to two endemic species of moss: *Aloina bifrons* (De Not.) Delg. and *Bryoerythrophyllum columbianaum* (Herm. & Lawt.) Zand.. Vascular plant species included on the Oregon Natural Heritage Program's (1993, Appendix A; hereafter "ONHP") "Special Plants" list of rare, threatened, or endangered species include many-flowered onion (*Allium pleianthum*), Robinson's onion (*Allium robinsonii*), Laurence's milk-vetch (*Astragalus collunus* var. *laurentii*), transparent milk-vetch (*Astragalus diaphanus* var. *diaphanus*), stalked-pod milk-vetch (*Astragalus sclerocarpus*), Columbia milk-vetch (*Astragalus succumbens*), and Columbia bladderpod (*Lesquerella douglasii*).

The distribution of plant communities on Boardman NWSTF generally follows the latitudinal distribution of soil types. In the sandy northern region, *Stipa/Poa* grasslands and downy wheatgrass (*Agropyron dasystachyum*)/*Stipa* grasslands are the two dominant communities. In the former, rabbitbrush (gray, *Chrysothamnus nauseosus*, and green, *C. viscidiflorus*), occasional forbs (e.g. Mariposa lily (*Calochortus macrocarpus*), and tidy tips (*Layia glandulosa*)), and wheatgrasses (downy and bluebunch) fill out the community. Mosses, lichens, and algae form a layer called the "cryptogram" which often occupies the space between the plants but indigenous fescues (*Festuca* spp.) and downy brome (*Bromus tectorum;* hereafter, "cheatgrass") also occur there. The latter, relatively open community contains fewer forbs but supports small amounts of Indian ricegrass (*Oryzopsis hymenoides*) and Sandberg's bluegrass. Space between plants is used by introduced forbs (e.g. tumble mustard, *Sisymbrium altissimum*) and cheatgrass. Disturbed areas of the sandy north support dense cheatgrass, often interspersed with squirrel tail (*Sitanion hystrix*), introduced forbs (e.g. scurf pea, *Psoralea lanceolata*), and prickly pear cactus (*Opuntia polycantha*). Also, bitterbrush (*Purshia tridentata*), rabbitbrush and occasional black greasewood (*Sarcobatus vermiculatus*) are common (see Appendix B1 for a list of plants occurring on the Boardman NWSTF).

On loamy southern soils, native communities include *Agropyron/Poa* grassland and *Artemisia/Agropyron* shrublands (Kagan 1987). Four species of lichens occur between the bunchgrasses on high quality sites in these communities (Appendix B2), along with mosses and forbs such as phlox (*Phlox longifolia*) and Pursh milk-vetch (*Astragalus purshii*). The half-shrub, snakeweed (*Gutierrezia sarothrae*), is also common. In the extreme south, highly disturbed regions dominated by cheatgrass with sparse rabbitbrush are found. Non-indigenous species such

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[1] Plant names in this report follow Hitchcock and Cronquist (1973). Although many names have changed since then, this reference is still widely used and its taxonomy is familiar.

as prickly lettuce (*Latuca serriola*), diffuse knapweed (*Centaurea diffusa*), Russian thistle (*Salsola kali*), and tumble mustard are common in such areas.

Between the extremes of north and south, there is a wide transition zone that shares characteristics of both soil groups (Kagan 1987). In Juniper Canyon (SE), big sagebrush and cheatgrass are dominant, and juniper trees (*Juniperus occidentalis*) can also be found.

The fauna of Boardman NWSTF potentially includes ten bird and one mammal species of Special Concern (Appendix A, Oregon Natural Heritage Program 1993). Reptiles have yet to be systematically studied on Boardman NWSTF, but there are potentially two families of lizards and three families of snakes. Western fence lizards (*Sceloporus occidentalis*), short horned lizards (*Phrynosoma douglassi*), Gopher snakes (*Pituophis melanoleucus*), and yellow bellied racers (*Coluber constrictor*) are relatively common. Western rattlesnakes (*Crotalus viridis*), western skinks (*Eumeces skiltonianus*), sagebrush lizards (*Sceloporus graciosus*), and side-blotched lizards (*Uta stansburiana*) are even less common. A list of species occurrences, with common and scientific names is provided in Appendix C.

Among the eight orders and 25 families of birds known to occur at Boardman NWSTF are the breeding populations of long-billed curlews (*Numenius americanus*), burrowing owls (*Athene cunicularia*), Swainson's hawks (*Buteo swainsoni*), ferruginous hawks (*Buteo regalis*), loggerhead shrikes (*Lanius ludovicianus*), and grasshopper sparrows (*Annodramu savannarum*). Golden eagles (*Aquila cyaneus*), northern harriers (*Circus cyaneus*), long eared owls (*Asio otus*), ravens (*Corvus corax*), short-eared owls (*Asio flammeus*), American kestrels (*Falco sparverius*), northern shrikes (*Lanius excubitor*), mountain bluebirds (*Sialia currycoides*), western flycatchers (*Empidonax difficilis*), sage thrashers (*Oreoscoptes montanus*), horned larks (*Eremophila alpestris*), western meadowlarks (*Sturnella neglecta*), savannah sparrows (*Passerculus sandwichensis*), lark sparrows (*Chondestes grammacus*), rock wrens (*Salpinctes obsoletus*), mourning doves (*Zenaida macroura*), and magpies (*Pica pica*) are some of the other species that can be observed (Appendix C).

Aside from the Washington ground squirrel, common mammals from five orders and 10 families include mule deer (*Odocoileus hemonius*), coyotes (*Canis latrans*), badgers (*Taxidea taxus*), black-tailed jack rabbits (*Lepus californicus*), mountain cottontails (*Sylvilagus nuttalli*), northern pocket gophers (*Thomomys talpoides*), Ord's kangaroo rats (*Dipodomys ordii*), Great Basin pocket mice (*Perognathus parvus*), and deer mice (*Peromyscus maniculatus*). Less common species include porcupines (*Erethizon dorsatum*), long-tailed weasels (*Mustela frenata*), northern grasshopper mice (*Onychomys leucogaster*), western harvest mice (*Reithrodontomys megalotis*), and vagrant shrews (*Sorex vagrans*). Potential species of interest due to their rarity include the pygmy rabbit (*Brachylagus idahoensis*), white-tailed jackrabbit (*Lepus townsendii*), bobcat (*Lynx rufous*), and Preble's (*Sorex preblei*) and Merriam's (*Sorex merriami*) shrews (Appendix C).

**B. Characteristics of the Washington Ground Squirrel**

1. Distribution

The Washington ground squirrel was first collected by J.K. Townsend in 1836 from the Palouse grasslands of eastern Washington and the type specimen was collected from Touchet, Walla Walla County, Washington, on May 18, 1891 (Bachman 1849, Howell 1938). The species formerly occupied low elevation (90 - 450m) shrub-steppe and grassland habitats on the Columbia Plateau; that is, south of the Columbia River to the foothills of the Blue mountains, and east of the Columbia River to the higher elevation Missoula Flood Scablands of eastern Washington and Oregon (Bailey 1936, Howell 1938).

Recent work demonstrates that the species' range has contracted considerably. An unsuccessful search in Oregon in 1971 led Olterman and Verts (1972) to report that no squirrels of this species had been seen in Oregon for 35 years. However, squirrels were "rediscovered" on the little-known Boardman NWSTF in 1978 (Rohweder, Melland, and Maser 1979). In the following year, 44 colonies were located, including 17 in Oregon (Carlson et al. 1980). Ten former collection sites (Howell 1938) were no longer occupied by the squirrels. In a comprehensive survey a decade later, Betts (1990) confirmed the presence of colonies on 80 (35 in Oregon) and suspected the presence of colonies on seven (one in Oregon) of 180 (63 in Oregon) historically occupied sites.[2] Sixty-eight (20 in Oregon) sites no longer supported squirrels, and 25 (seven in Oregon) were categorized as "highly vulnerable to extinction." Much of the reduction (35/68, or 51%) occurred in the ten years between Betts (1990) and Carlson et al. (1980).

Associated with the loss of over a third of its historically occupied sites in both states, the range of the Washington ground squirrel has fragmented. In Washington, the squirrel now occupies the west central portion of its former range, conspicuously absent in the northern Columbian Basin. The largest remaining cluster of colonies identified by Betts (1990) includes parts of the following central Washington counties: Adams, Franklin, Grant, Lincoln and Walla Walla. An isolated second cluster exists on Badger Mountain, northwest of the largest cluster in Douglas County. Due to the isolation and small size of the colonies, Betts (1990) rated this cluster as "highly vulnerable to extinction." In Oregon, the range has receded from the state's northern border, west from Pendleton, and north from Heppner. This third cluster includes Gilliam, Morrow, and Umatilla Counties of northcentral Oregon. Whereas the two largest clusters were contiguous in Howell (1938), only three colonies currently exist between the Snake River and northern Oregon (Betts 1990). Should these three "highly vulnerable" colonies just south of the Snake River become extinct, there is little chance that the Oregon and Washington clusters could be reunited as the river is likely a serious impediment to squirrels dispersing south and agricultural development is a serious impediment to squirrels dispersing north.

Habitat degradation may have also indirectly contributed to the shrinkage of the squirrel's range by heightening competition with its cogeners. Carlson et al. (1980) hypothesized that larger, neighboring ground squirrels (Columbian [*Spermophilus columbianus*] and Belding's [*Spermophilus beldingi*]) have a competitive advantage in disturbed habitats. They cite the minimal range overlap between these species and the Washington ground squirrel as evidence to support the competitive subordination of the latter.

The loss of the northern colonies deserves one further note. The smallest, isolated Washington cluster (Badger Mountain, Douglas County) is the only cluster that appears to contain colonies within Howell's (1938) range of the once recognized northern subspecies of *S. washingtoni*. Howell (1938) identified a narrow, discontinuous band at the north of the species range as the

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[2]Locations were obtained from museum records (Oregon State University, Washington State University, and University of Idaho), literature (Howell 1938, Scheffer 1941, Hill 1978, and Carlson et al. 1980), the Washington Department of Wildlife Nongame Database, and recommendations of local researchers and residents.

range of *S. washingtoni loringyi*, a slightly smaller version of the relatively more common *S. washingtoni washingtoni*. The type specimen for this subspecies was collected from Douglas, Douglas County. Since then, Dalquest (1948) merged the subspecies, regarding *S. washingtoni loringyi* as a synonym of *S. washingtoni washingtoni*. Hill (1978, in Rickart and Yensen 1991) confirmed the synonymy with a phenetic and karyotypic study.

2. Population Status
Washington ground squirrels were historically abundant. Howell (1938) quoted Vernon Bailey's field notes, reporting populations that averaged 120-150 animals/ha near Pendleton, Oregon; however, Howell cautioned that the animals were less numerous than indicated by this estimate due to the discontinuous distribution of ground squirrels over most of their range. Dalquest (1948) also reported colonies reaching 120 or more animals to the ha. Like some other ground squirrels, the Washington ground squirrel's insatiable appetite for cultivated grain and ability to multiply under favorable conditions quickly gave it an infamous reputation among the region's first settlers. Howell (1938) lists the species among those ground squirrels that "occasion the greatest damage to crops of grain and against which extensive control operations have been necessary" (p.5). In addition to gobbling grain, their burrowing habits which can damage irrigation systems or cause soil erosion, especially on steep slopes, led to their reputation as "serious pests." Poisoning, shooting and trapping methods were often employed to control the damage (Bailey 1936, Howell 1938).

Oregon's population of Washington ground squirrels plummeted between 1948 and 1989. The official status of the species was "uncertain" in 1971, when a search for them was unsuccessful (Olterman and Verts 1972). Although the squirrels were located again in 1978, their range had decreased considerably from its historic boundaries in both Washington and Oregon, as discussed above. Between 1979 and 1989, the population decrease accelerated, with as many colonies lost in those ten years as were lost in the forty years prior to 1978 (Betts 1990).

Currently, the Washington ground squirrel is classified as a "sensitive critical" species in Oregon (ONHP) and a "state monitor species" in Washington (WDFW). More specifically, the Oregon Natural Heritage Program (1993) placed the species on "List 2," as a species that is "threatened with extirpation," especially within Oregon. The Oregon Department of Fish and Wildlife categorizes the species as "critical," indicating that "listing as threatened or endangered is pending," especially if "immediate conservation actions" are not developed. The Nongame Wildlife Management Plan called for actions to secure and restore Oregon populations (priority two) and to specifically "reassess previous study and delineate secure habitat" of *S. washingtoni* (p.VII S-3; Marshall 1986).

3. Habitat Characteristics
While no systematic study of habitat preference of the Washington ground squirrel has yet been undertaken, the dry grasslands and open, low big sagebrush communities of the Columbia Plateau are the two most common habitat types cited for the species. All authors mention the importance of diggable soil as a habitat characteristic. Howell (1938) quoted Vernon Bailey's field notes:

> The country which they inhabit is open and either dry and sandy, grassy, or sagebrush covered. They are most numerous along steep hillsides, in gulches, and in sagebrush along river bottoms. On the smooth, grassy prairie, they are common and more evenly distributed. They collect where some protection is

> afforded by scattered bunches of sagebrush or *Chrysothamnus*, but avoid any dense cover from which they cannot look out on all sides.

They also occur along wheat fields, on rocky hillsides and on sandy prairies. Dalquest (1948) described a unusual colony near Farmer, Douglas County. The occupied area, a 15m buffer of endemic grass between a highway and wheat fields, stretched 24km and supported one ground squirrel for almost every 60m. Rohweder, Melland, and Maser (1979) reported their association with gently sloping topography and hummocks. Carlson et al. (1980) summarized the habitat types of 45 colonies (p. 8):

| | |
|---|---|
| rocky hillside | 2 sites |
| natural grassland presently undisturbed | 3 |
| seeded pasture grazed in spring and summer | 4 |
| weedy habitat surrounding grain elevator | 4 |
| weedy habitat bordering wheat field | 10 |
| unseeded grassland grazed in spring | 22 |

Betts (1990) captured the variance in suitable Washington ground squirrel habitats when he compared 23 habitat variables at 13 colony sites with 13 non-colony sites. Non-significant variables included percent cover by bare ground, litter, cryptogram, forbs, and perennial grasses along with the number, volume, and percent cover by sage and other shrubs. He concluded that the squirrels reach highest densities on sites with high grass cover.

On a smaller scale, Carlson et al. (1980) had successively greater success at trapping locations characterized by needle and thread grass/sage, cheatgrass/sage, and *Artemisia/Agropyron* vegetative associations. However, 45% of all captures within their trapping grid were in bluebunch wheatgrass and needle and thread grass areas without sage. They hypothesized that the grass/sage combination optimized the squirrel's needs for protection from predators and nearby food resources. With more shade near their food source, the squirrels could remain active longer and accumulate adequate fat to sustain them through hibernation. Also, there seemed to be sex-related habitat relationships with the activity center for female ground squirrels in *Artemisia/Agropyron* associations (74% of captures) while captures of males were evenly distributed among habitat types. It was hypothesized that greater visibility in grassy areas allowed easier detection of predators by females with litters.

4. Burrow Characteristics

No systematic investigations of Washington ground squirrel burrows have been undertaken. Bailey (1936) described simple, little branched burrows that descended 1.2-1.5 m from a single entrance before straightening for a few feet and entering a nest cavity. Howell (1938) quoted Scheffer to describe a 7.3m unbranched burrow lacking a nest cavity that reached a maximum depth of 1.7m. Betts (1990) concluded that Washington ground squirrels inhabit deeper, weaker soils with less clay, but this observation was not directly associated with burrow characteristics.

As indicated by Scheffer's (1941) observations that old pocket gopher runs and abandoned badger diggings are used by Washington ground squirrels, it is likely that the species' activities take place in more than one type of burrow. Both Townsend's (*Spermophilus townsendii*; Alcorn 1940, Reynolds and Wakkinen 1987) and Idaho (*Spermophilus brunneus*; Yensen et al. 1991) ground squirrels construct at least two kinds of burrows. Using terminology from Yensen et al. (1991), "auxiliary" burrows, those lacking nest chambers, are most common for both species.

There are four different types of auxiliary burrows, making up >90% of all burrows used by the species:

1) horizontal: 1-8 entrances, mostly unbranched tunnels; many originally constructed by pocket gophers or voles and later enlarged by squirrels;

2) shrub covered: 1-4 entrances, horizontal tunnels; trenches roofed by shrub branches and often curved around the main shrub root, incorporating shrub canopy shape ntoburrow design;

3) rock covered: 1-4 entrances, tunnels dug under rocks; flat on bottom, projecting less than 15 cm below ground surface;

4) plunging: single entrancse at angle of 15-90° continuing steeply for 11-45 cm, often ending in a small chamber; short and unbranched tunnel ; not near rocks or shrubs.

In contrast, "nest" burrows of Idaho ground squirrels are constructed in deeper (>1m) soil than auxiliary burrows, and are significantly longer and deeper with more entrances, branch tunnels, and chambers. A third, hypothesized burrow type may be a separate hibernating burrow: a single, deep tunnel with hidden or plugged entrances, that are not used for raising young (Yensen et al. 1991).

Some evidence indicates that burrow (hibernacula) characteristics may vary with the sex or age class of the occupant. Among Columbian ground squirrels of southwestern Alberta, the hibernacula of adult males were larger in proportion to their weight than those of adult females or juveniles (Young 1990). Also, larger squirrels may use larger hibernacula, and squirrels at higher elevation may use larger and shallower hibernacula than those at lower elevation, as was in the case with Columbian ground squirrels. There may be similar variation in burrow characteristics among Washington ground squirrels

Soil characteristics may influence the location or type of Washington ground squirrel burrow. For example, although Idaho ground squirrels extensively used shallow and rocky soils during the active season, they constructed nest burrows in deeper soils nearby (Yensen et al. 1991). The type of auxiliary burrow used by Idaho ground squirrels changed with the site's surface characteristics (influenced by soil): open sites or sites covered with shrubs or rocks contained more plunging, shrub, and rock burrows, respectively (Yensen et al. 1991). The morphology of a specific Washington squirrel burrow may change with soil structure, similar to Wyoming ground squirrels (*Spermophilus elegans*) that dig deeper, longer and more complex burrows as the percent of silt and clay increases and the percent of sand and bulk density decreases and Townsend's ground squirrels that build larger burrows on firmer, loamier soil (Laundre and Reynolds 1993).[3]

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[3] Laundre (1989) and Laundre and Reynolds (1993) concluded that neither soil texture, bulk density, nor the percent of sand, silt, nor clay affected burrow diameter, complexity, total length, or maximum depth of Townsend's ground squirrel burrows. However, it is not clear in the methods of these studies whether the type of burrow was considered before excavation. Associations between soil and burrow characteristics may be disguised given that Townsend's, and potentially Washington's, ground squirrels use more than one type of burrow and often utilize burrows created by other species.

5. Seasonal Activtiy Patterns

Generally, Washington ground squirrels are active for 4-5 months. Males emerge from hibernation approximately two weeks before females. The mating period (polygamous) of several weeks begins in late January or early February (Bailey 1936, Scheffer 1941, Carlson et al. 1980). The timing of emergence varies annually due to spring warming patterns and associated initiation of seasonal vegetative growth (Michener 1979, Rickart 1982). Also, Shaw (1921) observed that local populations of Townsend's ground squirrels at lower elevations immerged and began estivation (the period of dormancy between seasons of activity) before local populations at higher elevations, due to the effects of elevation on food and water resources. Timing was so specific that an individual moved from low to high elevation (300m difference) emerged two months before others and attempted to emerge earlier (in the presence of unaccustomed snow, it returned to hibernation).

One litter per year is born in February/early March and nearly all adult females reproduce (Bailey 1936, Scheffer 1941). If the amount of green forage available when the breeding season begins is inadequate (i.e. after a winter drought), it is possible that no litters will be produced, as was the case with Townsend's ground squirrels (Smith and Johnson 1985). Van Horne et al. (1993) observed a 50% decrease in production after a combination of summer drought and prolonged, early spring snowfall. Otherwise, gestation lasts approximately 25 days and there is an mean of 8 (5-11, n = 26) per litter (Scheffer 1941). Carlson et al. (1980) estimated five per litter from their trapping results. The reproductive organs of adults reduce by mid-March, so that by late April they may be indistinguishable from juveniles (Scheffer 1941).

Similar to Townsend's ground squirrels, there may be a third age class of Washington ground squirrels, the yearling adults, potentially comprising nearly 50% of the population (Smith and Johnson 1985). In Smith and Johnson (1985), yearling females appeared just after the adult females whereas the yearling males, which generally did not participate in breeding, emerged after breeding activity ended. Scheffer (1941) reported sexual activity in all captured female Washington ground squirrels. Yearling female Townsend's ground squirrels generally had lower pregnancy rates than the adults, but their accelerated production was critically important after reproductive failure during a drought year (Smith and Johnson 1985).

Weaned young (22-44g) appear above ground and can be observed feeding on green vegetation three weeks after birth (late March; Scheffer 1941, Carlson et al. 1980). Juvenile Townsend's ground squirrel males grow faster than juvenile females, and remain larger as adults (Rickart 1982). By late April, the young are half grown (89-139g) and often venture individually to sources of food and shelter away from the natal burrow (Scheffer 1941, Carlson et al. 1980). An example of how dedicated ground squirrels are at sequestering calories at this time of year is a young Townsend's ground squirrel collected by Scheffer (1941): 22g of its 81g total weight was stomach. Nearly adult-sized by late May, juvenile ground squirrels are difficult to distinguish from adults. Adults of both sexes begin estivation in late May/early June, with males usually preceding females. Juveniles remain active until late June or early July (Bailey 1936, Scheffer 1941, Shaw 1921, Carlson et al. 1980).

No information is available on dispersal by Washington ground squirrels. The only data on movement is derived from the live-trapping efforts (mean furthest distance moved) of Carlson et al. (1980): adult males = 239m (mean), adult females = 159m, juveniles = 131m. Immigration of Townsend's ground squirrels peaks in late February and early March, just after the end of the breeding season (Smith and Johnson 1985). Although transient squirrels were common throughout the season, males peaked in early March and females, in late April.

The timing of annual fattening and immergence in Washington ground squirrels is likely a function of the quality of food resources. For example, Townsend's ground squirrels begin to accumulate fat after the appearance of seeds in the diet (late April), males restoring their fat reserves two to three weeks prior to females (Rickart 1982, Smith and Johnson 1985). Early in the season, green vegetation is predominant in the diet, and some shrubs (i.e. big sagebrush) are eaten in early March. The ground squirrel diet switches to seeds and forbs as they become available in late April, May, and June, with insects and animal material occasionally taken throughout the season (Howell 1938, Carlson et. al 1980, Rickart 1982, Yensen and Quinney 1992). Therefore, although forage quantity may not be limiting, the availability of high energy items such as seeds significantly affects fattening both in the field and experimental settings (Rickart 1982). Near Pine City, Oregon, alfalfa-fed Washington ground squirrels began estivation three weeks earlier than squirrels on the native vegetation sites at Boardman NWSTF (Carlson et al. 1980), also perhaps indicating the effect of high quality food.

Estivation/hibernation may be a period of high mortality for Washington ground squirrels. For example, the over-winter survival rate of Townsend's ground squirrels was only 22% for males and 35% for females (Smith and Johnson 1985). In an experimental setting, Shaw (1925) observed a male Townsend's ground squirrel lose 59 g (280-221g) over 56 days, a loss of 1.05g/day. Rickart (1982) reported weight losses reaching 50% in Townsend's ground squirrels (0.3-0.5g/day), after 240-270 days of hibernating.

6. Diet Composition

No systematic studies of Washington ground squirrel forage preferences have yet been undertaken. However, specific taxa found in Washington ground squirrel stomachs include: filaree (*Erodium* spp.), globe-mallow (*Sphaeralcea munroana*), plantain (*Plantago purshii*), cheatgrass, slender wheatgrass (*Agropyron pauciflorum*), bluebunch wheatgrass, Sandberg's bluegrass, Indian rice grass, and tumble weed (Howell 1938, Carlson et al. 1980). Familiar crops like cabbage, peas, corn, oats, wheat, rye, barley, and alfalfa are also consumed when available (Bailey 1936, Howell 1938). As described in the preceding section, seasonality likely plays a major role in Washington ground squirrel diets.

The most important component of the Townsend's ground squirrel diet is grass, including both the leaves and seeds (Howell 1938, Rogers and Gano 1980, Smith and Johnson 1985, Yensen and Quinney 1992), although the leaves are eaten slightly more than seeds (Smith and Johnson 1985). At four sites in Idaho, grasses were often >75% (37-87%) of the diet, especially Sandberg's bluegrass and cheatgrass (Yensen and Quinney 1992). Sandberg's bluegrass leaves are preferred slightly more than cheatgrass leaves (Rogers and Gano 1980, Yensen and Quinney 1992), and are eaten in higher proportion than they are available (Van Horne et al. 1993). Six-weeks fescue (*Festuca octiflora*), winterfat (*Eurotia lanata*), big sagebrush, Russian thistle, tansymustards (*Descurainia* spp.), seeds of bur-butter cup (*Ranunculus testiculatus*), and insects were other items that contributed >10% to the diet (Yensen and Quinney 1992). Washington ground squirrels may have similar diets because many of these food items are also common within their range.

7. Ecological Relationship to Other Species

The Washington ground squirrel is not considered to be closely related to any other *Spermophilus* species (Nadler et al. 1984). Of all the species within the genus, Townsend's and Idaho ground squirrels are most similar in karyotype to Washington ground squirrels (Nadler 1966). Townsend's ground squirrels are also morphologically similar to Washington ground squirrels (Howell 1938). In fact, Bailey referred to the Washington ground squirrel as the Townsend's ground squirrel in his 1936 edition of *The Mammals and Life Zones of Oregon*. Howell (1938) separated the Washington from Townsend's ground squirrel in his *Revision of North American Ground Squirrels*. Biochemical comparisons indicate that the Washington ground squirrel is slightly more similar to the "big eared" squirrels, such as Belding's and Idaho ground squirrels, than to Townsend's and other "small eared" ground squirrels (Nadler et al. 1984). Washington ground squirrels can be distinguished from the Townsend's and Idaho relatives by cranial measurements (relatively narrow skull, Rickart and Yensen 1991), its discrete dorsal spots, and slightly bushier (than Townsend's) and shorter (than Idaho) tail.

Cogeners (*Spermophilus*) of the Washington ground squirrel with distributions bordering the species' range include the Townsend's (N), Columbian (E), and Belding's ground squirrels (S). While it was originally thought that no sympatry occurred between species, Carlson et al. (1980) observed overlap with Belding's 24 km NE of Heppner (periphery of the Washington ground squirrel). They further hypothesized that this larger species may have a competitive advantage in disturbed habitats.

**C. Population Census Techniques**

1. The Hole Census Method

*a. Original Methodology of the 1994 Washington Ground Squirrel Study*

The primary objectives of this study were to develop standardized census techniques to identify long-term population trends of the Washington ground squirrel and determine its distribution on the Boardman NWSTF (Quade 1994). To accomplish the monitoring objective, the study was designed to emulate the hole census method proposed by Nydegger and Smith (1985). Jim Russell, a volunteer scientist for The Nature Conservancy, previously collected hole census data and attempted trapping on Boardman NWSTF according to this method (Russell 1993). In 1994, the density of Washington ground squirrels was to be estimated from trapping grids using standard mark-recapture techniques on as many different sites within Boardman NWSTF as time would allow. Ground squirrel burrows defined as "active" according to Russell (1993)[4] were to be counted on transects within each grid and averaged. Using regression techniques, mean squirrel density was to be plotted against the mean number of squirrel holes per transect segment to derive the following equation:

$$\text{mean squirrel density} = r * (\text{mean \# holes/segment}) + C$$

It was hoped that the resulting equation could be applied to the past hole censuses of Russell (1993) and future hole censuses throughout the range of the Washington ground squirrel to crudely estimate squirrel density and thus provide long-term population trends upon which to evaluate the status of the species as well as determine its habitat requirements.

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[4]The criteria for an active Washington ground squirrel burrow (Russell 1993) included 1) a minimum diameter of 4cm and a maximum diameter of 10cm, maintained from outside the burrow to the farthest visible interior point, and 2) an open, unobstructed, passage.

More specifically, we planned to concurrently sub-sample the available habitat types (soils and associated vegetative communities generally follow a north-south gradient, see "General Habitat Characteristics", above) and cover the area of Boardman NWSTF by stratifying the study sites. The main area of Boardman NWSTF, covering 36 sections (excluding sections 25 and 26 of T4N, by the west gate), was divided into ten blocks: two 4x3 blocks in the north and eight 2x3 blocks to the south (Fig. 4). The southern blocks were smaller because squirrels were thought to mainly inhabit the southern region and wewished to focus our efforts on areas with squirrels. One section was randomly selected from each block and surveyed for potential ground squirrel colonies. Because large samples are a prerequisite for population estimates by mark recapture techniques, the trapping grids were to be placed over the specific areas of the sections that would most likely result in maximum capture of ground squirrels. If no potential ground squirrel colonies were found within the first section, another section was to be randomly selected from within the block.

To sample Washington ground squirrels, an 8x8 grid with 25m spacing and 64 live traps baited with peanut butter, whole oats, and/or apples would be operated on each study site. This scheme was successfully employed by Carlson et al. (1980). Two grids would be operated at the same time, with three days of prebaiting followed by 12 days of trapping. Traps would be checked once daily. Captured squirrels would be weighed and given unique marks with human hair dye (Clairol Nice and Easy, blue-black #124). Also, the fur on the end of the tail would be clipped straight across to indicate previous capture, in case the dye would wear off between recaptures. After each trapping period, the traps were to be relocated to new sections, to cover the 10 study blocks within Boardman NWSTF. Trapping was to continue from early March until the squirrels immerged (late June).

Originally (Quade 1994), one of the two grids was to be left in place for the entire 1994 season so that seasonal activity patterns could be observed. This data would have been directly comparable with Carlson et al. (1980) and would have helped with interpretation of the trapping results from the other grid, which was to be relocated every three weeks. The continuously monitored grid needed to be within a Research Natural Area (RNA) to minimize conflict with grazing and permitees. Therefore, the first two grids were placed within RNA B and RNA C, with the understanding that the most active site would become the stationary grid (Fig. 5). A list of locations where ground squirrels were trapped, tracked and sighted is provided in Appendix D.

*b. Initial Results and Revisions to the Study Design*

Compared to the relatively large number of animals captured by Carlson et al. (1980), the results of the first trapping session (12 days) were not what was hoped for. Only three individuals were captured 11 times on RNA C and none were captured on RNA B. Russell (1993) was similarly unsuccessful with trapping in 1992, capturing one animal in six trap days at a formerly active site. Because population density estimates using mark-recapture techniques based on 10 or 20 animals are imprecise and biased (White et al. 1982, Skalski and Robson 1992), the study design was reevaluated. Dr. B.J. Verts, a renowned small mammal ecologist at Oregon State University, was contacted on March 25. Given the low trapping success, his advice was to maintain data collection from two permanent grids and postpone the hole census method study. Solid information about seasonal activity patterns and use of space seemed more attainable at this time. Although a seasonal delay in squirrel emergence may have been responsible for the low trapping success, it seemed our methods might not enable us to decipher the relationship of animal to hole abundance as planned.

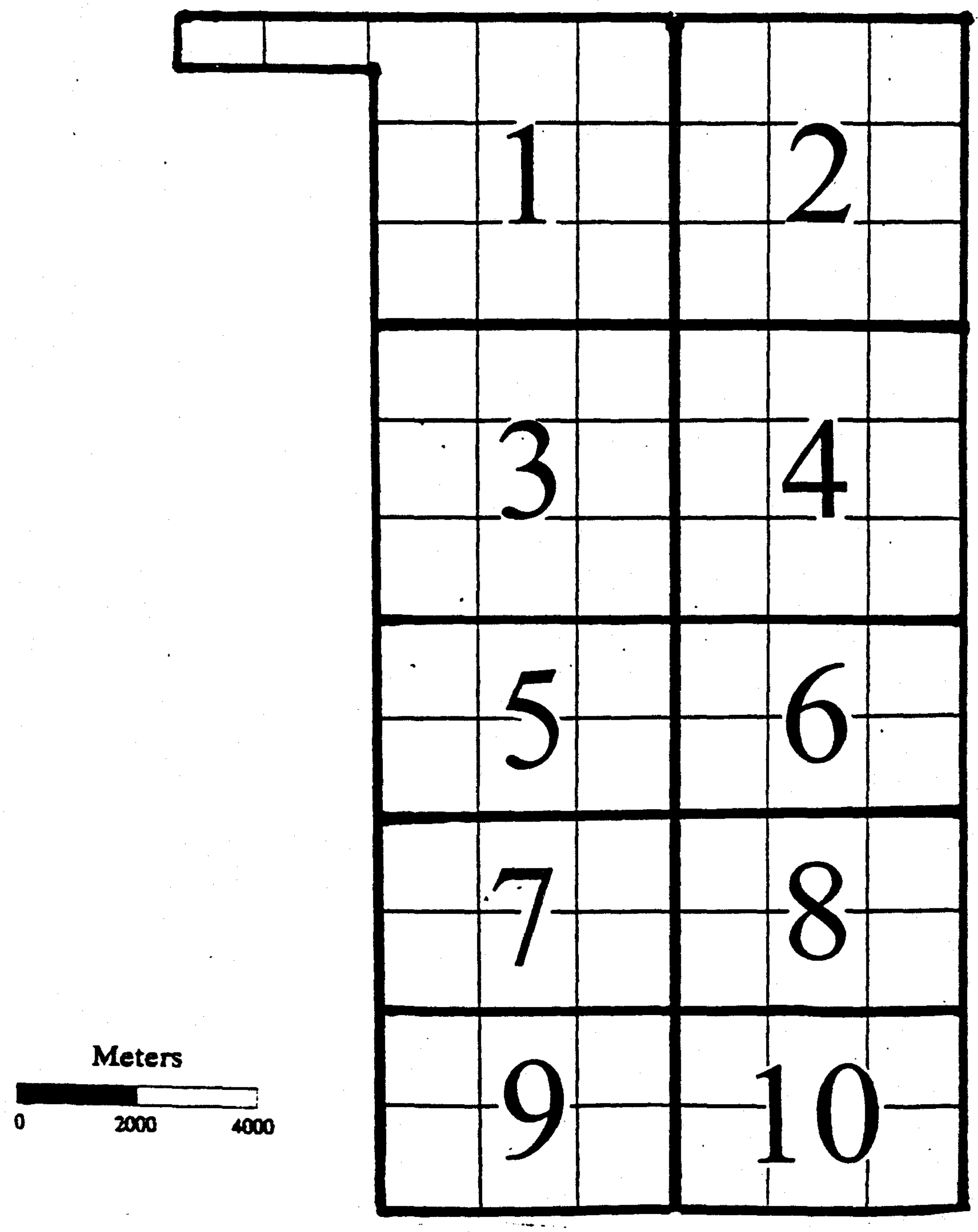


Figure 4: Stratification of the Boardman Naval Weapons Systems Training Facility for Washington ground squirrels study site selection.

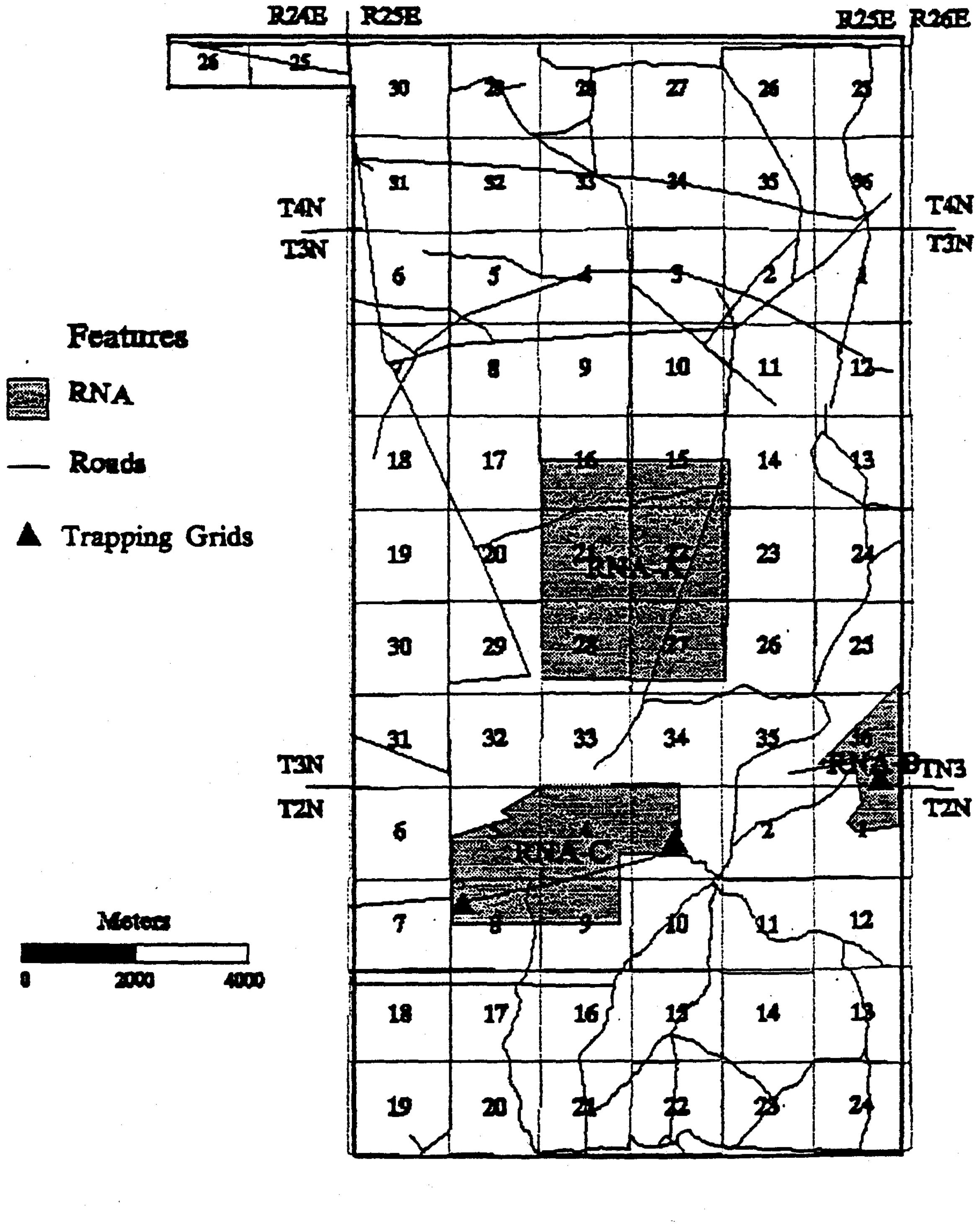


Figure 5: Location of Washington ground squirrel trapping grids within the Boardman Naval Weapons Systems Training Facility.

Meanwhile, serious doubts as to whether the hole census method could be developed into a "reliable, repeatable technique" had been raised by the researchers who first published the technique (Nydegger and Smith 1986) and were supported by my field observations. Upon critical examination of this first account of the hole method, the identity of the points in the graph that depict the reported relationship between holes and ground squirrel density could not be deduced by any of this project's cooperators (five sites were trapped for five years but six points were plotted). Dr. Don Johnson (University of Idaho), who co-authored a paper with the aforementioned G.W. Smith on Townsend's ground squirrel demography (Smith and Johnson 1985) also could not identify the six points (*pers. comm.*). He emphatically discouraged employment of this method and suggested developing a visual or acoustic technique for long-term monitoring instead, referring me to Steven Knick, a researcher at the Raptor Research and Technical Assistance Center, Boise District BLM office, for detailed information.

Knick commented that the slope of the line reported in Nydegger and Smith (1986) itself is not significantly different from zero (slope = 0.09), thereby implying that the number of burrow eåtrances (holes) and squirrel density are unrelated. After three more years of research at the Snake River Birds of Prey Research Area (hereafter, Snake River BOPA), near Boise, Idaho, Knick summarized that the hole census technique results in a false sense of precision while claiming to be accurate. He mentioned three main reasons why they abandoned attempts to correlate ground squirrel density with numbers of holes:

1) observers varied among themselves and between observers in what they called active ground squirrel holes (despite a given definition),
2) holes are used by more than one species,
3) and, over the course of the season and in a matter of weeks, the number of active holes changed significantly (less than half the holes active in June remained active by August 5).

Gail Olson, a Ph.D. candidate working on the project through Colorado State University, further commented that because holes persist from year to year and many species use the holes, perhaps the most meaningful way to employ the hole census method is in presence/absence surveys of the landscape where the absence of holes equals the absence of squirrels (but not the converse). Later, I learned that the number of holes per Townsend's squirrel varied from 127 (on a site with one captured squirrel or 0.3 squirrels/ha) to less than 22 active holes per squirrel (18/20 sites; Van Horne et al. 1992).

The results of population studies from Van Horne et al. (1991, 1992, 1993) provide specific examples of the dubious relationship between squirrel and hole densities within and among habitat types. Although ground squirrel density was positively correlated ($p<0.05$) to at least one category of hole counts[5] each year when results from different habitats were combined, the type of hole count which was most related to ground squirrel density changed between years: "active"[6] holes provided the correlation in 1991 and 1993 but "total" holes provided the best

[5] The following categories were used in the correlations: Total (sum of counts for all classes of activity and certainty), Active (active high + active low), and Possibly Active (active high + active low + inactive low). Holes classified with "high" certainty indicated that the observer was confident of the activity level assigned to the hole (Van Horne et al. 1992).

correlation in 1992. Furthermore, the relationships did not hold when the two habitat types of the study were considered separately. The correlation in 1991 held for shrub sites ($p<0.0001$) while remaining insignificant but positive on burned sites. In 1992, squirrel density was not significantly related to "total" holes on either burned or shrub sites, was not significantly related to "active" holes within burned sites, and "active" holes were only weakly but positively correlated ($p=0.08$) within shrub sites. Densities of "total" and "active" holes were actually inversely related to squirrel densities within burned sites. In 1993, neither habitat type offered significant relationships between ground squirrel and hole densities, although the correlations were positive. Van Horne et al. (1992) concluded that the usefulness of the hole method was limited to separating high from low density squirrel sites. Whereas sites with less than ca. 250 "Total" holes per ha supported generally low ground squirrels densities, sites with greater than ca. 250 holes per ha generally supported high densities of ground squirrels. Within each category of hole density, however, the density of ground squirrels was not strongly associated with the density of holes.

On April 1, Berta Youtie (Northeast Oregon Stewardship Ecologist, The Nature Conservancy), Russell, and I agreed to abandon the original plan to calibrate the hole census method as described in the proposal (Quade 1994) and continue monitoring seasonal trends in Washington ground squirrel activity on two trapping grids. Russell planned to investigate the validity of the hole census method while I operated the trapping grids, used trapping transects and walking surveys to locate new squirrel colonies, and searched for other possible monitoring techniques.

*c. Observations Concerning the Occupants of Burrows and the Shortcomings of the Hole Census Method*

Many field observations left me skeptical about the potential of enumerating squirrels by counting holes. At first, I attempted to distinguish holes by size, according to Russell (1993). However, preliminary trapping in early February revealed that Ord's kangaroo rats use holes within the size range expressed in the definition. I later learned that there is no statistical difference between the horizontal and vertical burrow diameters of Townsend's ground squirrels (similar in size to Washington ground squirrels) and Ord's kangaroo rats (Laundre 1989). Furthermore, nearly half the holes entered by ground squirrels as shown through tracking, passive observation, and observation after release from capture, were larger (i.e. the size created/excavated by a badger or rabbit) than 4-10cm. Careful examination of a specific large hole sometimes revealed a smaller hole within the larger hole that fit the size constraints of the definition, but I doubt that an observer casually counting holes along a transect would notice the smaller holes. An observer casually counting holes along a transect might miss other holes used by squirrels that are well concealed by sage and bunchgrasses. I walked by "active" holes on the trapping grids without noticing them until I watched released animals escape to them. If holes are differentially visible among habitat types, the inability of detecting holes might artificially decrease the apparent population size. For example, neither Russell nor I suspected ground squirrel presence on the RNA side of the trapping grid (RNA C West) due to the lack of obvious holes. Trapping later revealed that an adult and juvenile female used this area quite frequently. In addition, ground squirrels were directly observed to use at least seven different holes on the

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[6] "Active" holes were those that were beleived to be used by a ground squirrel in the past three weeks, indicated by presence of feces or evidence of fresh digging. Holes with low angles or tail drags in the entrance (characteristic of kangaroo rats) were not considered (Van Horne et al. 1992).

RNA side of the grid.

Secondly, I tried to separate holes by angle of entrance. Russell suspected that steeper holes within the size range belonged to another species (i.e. the lower angled holes were created and used by ground squirrels) and I observed several kangaroo rats using steeper holes. To test this, I inserted a wooden dowel into a hole used by a known species and measured the angle using a compass clinometer. I abandoned the idea when I followed kangaroo rats to holes ranging from 2-52° (n=5) and found references that associated low angled holes with kangaroo rats (Murie 1954, Van Horne et al. 1992). Tracking and direct observations revealed that ground squirrels frequented low and high angle holes. This implied that Washington ground squirrels may use several types of burrows, similar to the Idaho (Yensen et al. 1991) and Townsend's ground squirrels (Alcorn 1940, Reynolds and Wakkinen 1987; see "Burrow Characteristics" above). In fact, an astonishing number of new excavations that fit Yensen et al.'s (1991) description of "plunging" burrows appeared at RNA C East during the second week of May. The new holes were likely ground squirrel in origin, due to the presence of tracks in the freshly exposed dirt outside of some of the holes (Fig 6). However, squirrels were not directly observed entering or creating the burrows and the new excavations were only present in shrubby habitats characterized by relatively compact soils with cryptogramic cover. Such burrows were also seen specifically at RNA B (40m east of the area trapped by the grid), Zolaco N, Johnson A, East, and Rancher's site. None were seen in the grass-dominated squirrel sites of the western Boardman NWSTF (i.e. N. Interstate and RNA C West).

Unfortunately, identifying the creator of a hole did not necessarily mean identifying the current occupant. Ground squirrels, grasshopper mice, deer mice, and kangaroo rats all appear to use old gopher burrows. To test whether small mammals ran into the nearest hole available after release from capture, I released several kangaroo rats, pocket mice and ground squirrels (juveniles only) in front of a hole of my choice. Individuals often sniffed the hole entrance then either entered or scooted toward a different hole (observed in all three species). One hole was entered by a kangaroo rat in the morning and a ground squirrel in the afternoon. However, repeated observations of individuals fleeing to certain holes or groups of holes (burrows) confirmed that some burrows were likely species specific. These observations raise the questions as to whether some holes (e.g. along roads where a series of holes may be inter-connected) are used communally and to what extent seasonality affects which species uses what hole (i.e. in competitive encounters over hole entrance opportunities, the smaller species would probably lose against adult ground squirrels, especially during breeding season when both inter- and intra-species tolerance is low).

Hole sharing is extremely problematic to censuring squirrels by active holes. Even when the holes created by squirrels can be confidently separated from those created by kangaroo rats, it may be these species or others that keep them appearing active. Reptiles, beetles, and grasshoppers are commonly observed in holes at Boardman NWSTF. Yensen et al. (1991) commonly found darkling beetles (Tenebrionidae: *Eleodes* sp.) and crickets (Gryllidae) in nest burrows of Idaho ground squirrels. Without a more direct approach, it is unlikely that seasons of high ground squirrel density, when most of the suspicious holes are used by ground squirrels, could be accurately distinguished from seasons of low ground squirrel density, when other species utilize former ground squirrel burrows. In the extreme climatic conditions of the sagebrush desert, it might be adaptive to utilize holes already available. Less energy spent digging may mean more energy for reproduction or that can be assimilated as fat for hibernation. It alsoseems likely that an individual may use a number of burrows disassociated with its

a)

b)

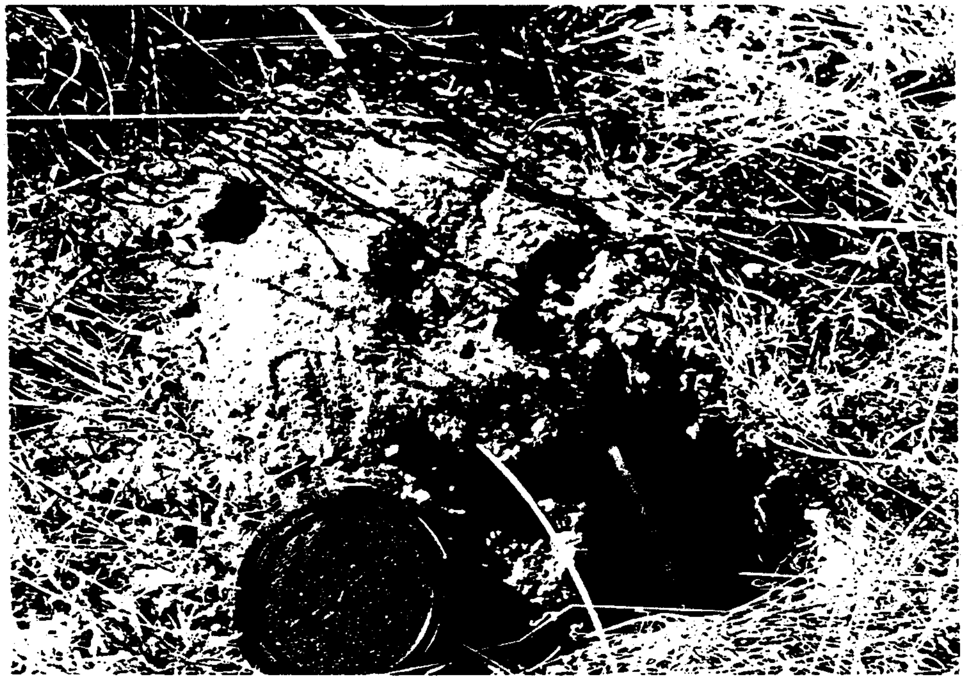

Figure 6: Potential "plunging" burrows of the Washington ground squirrel: a) a cluster of new burrows, and b) Washington ground squirrel tracks leading into a burrow.

defended territory to avoid heat stress or predation.

Finally, burrow switching may also complicate results. After radio-tracking several Townsend's ground squirrels, Olson (1993) concluded that counts of "active" burrows (a group of holes) were a poor index of squirrel activity at the time of study because many burrows were used by the same individuals. Washington ground squirrels on the Boardman study grids showed similar behavior: they escaped to certain holes or were frequently captured in certain traps at one area of a grid for awhile, then switched to a different location (e.g. an adult female on RNA C West, see "Recapture Rates...", below).

*d. Validating the Hole Census Method: Assessing Our Ability to Discriminate Inactive From Active Holes*

Precluded in the hole census methodology based on "active" holes is the assumption that we can confidently judge the activity level of holes. Less than half of the holes observed in the Snake River BOPA study were classified with high certainty (Van Horne et al. 1993). At Boardman NWSTF, three experiments were designed to indicate the level of certainty that should be placed on the classifications of "active" and "inactive" holes.

In a preliminary test, 15 "inactive" holes and 30 "active" potential ground squirrel holes were directly obstructed using sticks or toothpicks (Sadie's transect, Table 2). Those holes that had evidence of fresh digging, lacked spider's webs or other obstructions, and lacked evidence of occupancy by other species (i.e. tail drags from kangaroo rats) were considered "Active." "Active" holes were correctly classified as "Active" (obstruction removed) in 66% and 48% of the cases in two checks of obstruction at two day intervals. The experiment was not designed to detect how the obstructions were removed (e.g. by wind, grasshoppers, deer mice, or ground squirrels). "Active" holes retained their obstruction (incorrectly classified) in 13% and 41% of the cases with 21% and 11% uncertain (the obstruction could have been dislodged by wind or another factor not stemming from small animal use or it was suspiciously moved from its original place but not removed). "Inactive" holes were correctly classified in 53% and 73% of the cases and incorrectly classified in 40% and 13% of the cases with 7% and 14% uncertain.

The wide variance in classification error (13-41%) of this experiment is not surprising and does not necessarily indicate that an "active" hole cannot be discriminated from an "inactive" hole. There are many reasons why a hole might be active one day/night and not another, including the presence of predators, herds of grazing animals, climate, and/or moonlight. An error near 10% would be acceptable given the imprecise nature of the experiment. More trials of this technique would likely reveal that the errors of 40% are associated with conditions not conducive to animal movement and, over time (perhaps one to two weeks), holes that appeared active might be correctly classified nearly 10% of the time. A correction factor accommodating holes mistakenly identified as "inactive" might develop from observations of the state of obstructions on "inactive" holes over the same time (one to two weeks), to provide a more accurate estimate of the number of "active" holes at a site.

In a second test of hole activity, Russell identified 20 "active" holes (within his size definition) in another location (Arroyo transect). Three holes were active four times (one hole was active twice) over a five day period of monitoring where obstructions were checked twice daily, suggesting that "active" holes are not reliably discriminated from "inactive" holes. It is not clear what removed the obstructions at the chosen holes, resulting in their "active" appearance. These discouraging results may be an artifact of the particular location (an old wash-out/arroyo).

Table 2: The number (percent of total) of presumably active and inactive potential Washington ground squirrel holes whose activity levels were correctly confirmed or otherwise after two periods of three days and one 24 hr. period on Sadie's transect. Deliberate hole obstruction involved placing small sticks in an "X" in front of the holes in question.

| | Number of Holes | | |
|---|---|---|---|
| | April 19-22 | April 22-25 | April 25-26* |
| "ACTIVE" Holes (n=_____) | 30 | 29 | 31 |
| confirmed active (obstruction removed) | 20 (66%) | 14 (48%) | 10 (32%) |
| inactive (obstruction retained) | 4 (13%) | 12 (41%) | 18 (58%) |
| unknown (obstr. status uncertain) | 6 (20%) | 3 (10%) | 3 (10%) |
| "INACTIVE" Holes (n=_____) | 16 | 15 | 15 |
| confirmed inactive | 8 (50%) | 11 (73%) | 12 (12%) |
| active | 6 (38%) | 2 (13%) | 3 (20%) |
| unknown | 2 (13%) | 2 (13%) | 0 |

*Sheep went through the area and likely influenced hole activity.

However, the potential for false conclusions concerning the activity of these holes, and therefore the presence of squirrels, is apparent. During this time, four ground squirrels were regularly trapped at the arroyo but escaped to holes not used in the experiment when released from capture. The obstructed holes were mostly on the steep sides of the arroyo whereas the squirrels most frequently used the large "badgerized" burrows on the arroyo floor (Fig. 7). Smaller holes well hidden beneath sage and bunchgrass above the arroyo (on the sides) were also frequently used.
Most likely, this experiment would have greater success in different terrain (e.g. RNA C West), but its failure illustrates the potential of generating misleading conclusions from inaccurate assessment of hole activity.

A third test of hole activity assessed temporal use patterns (diurnal/nocturnal) of specific holes. Fourteen holes that were known to be "active" along Interstate Road (RNA C West)[7] were monitored for 10 days. The status of the artificial obstruction at each hole ("retained" or "removed") was recorded twice daily (Table 3). None of the obstructions were removed or retained consistently, suggesting that the holes were not specifically diurnally or nocturnally active (chi-square, $p \geq 0.07$). Whether a different set of holes would show discrete patterns of temporal use remains uncertain. This experiment infers that at least some portion of potential ground squirrel holes are used by both nocturnal and diurnal species. Counting holes to estimate squirrel abundance in such areas may lead to inflated abundance estimates to due to the portion of holes that are kept active by animals other than ground squirrels.

With further experimentation, artificial obstruction techniques may indeed enable us to define the activity level of burrows with a tested level of accuracy. However, they still won't enable us to identify what animal is keeping a specific hole "active." Van Horne et al. (1992,1993) further suggested that counts of both *inactive* and active holes give better results than active holes alone: "Total" holes resulted in higher correlation than "Active" holes in 1992. The effort required to refine the definition of an "active" hole may be more productively focused on developing an alternative monitoring technique.

*e. Conclusions Concerning the Use of the Hole Census Method to Monitor Ground Squirrel Populations*

The potential of the simple and broadly applicable hole census method is extremely attractive. However, it most certainly appears that the definition of a squirrel hole based on size and lack of obstruction alone are not adequate. It would be interesting to briefly trap the places within Boardman NWSTF that Russell identified as potential squirrel colony sites (based on hole density) to confirm squirrel presence, noting specific details on the types of burrows present. Appearance of new "plunging" burrows at a certain time may be an accurate way to ascertain squirrel presence, especially if the new burrows are distinct from burrows created by other species and if new burrows are created annually. However, "plunging" burrows did not appear on all sites occupied by Washington ground squirrels. Regardless, the problems with the hole method will only be amplified as the number of sympatric burrowing species (other ground squirrel, chipmunk, and kangaroo rat species) increases when the survey is extended to broader areas.

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[7]Monitoring of 20 holes 200m north of RNA C West was attempted as a replicate but later abandoned due to interference from grazing cattle.

Figure 7: A "badgerized" burrow used by four Washington ground squirrels on the floor of an old wash-out on the Arroyo transect.

Table 3: The number of occasions that potential Washington ground squirrel holes were active nocturnally or diurnally and the probability that the activity level was equal between temporal categories (Chi-square) according to artificial obstruction techniques.

| | Activity (Obstruction Removed) | | Chi-Square Value and |
|---|---|---|---|
| Hole # | Nocturnal | Diurnal | Probability |
| 1 | 14 | 6 | 0.79, p=0.074 |
| 2 | 9 | 4 | 0.68, p=0.17 |
| 3 | 9 | 11 | 0.42, p=0.65 |
| 4 | 8 | 12 | 0.54, p=0.37 |
| 5 | 9 | 11 | 0.42, p=0.65 |
| 6 | 13 | 7 | 0.68, p=0.18 |
| 7 | 9 | 6 | 0.51, p=0.44 |
| 8 | 9 | 5 | 0.59, p=0.29 |
| 9 | 13 | 7 | 1.67, p=0.18 |
| 10 | 13 | 6 | 0.81, p=0.06 |
| 11 | 12 | 6 | 0.75, p=0.09 |
| 12 | 12 | 8 | 0.54, p=0.37 |
| 13 | 10 | 10 | 0.32, p=1.00 |
| 14 | 14 | 6 | 0.79, p=0.78 |

Even if there is a way to make the hole census method work, it may be more beneficial to explore other ideas given the doubt cast on the method. Van Horne et al. (1993) stated that the hole census method did not meet the minimum requirements of "a reasonable index of squirrel density" (p.175) because it could not detect major fluctuations in the density of Townsend's ground squirrels between years. When these populations plummeted to 69% of former mean densities on burned sites and 54% on shrub sites, mean "Total" (both active and inactive) hole counts only declined 40% on burned sites and 37% on shrub sites, and mean "Active" hole counts declined 33% on burned sites and 37% on shrub sites after a drought in 1992. Despite its ability to indicate the direction of the decline, the hole census method has little value as a monitoring tool due to its insensitivity to magnitude. For this reason, Stephen Watts, Research Ecologist for the Raptor Research and Technical Assistance Center, BLM, is now using livetrapping transects to provide an index of Townsend's ground squirrel abundance for long-term monitoring at Snake River BOPA (Watts 1994).

A counter argument to the above is that the problems with the hole census method are within the accepted level of uncertainty for this and future Washington ground squirrels studies, and furthermore, that we need not be as confident in our future monitoring efforts as the Snake River BOPA research group, which has far more resources available to answer their questions. To address this argument, the desired degree of precision and accuracy and the eventual purpose and analysis of the monitoring data needs to be explicitly defined. Meanwhile, the proximate goal of monitoring is to identify the status of a potentially threatened species (as stated in the Legacy proposal, U.S. Navy and TNC 1993). If dependable results are truly sought so that management action can be taken as necessary, we must be *more* careful than the Snake River BOPA group. In the contemporary political climate of the Pacific Northwest, where residents have been inundated with controversies surrounding Columbia salmon, the timber industry, and grazing practices, we can't afford to make erroneous assertions and must provide defensible results.

2. Alternative Monitoring Techniques

*a. Trapping Transects*

An established method of monitoring trends in small mammal abundance involves trapping transects. Livetrapping transects as a monitoring technique for ground squirrels were tried at Snake River BOPA in 1994 (Watts 1994). At each site, 40 traps with 10m trap spacing were prebaited for two days and trapped for three days on two 190m trap lines separated by 20m. Traps were checked three times a day at 1 hr. intervals. Fifty sites were trapped during the month of April with this method. The results have not yet been analyzed, but the project's coordinator feels that the technique was successful (Stephen Watts, *pers. comm.*).

Transect trapping is somewhat labor intensive and involves the initial high cost of traps. However, the scope of monitoring at Boardman could be down-sized to accommodate limited personnel and resources. I suggest following the Snake River trapping scheme, to facilitate comparison of results. For example, one employee and a volunteer could trap four places in two weeks given eighty traps, trapping two sites per week concurrently, during mid-April. Two transects (one per week) could be placed within an RNA (protected from grazing) and two others in disturbed areas (grazed). It is likely that the trapping would not take the whole day, so that the employee and volunteer would be free in the afternoons to perform other tasks. Of course, having more transects would reduce error and increase our ability to correctly identify trends in squirrel abundance, and the ideal test of the effects of grazing on Washington ground squirrels would involve a controlled experiment with random site selection.

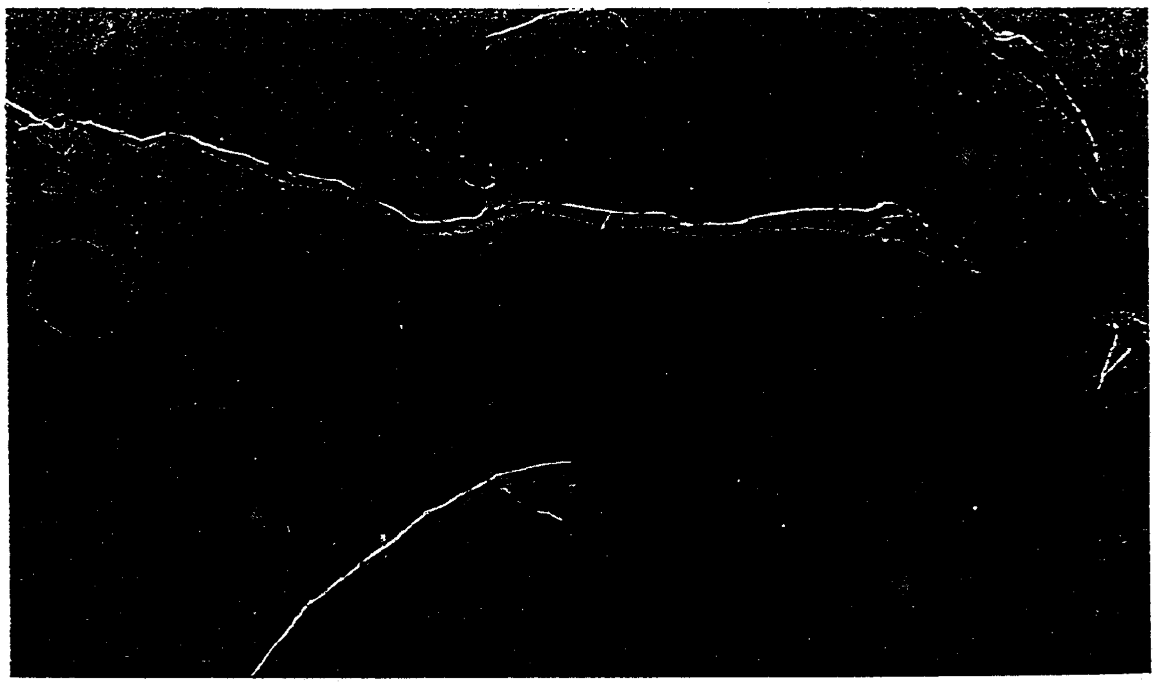
*b. Vocalizations/Sightings Transects*
Another possible alternative monitoring technique involves ground squirrel vocalizations, as suggested by an afternoon of squirrel observation when an adult female was heard calling her young with a double note call of lower frequency than her usual alarm call. With some refinement, we may be able to "call" squirrels at prospective burrow sites and confirm their presence. So far, high-pitched whistling (drawing air through tight lips) has attracted juvenile squirrels from their holes after release from capture (three times), an adult female to within 5m of the caller (she was visible before calls were tried), and one adult female and two of her young (calls were tried after they issued an alarm call). In the latter case, the adult female uttered a single note at a slightly higher frequency than used to call her young but a lower frequency than the alarm call. I answered with an adjustable-pitch dog whistle. She continued calling 13 times after I stopped. When I started again, she resumed calling. The second time I stopped, she called 20 times before stopping. During the first episode, there was a second squirrel, farther south, that answered the female's single note call in the same manner as I.

A future monitoring technique might entail walking a number of transects and listening for alarm calls. Direct observations could be recorded at the same time. Transects could be surveyed several times over a short period (one week) to estimate error. At a minimum, data from these transects would provide presence/absence information, although future observations of ground squirrel calling behavior may reveal more detailed patterns that could lead to density estimates (e.g. detection of certain calls might indicate a successful breeding area if the call is elicited mainly by adult females toward their young). The monitoring should generally occur when the squirrels are most vociferous: after the young have left the nest but before the natal groups dissolve (early to mid-April, depending on when the squirrels emerged and produced young in the particular year). Additionally, the specific technique used should enhance calling to maximize detection. For example, squirrels may elicit calls more consistently if the observer uses a calling device at a specified interval or if he/she is accompanied by a domestic dog (artificial coyote) rather than the observer surveying silently and alone. Techniques could be tested early in the season at known ground squirrel colonies.

*c. Tracking Transects*
By confirming the presence of ground squirrels, tracking may be a less expensive substitute for trapping in outlining habitat use and identifying dispersal corridors. Tracking may have an advantage over trapping in detecting trap-shy individuals (those who are relatively disinclined to enter traps). In early spring, track boxes were placed near suspicious holes and along evident rodent highways at Boardman NWSTF. To make track boxes, cardboard (sides of milk cartons) was blackened using a kymograph smoker and diesel fuel. The carboned cardboard was then inserted into empty milk cartons that were open on both ends and secured on opposite ends with paper clips. The milk cartons (track boxes) were pinned into position with a U-shaped wire and baited with apple or peanut butter and oats. The major advantage of this scheme was the low cost per unit (300 milk cartons for $20, plus wire, a small amount of fuel, and paper clips). However, blackening the cardboard was messy and most of the smoked cardboard needed replacement in 24-48 hr. For a large scale study, a more convenient technique would need to be developed.

Identifications to species could sometimes be made but the soot was often almost completely worn off by the abundance of small mammal tracks. Nevertheless, track boxes crossed by kangaroo rats could often be readily distinguished by the prints from their elongated furred hind feet and/or their long tail with a tuft of fur at the end (Fig. 8). Track boxes used by Washington ground squirrel holes could be distinguished by the tracks of their relatively large, naked feet or

a)



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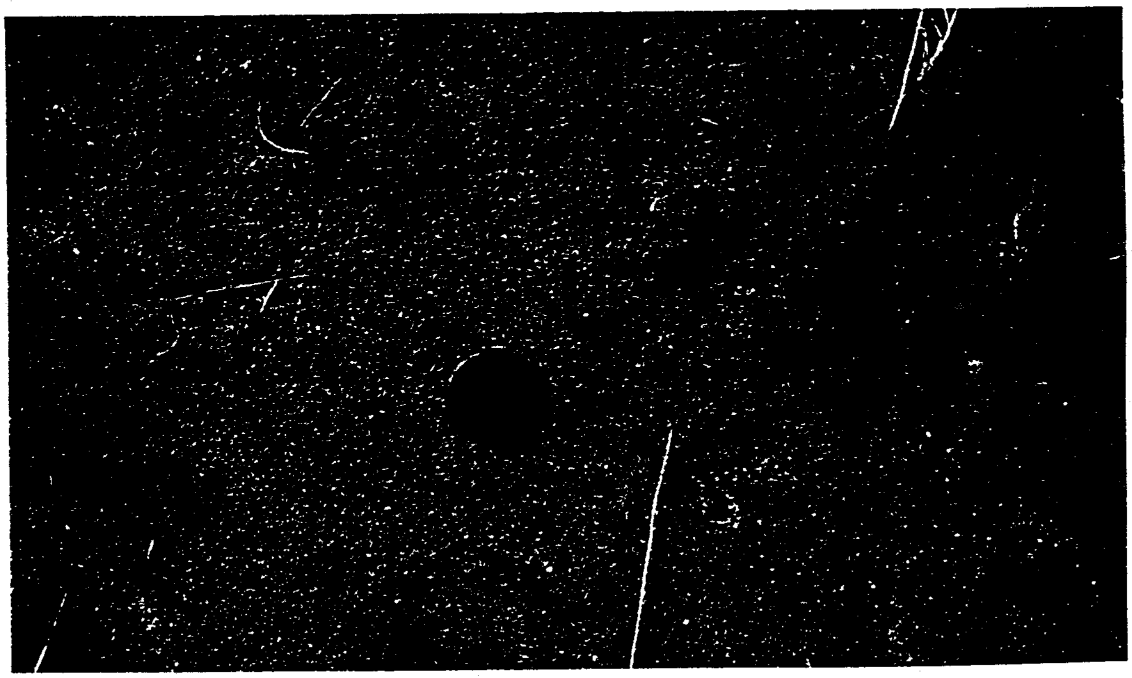

Figure 8: Tracking technique: a) prints left by Ord's kangaroo rat in sand; and, b) prints left by Washington ground squirrels in sand.

their relatively short and bushy tails.

As a monitoring technique, track boxes could be used to confirm occupation of a number of sites over time. A standardized number of track boxes could be arranged over a particular site and checked daily for a limited number of days. By setting the boxes in the morning and checking them at night, much interference from other members of the small mammal community could be reduced. However, it would be informative to open the boxes for at least one night, to elucidate whether any holes suspected to be occupied by ground squirrels were primarily used by Ord's kangaroo rats. The proportion of boxes with tracks could be compared over time as a crude index of activity (assuming the proportion of boxes with tracks will fluctuate with population abundance).

## III. SUMMARY AND DISCUSSION OF FINDINGS

### A. Base Map of the Distribution of the Washington Ground Squirrel

Most Washington ground squirrels were observed in the southern third of the NWSTF during 1994 (Fig. 9), primarily in the silty Warden and Sagehill soils. From discussions with grazing permitees, The Nature Conservancy ecologists, military personnel, and J. Anderson (Soil Conservation Service), it seems that the squirrels have historically occupied this area. Aside from the southern areas, Betts (1990) observed ground squirrel burrows in the mixed sandy/silty Koehler soils along Tison/Page Road (the main east-west gravel road). This is approximately 800m west of the site where one squirrel was caught in 1994 (N. Interstate).

In terms of rangeland production, both the Warden and Sagehill soils are associated with *Agropyron/Poa* communities (SCS 1983). Most of the squirrel sightings on Boardman NWSTF are located in the zone where Sandberg's bluegrass contributes the most to expected total annual production (Fig. 10). This association suggests that Sandberg's bluegrass may be similarly important to Washington ground squirrels as it is to Townsend's ground squirrels (see "Diet Composition," above). Cheatgrass is also one of the first to green up in the spring, and may thus provide early nutrition to squirrels in the northern pastures not shown to include significant amounts Sandberg's bluegrass in the native condition.

### B. Mark-Recapture Population Census Data

1. Abundance

The trapping grid on the east side of RNA C (RNA C East) was retained after the first trapping session and trapped 4-5 days per week until June 4. Including the first trapping session, RNA C East was open for 55 trap days (12 weeks), or 86 trap sessions (traps were generally left open at night and checked twice a day except during hot and dry weather in mid-May and June). Eight squirrels were captured 49 times including three adult males, one adult female, one juvenile male, one juvenile female, and two yåarling males. Another grid was established on the west side of RNA C (RNA C West) on April 5 and trapped 4-5 days per week until June 23. Originally, two of the ten rows of the 10x8 grid were within the RNA. By the beginning of May, the grid was converted to an 8x8 array, with only three rows remaining outside the RNA to minimize interference from grazing cattle. RNA C West was open for 51 trap days (12 weeks), or 76 trap sessions. Eight squirrels were caught 87 times including one adult female, two juvenile females, and five juvenile males. The small number of individuals caught on each grid contrasts sharply with the 86 squirrels caught on a single, identical trapping grid in the same area in 1979 (Carlson et al. 1980).

It is difficult to assess the causes of the large discrepancy in relative abundance between 1979 and

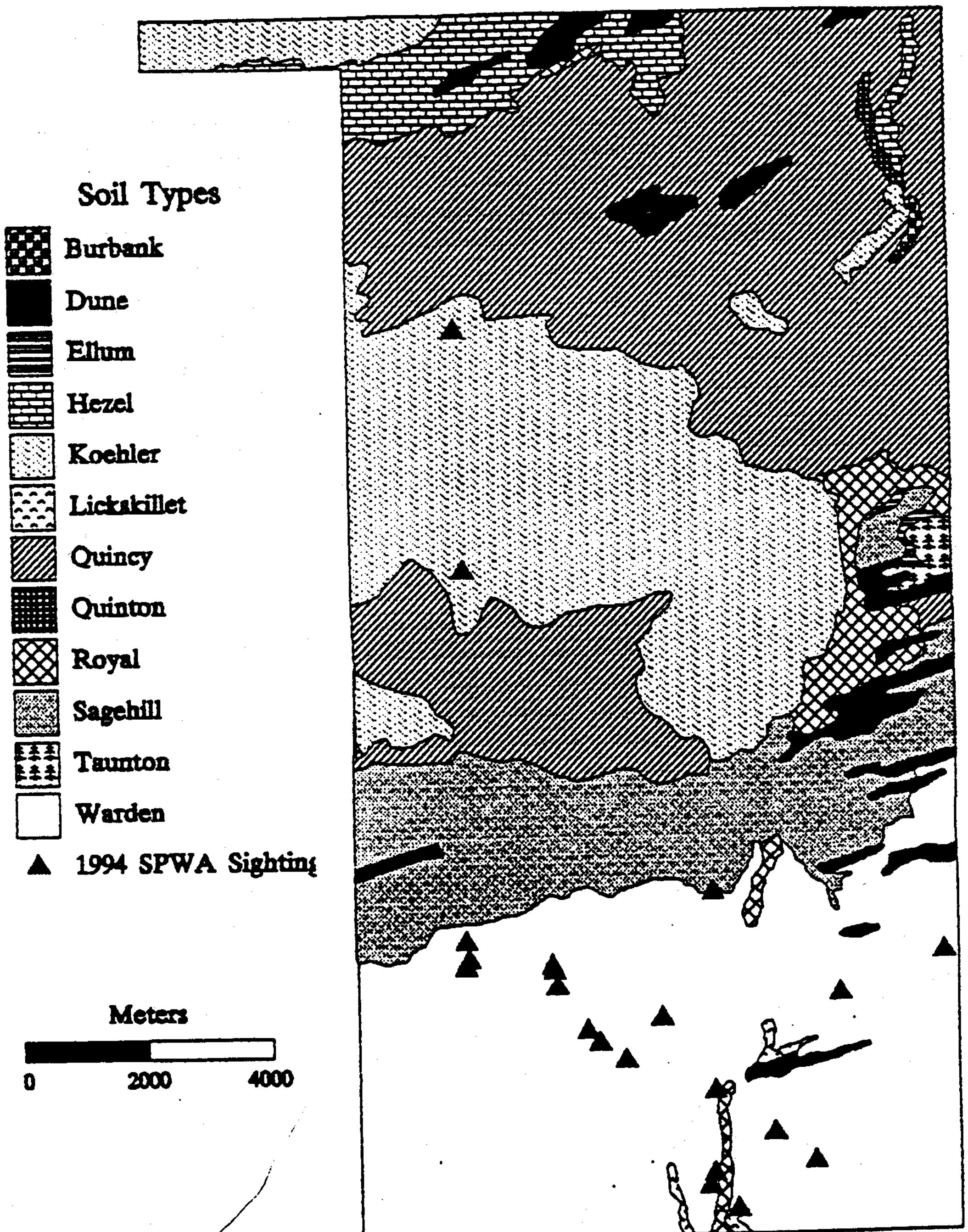


Figure 9: Locations of 1994 Washington ground squirrel sightings on the Boardman Naval Weapons Systems Training Facility.

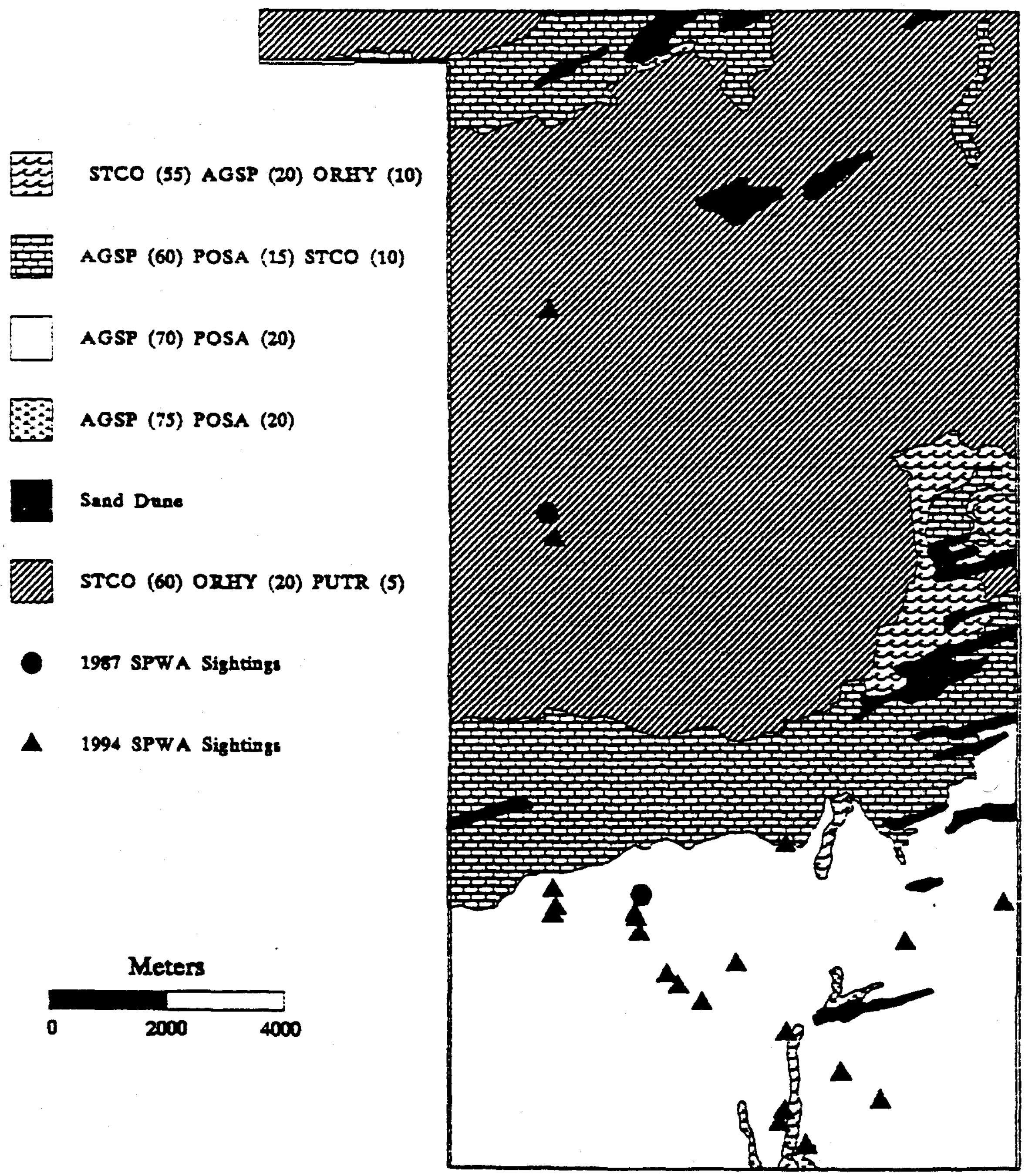


Figure 10: Potential rangeland production on the Boardman Naval Weapons Systems Training Facility (Soil Conservation Service 1983).

1994. An interesting pattern in abundance of Great Basin pocket mice over a ten-year monitoring period on the PGE Coal Fire plant adjacent to Boardman NWSTF (PGE 1986) suggests that a broad-scale factor, such as climate, may be partly responsible for the apparent fluctuations in rodent abundance. The highest number of individuals caught on the PGE livetrapping grids (n=3) was nearly 90 individuals in 1979. In 1980, the highest number of captures was less than 30. The numbers captured continued to decline through the monitoring period, reaching a low of less than 10 animals per grid in 1984. Captures reaching 30 animals per grid on control (ungrazed) sites were again recorded in 1986 and 1987. Because the decline in abundance was recorded for both control and experimental sites, a broad-scale factor that would similarly affect all habitat types, such as climate, may be responsible. Density of heteromyids (the family that includes pocket mice and kangaroo rats) are known to fluctuate with climate (Brown and Harney 1993). Like Townsend's (and potentially Washington's) ground squirrels, they are known to sacrifice recruitment of offspring for adult survival during drought periods (Brown and Harney 1993). Washington ground squirrels may have followed a similar pattern of decline in abundance from 1979 to 1984.

As for 1994, dry weather and the late snowfall (Feb. 24) may be responsible for part of the recent decline of Washington ground squirrels. Reproductive success in ground squirrels depends on the availability of green forage at the beginning of the breeding season (see "Seasonal Activities Patterns", above). Smith and Johnson (1985) documented 50% reductions in population size resulting from a 1977 drought, and Van Horne et al. (1993) suspected that almost no juvenile Townsend's ground squirrels survived the severe drought that was followed by the late, persistent, and heavy snow of 1992 (only nine juveniles of over 1,400 marked in 1992 were recaptured in 1993). Ground squirrels in the latter study had not reached pre-drought densities by 1994 (Gail Olson, *pers. comm.*). Similarly, ground squirrel abundance at Boardman is probably still recovering from the climatic conditions of 1992.

The extremely low number of individuals trapped at Boardman in 1994 precludes formation of conclusions concerning population structure, movements, or seasonal activity patterns. The discussion that follows is provided for informational purposes only.

2. Population Structure

The trapped population was slightly male biased both in 1979 and 1994, despite differences in numbers of captures. Whereas Carlson et al. (1980) captured a ratio of five males to four females (47:39) in 1979, a ratio of two males to one female (22:11, pooling transect and grid trapping data and lumping yearlings with adults) were caught in 1994. The male bias in 1979 was slightly higher for adults, with 27% more adult males (15:11), than juveniles, with 13% more males (32:28). In 1994, the bias towards males followed an opposite trend, with 44% more adult males than females (9:5) and 54% more juvenile males than females (13:6). Although male bias is a known an artifact of trapping in species with dispersing males because opportunities to catch this transient group are more frequent, a slight female skew has been reported for Townsend's ground squirrel populations (Rickart 1982, Smith and Johnson 1985). Van Horne et al. (1993) also reported a female skew in Townsend's ground squirrel populations, except when squirrel abundance was low due to extreme climatic conditions in 1992-1993.

Although Carlson et al. (1980) did not recognize the age class, yearling males were apparent in 1994, similar to the yearling class reported in Smith and Johnson (1985) for Townsend's ground squirrels (see "Seasonal Activity Patterns", above). Individuals thought to be yearlings (three males) were lighter than adults but heavier than juveniles captured in the same area, did not show signs of reproductive activity (descended testes), and, in two cases, were captured before juveniles were caught in the area. No attempts were made to distinguish yearlings from adults late in the season (late April/May) when the reproductive organs of adults are generally reduced. Similar to juvenile Columbian ground squirrels that have a higher chance of survival if they hibernate within 20m of their natal burrow (Young 1990), there may be a survival advantage for juvenile Washington ground squirrels that hibernate near their natal burrow. Two yearlings were caught on RNA C East on the same day in March, the first ground squirrel captures of the season. One was not recaptured but the other was caught almost daily until April 19, two days before juveniles were caught on the grid. Dispersal of yearling Columbian ground squirrels has been correlated with emergence of new litters (Wiggett and Boag 1989a). The third male yearling was caught on the Arroyo transect, in the presence of an adult male, adult female, and juvenile male.

In 1979, there were 60% more juveniles than adults (5:2, Carlson et al. 1980). The ratio of juveniles to adults declined in 1994 (9:7 on the trapping grids, classifying yearlings as adults), with only 22% more juveniles captured than adults. The trend was maintained when transect and grid captures were pooled: 19 juveniles to 14 adults, or 26% more juveniles than adults. With only twice as many adult females in 1979 (11 individuals) as 1994 (five individuals), there were three times as many juveniles in 1979 as 1994. The indicated decrease in juvenile production may be a consequence of unfavorable climate and forage conditions similar to that observed for Townsend's ground squirrels (see "Seasonal Activities Patterns", above).

3. Recapture Rates and Movements Within the Trapping Grids

The recapture rate on the trapping grids was relatively high. Whereas 40% of the adult males were never recaptured in Carlson et al. (1980), only one of the three adult males and one yearling male (20%) were never recaptured in 1994. The small sample size of each age class in 1994 reduces the value of reporting mean recapture rates for comparison with 1979 statistics. Nonetheless, there were more captures of adults (84, including 23 yearling captures) than juveniles (53 captures), which is opposite of Carlson et al. (1980), where juveniles were recaptured more frequently than adults. Of course, this is likely related to a reduced proportion of juveniles in 1994 (discussed above). The recapture rates expressed as the number of captures per individual on the trapping grids by age and sex follow:

| | | |
|---|---|---|
| Adults | Females | **42**, 3 |
| | Males | 10, 6, 1 |
| Juveniles | Females | **17, 7, 5** |
| | Males | **10, 8, 2, 2, 1,1** |
| Yearlings | Males | 21, 1 |

The 10.3 mean (or 7.5 median, to reduce the influence of individuals more (trap happy) or less (trap shy) inclined to enter traps) captures per squirrel on RNA C West (82 captures of eight squirrels, in **bold**) is nearly twice the 5.5 mean (or 4 median) captures per squirrel RNA C East (44 captures of eight squirrels). This discrepancy could indicate a reduced availability of forage and subsequent willingness to risk entering the traps on RNA C West. However, the small sample size prevents separation of site from individual effects.

In 1979, the mean number of unique traps visited per individual varied from 4.3 for adult males, to 4.7 for adult females and juvenile males, and to 4.5 for juvenile females (Carlson et al. 1980).

In 1994, the small sample size again reduces the value of reporting means. Also, the number of recaptures is highly correlated with the number of unique traps visited per individual (Pearson r=0.98). This may not have been the case in Carlson et al. (1980). For comparison, the number of traps used by each squirrel was:

| | | |
|---|---|---|
| Adults | Females | 22, 3 |
| | Males | 7, 5, 1 |
| Juveniles | Females | 12, 7, 3 |
| | Males | 7, 4, 2, 2, 1,1 |
| Yearlings | Males | 12, 1 |

Not surprisingly, given the high correlation with the number of captures per squirrel, the mean of 7 (or 5.5 median) unique traps per squirrel on RNA C West (in **bold**) is nearly twice the 4.3 mean (or 3 median) captures per squirrel on RNA C East.

The number of traps used per squirrel may be related to time of season. An adult female on RNA C West appeared to show more restricted movements in early April when her young were still in or near the natal burrow. By June, she expanded the number of traps used by crossing into another part of the trapping grid (Fig. 11).

Movement distances based on trapping studies should be interpreted with caution as detection of movement is limited by trap placement. Carlson et al. (1980) reported values for distance moved among age and sex classes. In this study, distance moved (farthest distance between stations where captured) was again correlated with number of stations visited by the individual (Pearson r=0.73) and limited by the small sample size. Nonetheless, the farthest distance each individual moved (in m) was:

| | | |
|---|---|---|
| Adults | Females | 215, 152.5 |
| | Males | 135, 160 |
| Juveniles | Females | 185, 80, 55 |
| | Males | 135, 80, 135, 80 |
| Yearlings | Males | 178 |

The 138m mean (or 135m median) distance moved per squirrel on RNA C West (in **bold**) is nearly equal to the 127m mean (or 144m median) distance moved per squirrel on RNA C East. Similar to Carlson et al. (1980), juveniles moved less than adults in 1994. The mean distance moved by juveniles was 131m in 1979, and 107m in 1994. The discrepancy in distance was likely due to small sample size, as was the discrepancy in trend for which sex moved farthest in adults: females moved farther than males (184m to 160m) in 1994, but males moved farther than females (239m to 159m) in 1979.

**C. Analysis of Seasonal Activity Patterns**

Although they were first seen on Feb. 16 (High Plains), Washington ground squirrels were not trapped until March 16 (RNA C East). The first juveniles were captured on April 18, approximately two weeks later than Carlson et al.(1980, April 5). In fact, a pregnant ground squirrel was captured on April 12, implying that her young would not be out of the nest for at least three more weeks (see "Seasonal Activity Patterns", above). Most sources report that litters

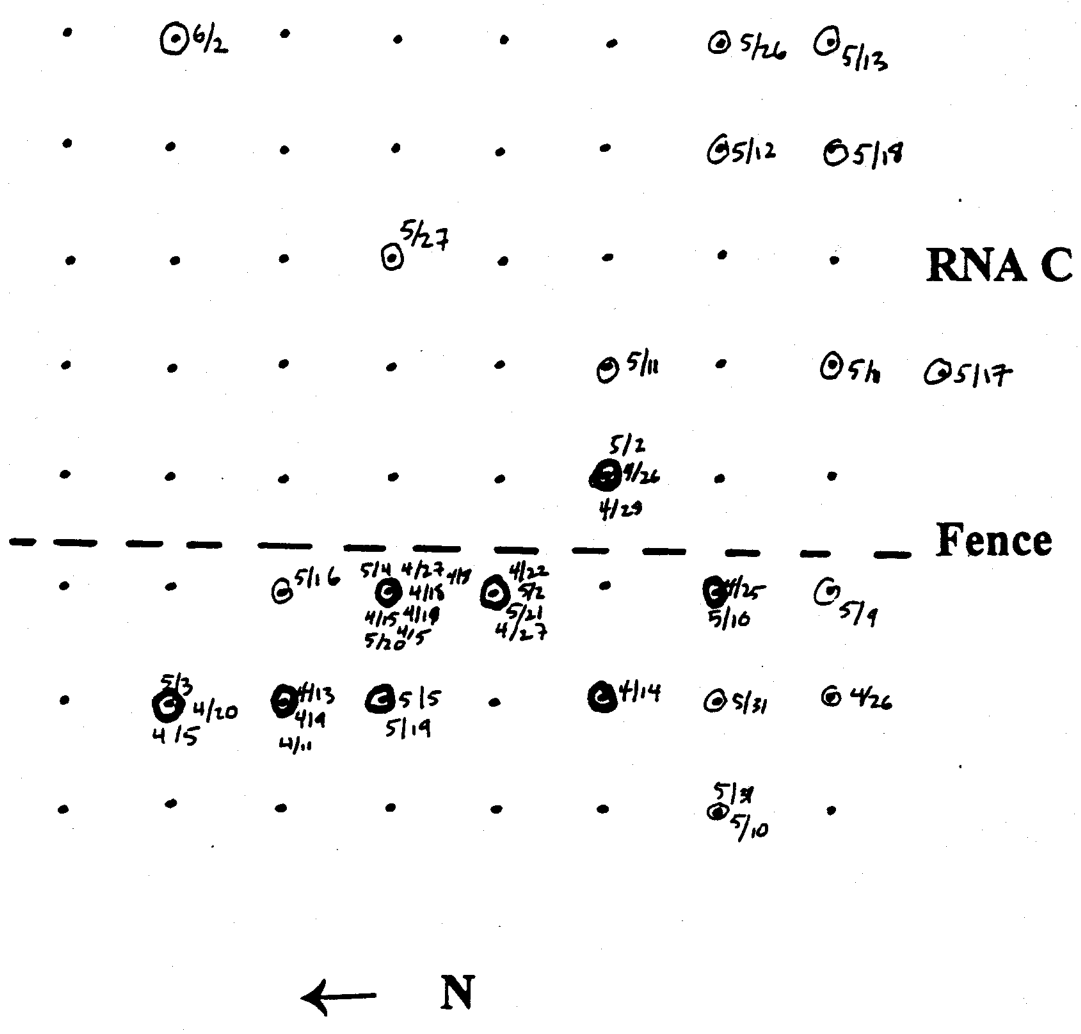


Figure 11: Locations of captures and capture dates of an adult female Washington ground squirrel on RNA C West (bold circles indicate captures between April 5 and May 5).

are usually born in February/early March (Bailey 1936, Scheffer 1941). Females Townsend's ground squirrels emerged almost two weeks (avg. 12.8 days) later than normal during a year with late and persistent snow (Van Horne et al. 1993). The delay seemed to extend to reproduction, in that males remained scrotal nearly two weeks longer, lactation persisted longer, and juveniles appeared later (18 days).

Juveniles were caught earlier on RNA C West but weighed less at first capture than on RNA C East, suggesting that the appearance of juveniles was relatively synchronous across the trapping grids despite differences in habitat. Van Horne et al. (1993) reported delayed lactation and appearance of juveniles (nearly one month) on some of their shrubby trapping sites.

The highest number of captures per week occurred during May 1-May 8 (35 captures, Fig. 12). Only two captures of ground squirrels occurred in June (RNA C West, juveniles). In 1979, the highest population estimate on the trapping grid occurred during April 22-28 (95 squirrels), decreasing steadily as adults immerged during May 20-June 2 (Carlson et al. 1980). The latter period was when captures were highest (60/wk), three weeks later than in 1994.

Three juvenile males (two not recaptured, one caught twice in early June) appeared on RNA C West during May 4-May 6. On May 11, one adult male (not recaptured) appeared on RNA C East. Smith and Johnson (1985) reported two peaks of captures of transient Townsend's ground squirrels: one in early to mid-March (yearling males) and the other in late April (females, and a secondary peak of males).

Similar to 1979, the last capture of an adult female (May 31) occurred after the last capture of an adult male (May 13). However, the last adult male capture of 1979 (May 26) was two weeks later than 1994 (Carlson et al. 1980). The trend for juveniles immerging in mid-June during 1979 was perhaps similar in 1994, with juveniles on the 1994 transects being captured through June 16. On the 1994 trapping grids, the last capture of juveniles occurred a week earlier, with the last female capture occurring a week after the last capture of a male (June 1 vs. June 9). Townsend's ground squirrels similarly immerge in mid-June to early July (Rickart 1982, Smith and Johnson 1985, Van Horne et al. 1993).

If the individual in question sequestered enough fat to survive estivation, early immergence could be beneficial to a ground squirrel by decreasing exposure to predation and the elements. However, early immergence could be fatal without enough fat. It appears that the squirrels in 1994 emerged at relatively light weights and that the adults lacked significant weight gain over the active season (Fig. 13). Carlson et al. (1980) reported the following weight means before estivation: adult males, 287g (250-315g); adult females, 239g; juvenile males, 216g; juvenile females, 191g. In this study, the largest adult male weighed 229g at last capture on April 21 (High Plains, trapping ended April 25). This individual likely gained more weight before estivating and so may have reached the mean adult male weight of 1979. The highest weights for the other age classes follows: adult female, 166g; juvenile male, 190g; juvenile female, 186g.

The lowered weights observed in Washington ground squirrels during 1994 may be the result of the effects of climatic factors on food and water resources. Van Horne et al. (1993) reported mean weight discrepancies of 100g (adult males), 50g (adult females), 150g (juvenile females), and 75g (juvenile males) for Townsend's ground squirrels between a normal and combination drought/persistent snow year. The discrepancies between 1994 (highest weights) and 1979 (mean weights, Carlson et al. 1980) were 96g (adult males), 50g (adult females), 26g (juvenile males),

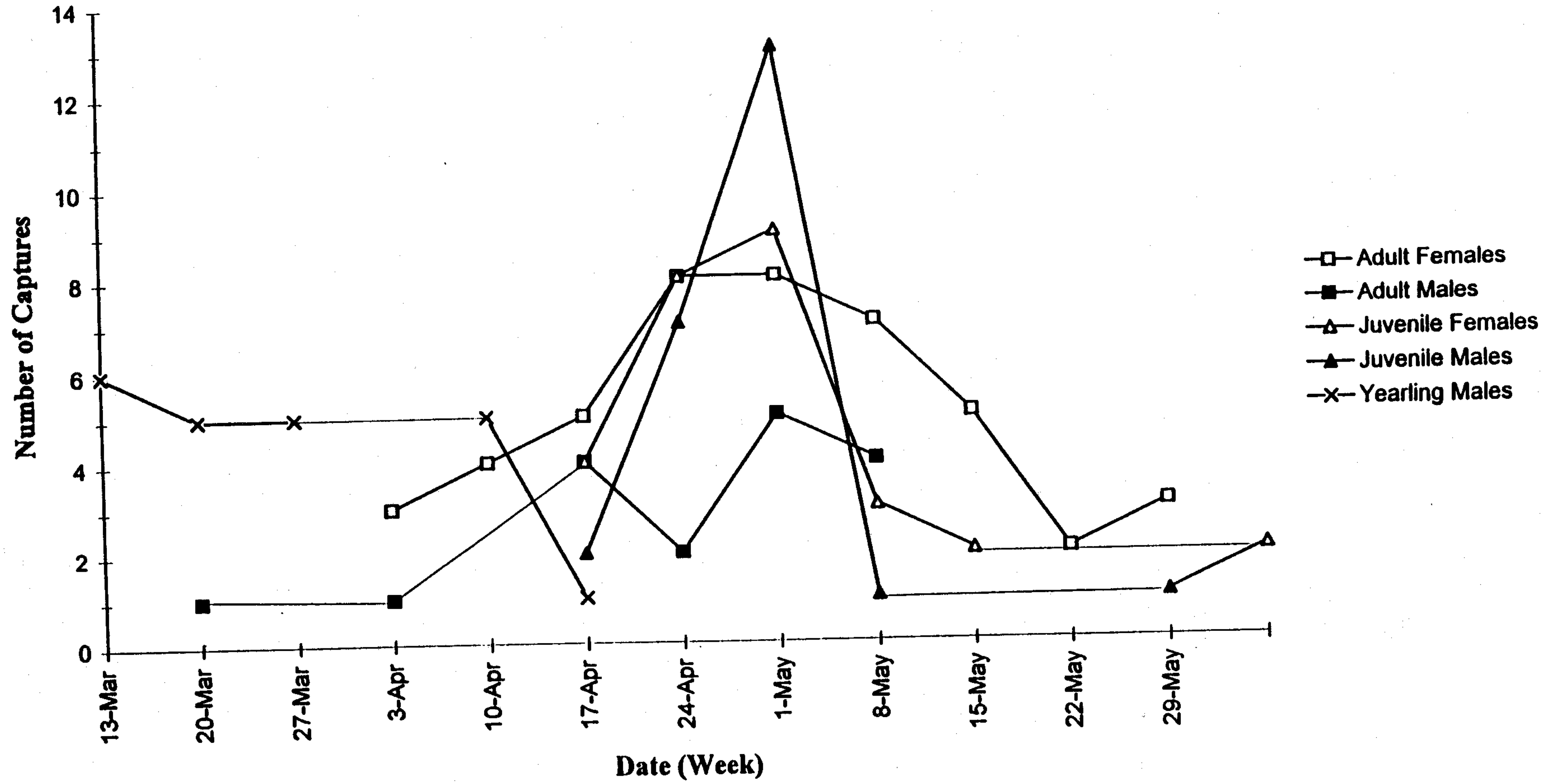


Figure 12: The number of captures per week of Washington ground squirrels on RNA C West and RNA C East by sex and age class.

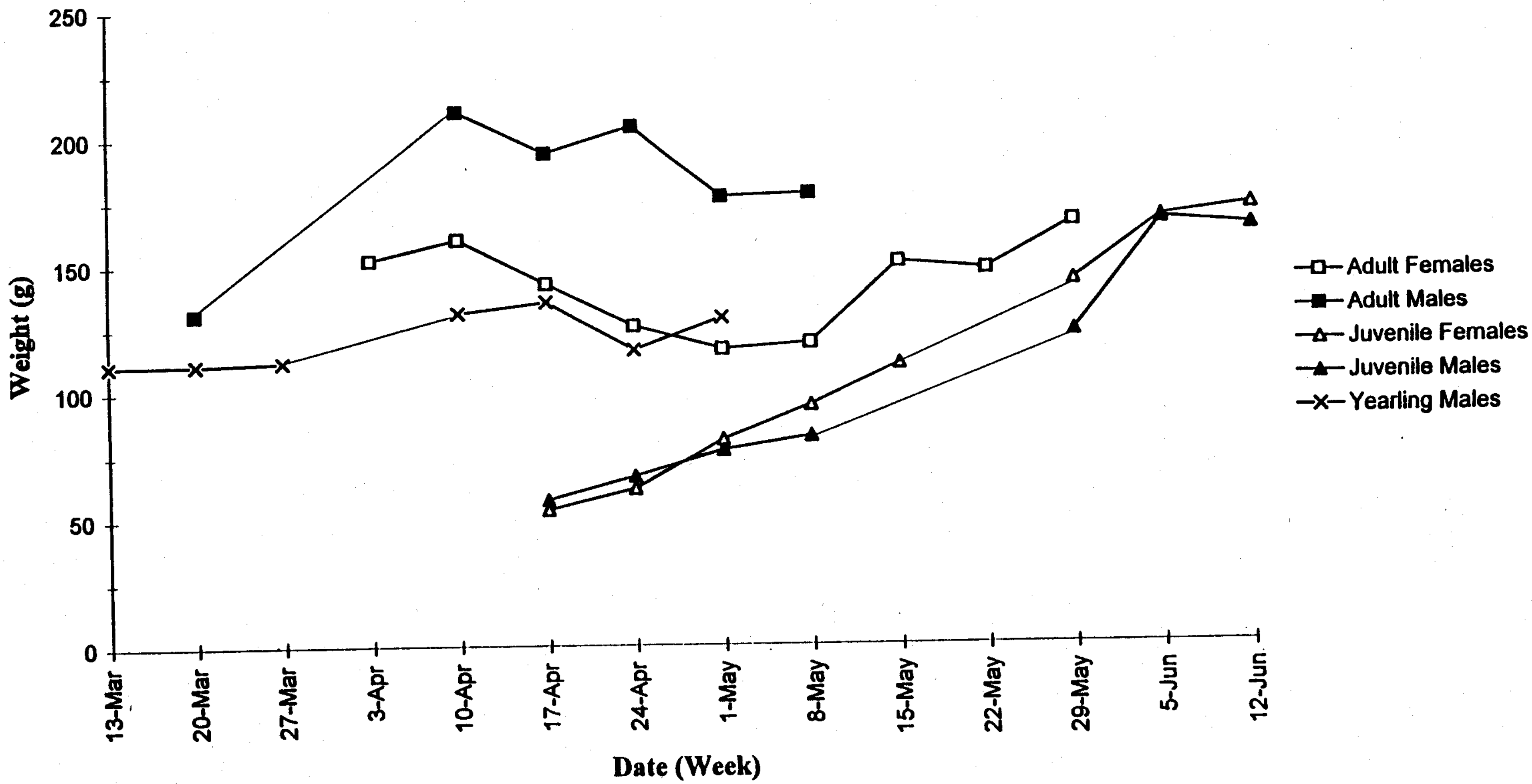


Figure 13: The average weight per week of Washington ground squirrels on RNA C West and RNA C East by sex and age class.

and 5g (juvenile females). The last adult male was captured before the heavy, late May rain. In climatically stressful years, timing of estivation may involve a a number of trade-offs. Emerging at an early date could prevent a loss of calories that could be used to sustain life during hibernation, especially if food availability was to steadily decline or arid conditions to increase. However, there may be a caloric threshold where it is no longer adaptive to begin estivation. If an individual were to face certain premature death due to lack of calories to survive estivation, it might be a last alternative to risk a temporary loss of calories and stay active until a late spring or early summer storm brings rain and renewed vegetative growth. Several days of heavy rains during the third week of May did seem to spur a temporary resurgence of green forage on Boardman NWSTF. During this period, the mean weight of adult females increased (Fig. 13).

Conditions compounding the latent effects of the 1992 drought and prolonged 1992-93 winter was the relatively dry winter of 1993-4 and perhaps, the late snow fall (9" on Feb. 24, 1994, still lingering after Feb. 28). Forage resources available to ground squirrels varies greatly according to the precipitation in a given year. In fact, Yensen and Quinney (1992) found nearly as much fluctuation in percent cover on their study sites between years as among their study sites. The size and quality of many plants of the Columbia region were reduced in 1994 compared to 1993 (B. Youtie, M. Leu, *pers. comm.*). Snow likely hinders the activities of Washington ground squirrels as it may hinder Townsend's ground squirrel activity. Extended snow cover may impede the greening of forage material beneath the snow (Shaw 1921), inhibit movement, and/or decrease foraging efficiency (Van Horne et al. 1993), although it is temperature rather than snow cover that is associated with Townsend's ground squirrel emergence (Rickart 1982).

Predation may have also taken a toll on the already reduced population of Washington ground squirrels. Evidence of badger predation was apparent, especially on Sadie's transect and RNA C East. Badgers took an estimated 56% of annual juvenile production by Columbian ground squirrels in eastern Washington (Murie 1992), although the loss did not result in a decline in the population of ground squirrels. Townsend's ground squirrels were the most important food item of badgers on the Snake River BOPA, occurring in 70% of badger stomachs, colons, and scats (Messick and Hornocker 1979). When the total number of trapped ground squirrels decreased from 79% (1976) to 55% (1977). Gopher snakes were common on the areas trapped at Boardman NWSTF, with up to three large individuals observed in a single morning (one hour) on RNA C East. Juvenile ground squirrels and cottontail rabbits may comprise up to 60% of the diet of gopher snakes (Townsend's ground squirrels, Diller and Johnson 1988). Raptors, including northern harriers, Swainson's hawks, ferruginous hawks and golden eagles, were also commonly observed near trapped areas and fragments of ground squirrel jaws could be found below fence posts along the border of RNA C, both to the east and west.

**D. Sherman Live Trap Sampling Data**

Aside from a prey base survey accompanying a burrowing owl study (Green 1983), the small mammal community at Boardman NWSTF has scarcely been studied. I operated 20 Sherman live traps throughout the trapping season to assess the small mammal communities of the trapping grids and aid understanding of burrow use. Few modern ecological studies focus on single species in isolation. Without the context of the community, observed patterns can be distorted and misleading. For example, consider the hole census surveys of this study. Although the primary interest of this study was Washington ground squirrels, a tunneled focus on that species (e.g. only trapping during the day) would have prevented the observation that other species use similar holes. Specifically, use of the Sherman live traps and tracking led to many helpful observations: kangaroo rats often leave tail drags in the entrances of their holes and often close their burrows behind them (sometimes several cm from the opening), pocket mice have similar behavior but smaller tail drags (confirmed by Murie 1954), and both of these species seem more sensitive than ground squirrels to extremes in weather. I used this information when surveying new sites for ground squirrel presence, i.e. "if an open hole without a tail drag is observed in relatively poor weather, there may be a higher probability that this hole is occupied by a squirrel."

Most of the Sherman live traps were set on the ground squirrel trapping grids (ten traps each) at suspicious holes. However, some were used along the trapping transects as well. Ord's kangaroo rats were common on the trapping grids in RNA C (especially on RNA C East) and on all of the trapping transects. This species is frequently captured in Tomahawk live traps as well. Although none were captured in RNA B, Ord's kangaroo rat sign, such as tracks, digging, and tail marks, were found along the road crossing the RNA. Great Basin pocket mice were similarly common on all sites except RNA B. Deer mice and evidence of recent northern pocket gopher activity were found on all trapping grids. Three more restricted or rare species included the northern grasshopper mouse (RNA C East and RNA B only), the western harvest mouse (RNA B only), and the domestic house mouse (*Mus musculus*; Johnson B only). A female western harvest mouse made a home in one of the Tomahawk live traps on RNA B.

Domestic house mice and western harvest mice were not previously trapped on Boardman NWSTF and have not been included on species lists of resident mammals occurring there. The presence of the former species is not surprising considering its ubiquitous distribution among disturbed habitats, but perhaps indicates that the habitat degradation on some areas within the Boardman NWSTF is severe enough to disrupt indigenous small mammal communities. Whether the species was overlooked before or a recent immigrant (implying recent reduction in habitat quality for indigenous species) remains unknown. The western harvest mouse is often common in grassy habitats (Webster and Jones 1982). Its presence in 1994 might be related to habitat type, as RNA B was not previously surveyed, thereby underscoring the unique character of the grasslands found there. However, the species is relatively similar in appearance to the common deer mouse, and may have been previously overlooked.

Other species expected to be present but were not captured in this study or Green (1983), and that are not listed in Boardman NWSTF species lists (McClelland and Bedell 1987, Kagan 1987), include the sagebrush vole (*Lagarus curtatus*) and Merriam's shrew. Runways in grass characteristic of arvicoline (vole) species were observed in Well Spring Canyon, but this area was not trapped. Fragments of arvicoline jaws were found in owl pellets but have not yet been identified. Because shrews are more efficiently caught in pitfall style traps, it is not surprising that none were captured. However, pieces of shrew rostrums were found in long-eared owl pellets. Green (1983) primarily caught vagrant shrews in his pitfall traps, but from habitat descriptions and it appears that Merriam's shrew (Armstrong and Jones 1971) and Preble's shrew (Cornely et al. 1992), a U.S.F.W.S. C2 candidate for listing as endangered or threatened, may also be present.

**E. Transect Census Data**

As originally planned (Quade 1994), Boardman NWSTF was divided into 10 blocks and one section in each was randomly selected for potential placement of a trapping grid. Although the plan to place grids in each of the ten parts was later abandoned (discussed previously), these sections and others were still searched for potential ground squirrel colonies (Table 4). Some of the potential sites were investigated further with trapping.

Table 4: Comments on the sections of Boardman Naval Weapons Systems Training Facility searched for indications of occupancy by Washington ground squirrels.

| Section | Comments |
|---|---|
| T4N R24E S26 | no signs of presence around maintenance buildings or from roads to northern fence |
| T4N R24E S25 | no signs of presence from road to northern fence |
| T4N R25E S27, 28 | no signs of activity along roads or near sand dune |
| T4N R25E S30 | no signs of activity along eastern third of section |
| T4N R25E S31, 32, 33, 34, 35, 36, | no signs of squirrel presence especially along road cuts of 31,32,33 and throughout sections 34,35,36 |
| T3N R25E S2, 3, 4 | no signs of activity in northern half of sections |
| T3N R25E S5 | no obvious signs 100m north of Tison/Page Road |
| T3N R25E S6, 7 | no signs of activity |
| T3N R25E S8 | squirrel(s) definitely present |
| T3N R25E S17, 18, 19, 29, 30, 31, 32 | possible along road (sighting in S29), no other obvious signs of activity within 400m of Interstate Road |
| T3N R25E S36 | tracks visible within RNA B; no signs in sage heading west or dunes to north; plunging burrows near eastern border |
| T3N R25E S35 | Cris Shattuck observed squirrels along road cut; no obvious signs west to central Juniper Canyon |
| T2N R25E S1 | walked much of area except SW corner, no obvious signs of activity |
| T2N R25E S2 | tracks on track plates along road cut |
| T2N R25E S3 | definitely in southern third of RNA C, possibly extending north; tracks and plunging burrows outside of RNA on hills facing east and south to Juniper Canyon; tracks on north slope of sand dune |
| T2N R25E S4 | possible along drainages, especially on hillsides; sighting in south central drainage |
| T2N R25E S5 | possible along Interstate Road and in Well Spring Canyon (SE) |
| T2N R25E S6 | no signs from just west of pipeline to Interstate Road |
| T2N R25E S7 | extensively walked area under snow (Feb.) and in June: possible in southwest ravine, briefly trapped along bluffs but no capture, possible along Interstate Road |
| T2N R25E S8 | definitely present in Well Spring Canyon, likely on hillsides; definitely along Interstate Road both in and outside RNA C (West); not in SE corner of RNA C |
| T2N R25E S9 | extensively walked this area: possible on hillsides and in Well Spring Canyon; no obvious signs in flat, central third of section |
| T2N R25E S10 | possible on highlands north of road cut (some plunging burrows), definitely along road cut to SE, possible in SE drainages, definitely along road cut in Juniper Canyon |

Table 4: *Continued*

| Section | Comments |
|---|---|
| T2N R25E S11 | definitely present along road cut, within 75m or road; no signs in or around major N-S drainage |
| T2N R25E S12 | possible along road cut on eastern border; plunging burrows on bluffs to west of eastern drainage; no signs on rabbitbrush-covered plateau of central area |
| T2N R25E S13, 24 | along road cut looks possible, did not extensively walk here |
| T2N R25E S14 | walked through major drainages and visited most Juniper trees, no obvious signs |
| T2N R25E S15 | definitely along road cuts in Juniper Canyon, possible in NE drainage, no signs in Juniper forest (east); much of western plateau is dense cheatgrass |
| T2N R25E S16 | definitely in northern third of section, southern 2/3 less promising due to thick cheat grass |
| T2N R25E S17 | possible in west drainage and main N-S Well Spring Canyon, especially on hillsides; much of areas is dense cheat grass |
| T2N R25E S18 | extensively walked area: possible in west drainages and along Interstate Road |
| T2N R25E S19 | no visible signs in northern third of section or within 400m of road |
| T2N R25E S20 | possible in northern and west canyon, including bluffs: southern and eastern areas are highly disturbed: no signs in old corral |
| T2N R25E S21 | possible in NE corner, no success at trapping SE corner, west of road cut is fairly disturbed |
| T2N R25E S22 | definitely along road cuts in Juniper Canyon and eastern highlands, no obvious signs on SW highlands |
| T2N R25E S23 | definitely present along western road cuts (sight), possible elsewhere |

Additional trapping at 15 potential ground squirrel sites (Appendix D) resulted in capture of 18 more squirrels. No ground squirrels were caught on seven of the trapped sites. This extra trapping effort was a lower priority than grid trapping, often limited by time and traps. Reflecting these constraints, the number of traps used and days trapped at each location were not standardized: 4 to 18 traps were set for 4 to 19 days at each site. Specific sites were chosen by the presence of tracks or active burrows. Traditional transect methods were abandoned for placement of traps directly in front of active holes, spaced to cover the active-appearing area (usually approximately 180m), as this proved to be the most efficient method for detecting the presence of ground squirrels. The sex and age structure of the "transect"- trapped population was discussed concurrently with the grid-trapped population, above.

No squirrels were caught or observed in the sandy bitterbrush/rabbitbrush communities of the northern Boardman NWSTF (Bipes and Rose Road).

**F. Habitat Evaluation**

1. Methods

A simple index was designed to describe the structure of vegetative communities surrounding 15 squirrel sites with the purposes of 1) objectively demonstrating that Washington ground squirrels live in a variety of habitats, and 2) elucidating similarities and/or differences among sites that could be investigated in a specific and quantitative manner in future study. On 11 of the sites, Washington ground squirrels were successfully trapped (eight "active" sites) or repeatedly sighted (three "active" sites). The remaining four sites were unsuccessfully trapped ("inactive" sites), although ground squirrels were tracked[8] on two of them.

Count and ground cover data were collected along two 400m transects at each site. The first transect was placed using a random compass direction and centered over the most active burrow, or near the center of the area trapped at inactive sites. The second transect bisected the first to create four 200m transects. Although Washington ground squirrels easily move 180m or more (data from this study and Carlson et al. 1980), I suspect 200m covers the area traversed by most individuals in an average day.

Shrubs, dead shrubs, rabbitbrush, and snakeweed were tallied by height class and large bunchgrasses (>30cm), cow and sheep dung, gopher mounds and badger diggings, and animal trails were counted along each transect in 25m intervals. Ground cover, including vegetation (by species when possible) and other characteristics (i.e. sand, dirt, rock, litter), was recorded along the transect at points underneath a tape measure (every 1m for the first 50m and at every 5m from 55-200m). Recorded observations were grouped into 20 categories based on possible biological importance to Washington ground squirrels (Table 5).

For analysis, data from the four transects were combined and examined at distances of 0-15m, 0-25m, 0-50m, and 0-200m for the habitat cover data and 0-25m and 0-200m for the habitat count data. Both types of data were assessed for variation and contrasted between the eleven active (trapped and sighted) and four inactive (unsuccessfully trapped) sites using Mann-Whitney U nonparametric tests.

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[8]At RNA B, ground squirrel tracks were observed in snow in late February. At Hitchcock, ground squirrel tracks were observed in mud in mid-March).

Table 5: Categories used for vegetation analysis. Vegetation and other characteristics (i.e. dirt, litter) were observed at points along transects. When combinations of vegetation and other characteristics were observed at one point, they were placed in the following categories according to the description.

| Variable | Description |
|---|---|
| Bluebunch Wheatgrass | *Agropyron spicatum* (*A. dasystachum* at N. Interstate, Bipes, and Rose); sometimes associated with moss, litter, *Poa secunda*, or *Phlox longifolia* |
| Bluebunch Wheatgrass/Cheat | *Agropyron spicatum* or *A. dasystachum* associated with *Bromus tectorum* |
| Needle and Thread | *Stipa comata*; sometimes associated with dirt, litter, moss, lichen, *Poa secunda*, or *Plagiobothrys tennellus* (slender popcorn flower) |
| Needle and Thread/Cheat | *Stipa comata* associated with *Bromus tectorum* |
| Continuous Cheat | *Bromus tectorum* in a solid mat, sometimes associated with litter |
| Dispersed Cheat | *Bromus tectorum* dispersed in litter, dirt, or sand |
| Squirrel Tail | *Sitanion hystrix*; sometimes associated with litter, *Poa secunda*, or *Stipa comata* |
| Squirrel Tail/Cheat | *Sitanion hystrix* associated with *Bromus tectorum* |
| Salt Grass | *Distichlis spicata*; sometimes associated with dirt or litter |
| Salt Grass/Cheat | *Distichlis spicata* associated with *Bromus tectorum* |
| Crested Wheatgrass | *Agropyron cristatum*; sometimes associated with dirt or litter |
| Crested Wheatgrass/Cheat | *Agropyron cristatum* associated with *Bromus tectorum* |
| Unidentified Grass | unidentified grass; in northern sites (RNA C West, N. Interstate, Bipes, and Rose), likely either *Stipa comata* or *Agropyron cristatum* |
| Exotic Weed | *Salsola kali*, *Sisymbrium altissimum*, *Erodium cicutarium*, *Latuca serriola*, *Centaurea diffusa*; sometimes associated with sand, dirt, litter, *Oenothera pallida* (pale evening primrose), or *Amsinckia* spp. (fiddleneck) |
| Exotic Weed/Cheat | non-indigenous weeds (above) associated with *Bromus tectorum* |
| Forb | a variety of forbs; sometimes associated with sand, dirt, or litter; on Bipes, includes a crop of alfalfa |
| Forb/Cheat | forbs associated with *Bromus tectorum* |
| Dead Shrub | dead shrubs; sometimes associated with dirt, grasses, forbs, non-indigenous weeds, or litter |
| Bare Ground | dirt, sand, rock, or litter |
| Moss/Lichen | mosses and lichens; sometimes associated with dirt, rock, sand, litter, or *Plagiobothrys tennellus* |
| Moss/Cheat | moss and lichens associated with *Bromus tectorum*, *Distichlis spicata*, or *Sisymbrium altissimum* |

Table 5: *Continued*

| Variable | Description |
|---|---|
| Bluegrass/Moss | *Poa secunda* associated with mosses and lichens; sometimes also associated with dirt, litter, sand, rock, *Stipa comata*, *Agropyron spicatum*, *Plagiobothrys tennellus*, *Phlox longifolia*, or *Sitanion hystrix* |
| Bluegrass/Cheat | *Poa secunda* associated with *Bromus tectorum* |
| Snakeweed | *Gutierrezia sarothrae*; sometimes associated with dirt, sand, moss, litter, *Bromus tectorum*, indigenous grasses, or *Salsola kali* |
| Sagebrush | *Artemisia tridentata*; sometimes associated with dirt, sand, moss, litter, *Agropyron spicatum*, *Poa secunda*, forbs, or *Salsola kali* |
| Rabbitbrush | *Chrysothamnus nauseosus*; sometimes associated with *Bromus tectorum*, litter, *Poa secunda* ,*Sitanion hystrix*, or *Salsola kali* |
| Bitterbrush | *Purshia tridentata*; sometimes associated with sand, litter, *Bromus tectorum*, forbs, *Salsola kali*, or *Sisymbrium altissimum* |
| Cow | excrement of cows, sheep, or deer; sometimes associated with *Bromus tectorum*, litter, *Poa secunda*, *Stipa comata*, lichen, forbs, or *Salsola kali* |

2. Results

a. Comparison Between Active and Inactive Sites

*Small Scale (0-50m)*

**Forb/Cheat** (habitat categories defined in Table 5 are indicated in **bold**) was significantly higher on inactive (unsuccessfully trapped) sites at 15m, 25m, and 50m. **Exotic Weed/Cheat, Bitterbrush, Rabbitbrush,** and **Needle/Cheat** were also significantly higher on inactive sites at 15m. **Bitterbrush** and **Rabbitbrush** continued to be significantly higher on inactive sites at 25m (Table 6). **Bare Ground** was significantly higher on active sites at 50m. A few habitat categories were only found within one site classification at 25m: **Bitterbrush** was only found on inactive sites (one of four sites) whereas **Crested Wheatgrass** (1/11), **Needle** (2/11), and **Salt Grass** (1/11) were unique to active sites. Inactive sites had the highest values for **Exotic Weed/Cheat, Forb, Forb/Cheat, Bluegrass/Moss, Rabbitbrush, Snakeweed, Needle and Thread,** and **Needle and Thread/Cheat**; and the lowest values for **Bare Ground** and **Dispersed Cheat**. Active sites had the highest values for **Bluebunch Wheatgrass, Bare Ground, Dispersed Cheat, Moss/Cheat, Bluegrass/Cheat,** and **Sage**; and the lowest values for **Forb/Cheat**. Both the highest and lowest values for **Moss/Lichen, Continuous Cheat,** and **Dead Shrub** were found within active sites.

Habitat count variables were unable to statistically distinguish active from inactive sites at 25m (Table 7) except that active sites had slightly more low big sagebrush (less than 1m).

*Large Scale (200m)*

The most common ground cover on all sites was cheatgrass. Only **Bitterbrush** and **Sage** were significantly different between active (successfully trapped) and inactive sites (Table 8). A few habitat categories were only found within one site classification: **Bitterbrush** was only found on inactive sites (2 of 4 sites) whereas **Squirrel Tail** (4 of 11 sites), **Crested Wheatgrass** (2/11), and **Salt Grass** (1/11) were unique to active sites. Inactive sites had the highest values for **Bluebunch Wheatgrass, Exotic Weed/Cheat, Forb, Rabbitbrush, Snakeweed, Needle and Thread,** and **Needle and Thread/Cheat**; and the lowest values for **Moss/Lichen** and **Bluegrass/Moss**. Active sites had the highest values for **Dead Shrub, Forb/Cheat, Moss/Lichen, Moss/Cheat, Bluegrass/Moss, Bluegrass/Cheat,** and **Sage**. Both the highest and lowest values for **Dispersed Cheat, Continuous Cheat,** and **Bare Ground** were found within active sites.

According to habitat count data (Table 9), active sites could be distinguished from inactive sites by the lack of **Bitterbrush**, lower quantities of rabbitbrush, and higher quantities of dead shrubs, low snakeweed (<25cm), tall big sagebrush (>1m), and low big sagebrush (<1m).

b. Comparison Within Active and Inactive Sites

Active sites included a diverse mixture of grasslands and shrublands. Figures 14-17 graphically depict this diversity. Big sagebrush was found on nine of ll sites. The most frequently counted big sagebrush were 50-100cm, ranging from 28-117 plants per 800m (200m * four transects). Snakeweed was another common shrub-like plant (9/11 sites), ranging from 50-

Table 6: Medians and ranges of habitat cover categories on "active" and "inactive" sites (1-25m). Ground cover was examined every 1m from the most active burrow to 25m along four transects and tallied by category for each of 15 sites. Where Mann-Whitney U tests were significant, the highest median is indicated with a letter ($\alpha$ =0.10); *P≤ 0.10; **P≤ 0.05; ***P≤ 0.01.

| Habitat Category | Inactive Sites (n=4) Median (Range) | Active Sites (n=11) Median (Range) |
|---|---|---|
| Bluebunch Wheatgrass | 0.5 (0-24) | 0 (0-16) |
| Bluebunch Wheatgrass/Cheat | 0 (0-1) | 0 (0-1) |
| Needle and Thread | 0.5 (0-32) | 0 (0-12) |
| Needle and Thread/Cheat | 0 (0-8) | 0 (0-6) |
| Continuous Cheat | 33 (18-44) | 28 (14-54) |
| Dispersed Cheat | 10.5 (5-28) | 7 (1-30) |
| Squirrel Tail | ----- | 0 (0-3) |
| Squirrel Tail/Cheat | ----- | 0 (0-5) |
| Salt Grass | ----- | 0 (0-9) |
| Salt Grass/Cheat | ----- | 0 (0-1) |
| Crested Wheatgrass | ----- | 0 (0-3) |
| Unidentified Grass | ----- | 0 (0-20) |
| Exotic Weed | 8 (1-17) | 4 (0-10) |
| Exotic Weed/Cheat | 8 (0-25) | 2 (0-8) |
| Forb | 10 (1-51) | 4 (1-14) |
| Forb/Cheat*** | 2.5 (2-5)[a] | 1 (0-10) |
| Dead Shrub | 1.5 (0-4) | 2 (0-6) |
| Bare Ground | 14 (10-33) | 21 (6-52) |
| Moss/Lichen | 6.5 (0-12) | 11 (2-29) |
| Moss/Cheat | 1 (0-4) | 3 (0-11) |
| Poa/Moss | 8.5 (0-25) | 17 (1-27) |
| Poa/Cheat | 0.5 (0-9) | 5 (0-18) |
| Snakeweed | 2 (0-19) | 5 (0-16) |
| Sagebrush | 0 (0-10) | 12 (0-27) |
| Rabbitbrush* | 4 (0-11)[a] | 0 (0-5) |
| Bitterbrush* | 1.5 (0-14)[a] | ----- |
| Cow | 0 (0-2) | 0 (0-3) |

Table 7: Medians and ranges of the number of occurrences of each habitat count category observed from 0-25m (100m total, sum of four transects) on "active" and "inactive" sites. No Mann-Whitney U tests were significant.

| Habitat Count Category | Inactive Sites (n=4) Median (Range) | Active Sites (n=11) Median (Range) |
|---|---|---|
| cow | 0 (0-2) | 0 (0-23) |
| sheep | ----- | 0 (0-23) |
| badger | 0.5 (0-1) | 0 (0-23) |
| gopher | 2.5 (0-5) | 0 (0-2) |
| trails | 1.5 (0-4) | 2 (0-7) |
| diffuse knapweed | ----- | 0 (0-8) |
| Russian thistle | 2.5 (0-99) | 4 (0-42) |
| sage >1m | 2 (0-6) | 3 (0-23) |
| 0.5cm > sage < 0.25cm | 0 (0-1) | 1 (0-17) |
| 1m > sage < 0.5cm | 2.5 (0-8) | 10 (0-17) |
| sage < 25cm | ----- | 1 (0-11) |
| snakeweed < 25cm | ----- | 0 (0-37) |
| snakeweed > 25cm | 0 (0-4) | 0 (0-17) |
| dead shrubs < 1m | 0.5 (0-2) | 3 (0-8) |
| dead shrubs > 1m | ----- | 0 (0-4) |
| rabbitbrush | 5.5 (0-15) | 0 (0-2) |
| grass clumps (>30cm diam.) | 0 (0-13) | 0 (0-27) |
| snakeweed | 2 (0-54) | 2 (0-43) |
| bitterbrush > 50cm | 0 (0-4) | ----- |
| bitterbrush > 1m | 0 (0-4) | ----- |
| bitterbrush < 50cm | 0 (0-2) | ----- |
| rabbitbrush > 25cm | 0 (0-4) | ----- |
| rabbitbrush < 25cm | 0 (0-4) | 0 (0-2) |

Table 8: Medians and ranges of habitat cover categories on "active" and "inactive" sites (5-200m). Ground cover was examined every 5m from the most active burrow to 200m along four transects and tallied by category for each of 15 sites. Where Mann-Whitney U tests were significant, the highest median is indicated with a letter ($\alpha$ =0.10); *P≤ 0.10; **P≤ 0.05; ***P≤ 0.01.

| Habitat Category | Inactive Sites (n=4) Median (Range) | Active Sites (n=11) Median (Range) |
|---|---|---|
| Bluebunch Wheatgrass | 0 (0-14) | 0 (0-19) |
| Bluebunch Wheatgrass/Cheat | 0 (0-2) | 0 (0-1) |
| Needle and Thread | 0 (0-23) | 0 (0-12) |
| Needle and Thread/Cheat | 0 (0-5) | 0 (0-1) |
| Continuous Cheat | 14.5 (9-33) | 15 (1-36)) |
| Dispersed Cheat | 7.5 (0-10) | 4 (1-23) |
| Squirrel Tail | ----- | 0 (0-1) |
| Squirrel Tail/Cheat | ----- | 0 (0-3) |
| Salt Grass | ----- | 0 (0-4) |
| Salt Grass/Cheat | ----- | 0 (0-1) |
| Crested Wheatgrass | ----- | 0 (0-2) |
| Unidentified Grass | ----- | 0 (0-4) |
| Exotic Weed | 4 (0-23) | 1 (0-25) |
| Exotic Weed/Cheat | 3 (0-6) | 0 (0-5) |
| Forb | 2.5 (0-17) | 1 (0-5) |
| Forb/Cheat | 2.5 (2-9) | 1 (0-2) |
| Dead Shrub | 1 (1) | 1 (0-8) |
| Bare Ground | 20 (2-25) | 27 (3-51) |
| Moss/Lichen | 4 (1-11) | 2 (0-36) |
| Moss/Cheat | 4 (0-3) | 0 (0-10) |
| Bluegrass/Moss | 5 (0-22) | 11 (0-17) |
| Bluegrass/Cheat | 0 (0-7) | 3 (0-11) |
| Snakeweed | 2 (0-15) | 1 (0-9) |
| Sagebrush* | 1.5 (0-7) | 8 (0-20)[a] |
| Rabbitbrush | 1 (0-7) | 0 (0-1) |
| Bitterbrush** | 0 (0-8)[a] | ----- |
| Cow | ----- | 0 (0-2) |

Table 9: Medians and ranges of the number of occurrences of each habitat count category observed from 0-200m (800m total, sum of four transects) on "active" and "inactive" sites. Where Mann-Whitney U tests were significant, the highest median is indicated with a letter ($\alpha$=0.10); *p≤ 0.10; **P≤0.05; ***P≤ 0.01.

| Habitat Count Category | Inactive Sites (n=4) Median (Range) | Active Sites (n=11) Median (Range) |
|---|---|---|
| cow | 2.5 (0-48) | 12 (0-95) |
| sheep* | 0 (0-2) | 5 (0-65)[a] |
| badger | 3.5 (0-9) | 2 (0-43) |
| gopher | 8 (0-26) | 2 (0-15) |
| trails | 10 (4-26) | 16 (2-42) |
| diffuse knapweed | ----- | 0 (0-8) |
| Russian thistle | 32.5 (0-629) | 1 (0-80) |
| sage >1m* | 3 (0-14) | 26 (0-104)[a] |
| 0.5m > sage < 0.25m* | 4 (0-58) | 13 (0-78)[a] |
| 1m > sage < 0.5m | 0 (0-3) | 56 (0-117) |
| sage < 25cm* | 0 (0-1) | 6 (0-56)[a] |
| snakeweed < 25cm* | 0 (0-40) | 36 (0-228)[a] |
| snakeweed > 25cm | 0 (0-35) | 31 (0-52) |
| dead shrubs < 1m* | 1 (0-14) | 18 (0-71)[a] |
| dead shrubs > 1m* | 0 (0-2) | 2 (0-18)[a] |
| rabbitbrush* | 36.5 (2-192[a]) | 3 (0-496) |
| grass clumps (>30cm diam.) | 0.5 (0-130) | 10 (0-106) |
| snakeweed | 37.5 (0-327) | 67 (0-270) |
| bitterbrush > 50cm** | 6.5 (0-32)[a] | ----- |
| bitterbrush > 1m** | 8 (0-30)a | ----- |
| bitterbrush < 50cm* | 0 (0-7)[a] | ----- |
| rabbitbrush > 25cm | 3 (0-47) | 0 (0-16) |
| rabbitbrush < 25cm | 0 (0-22) | 0 (0-10) |

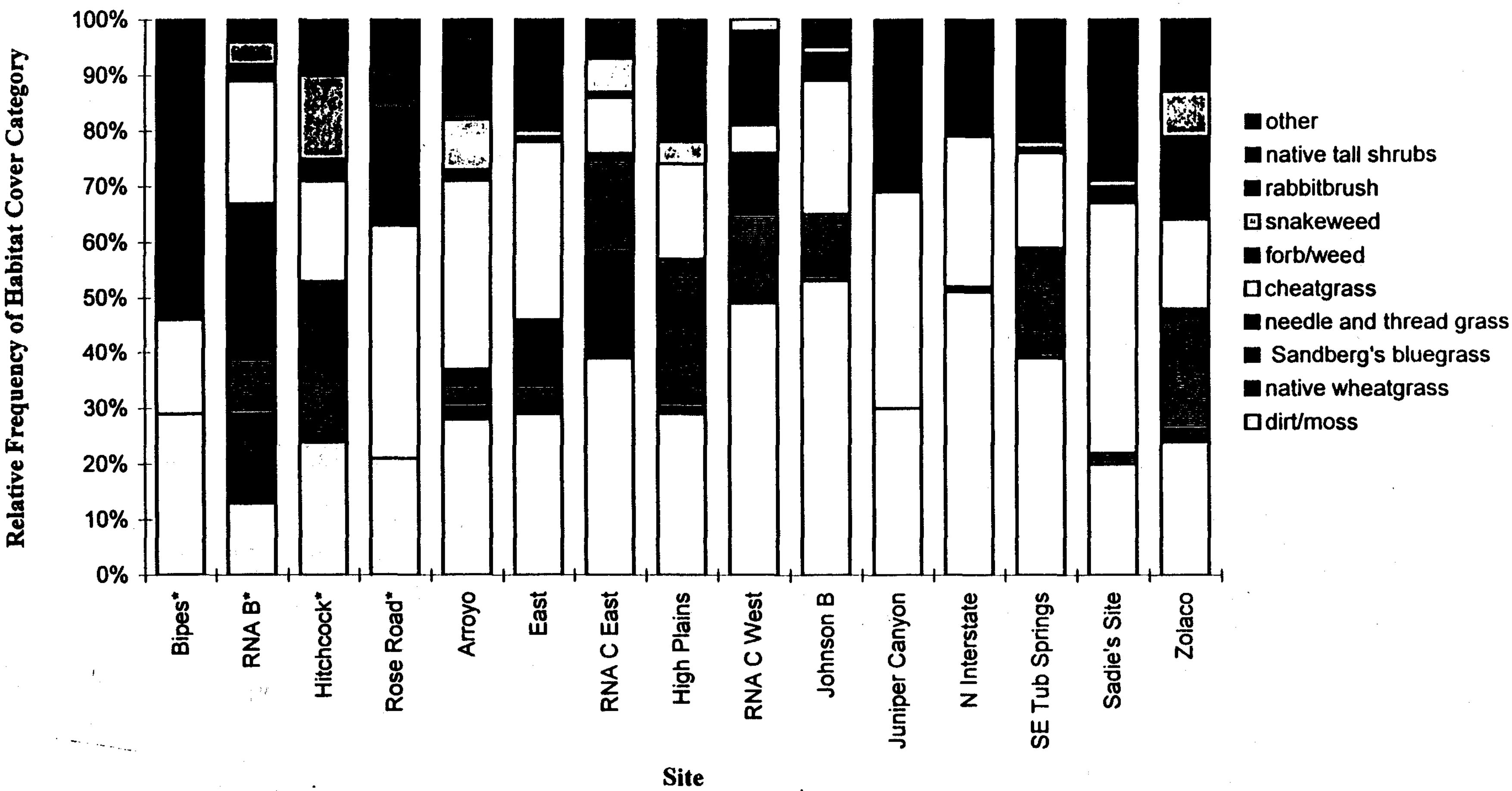



Figure 14: Relative frequencies of habitat cover categories observed from 1 - 25m along four transects at each site (*= "inactive" site).

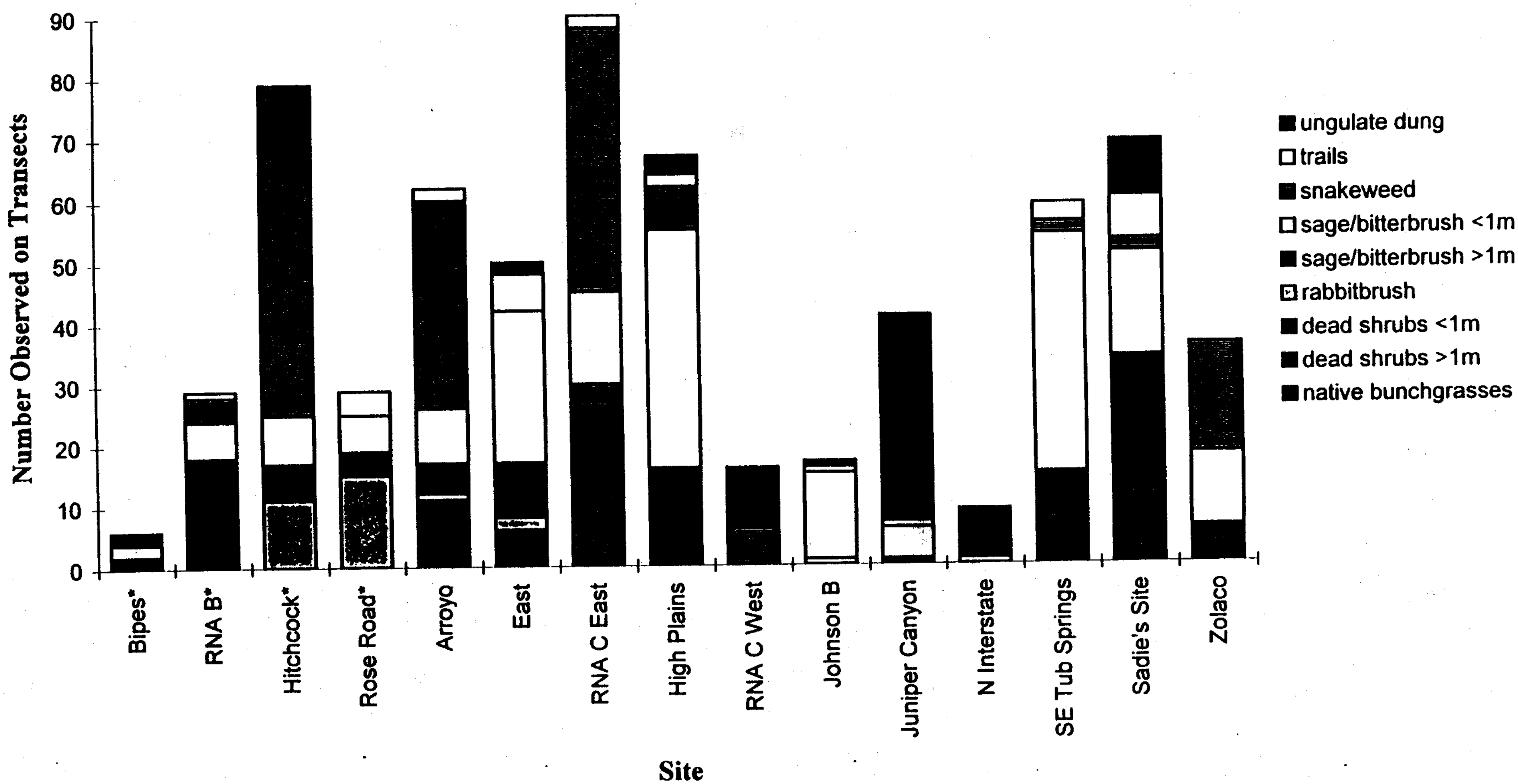



Figure 15: Number of each habitat count variable tallied from 1 - 25m along four transects at each site (* = "inactive" site).

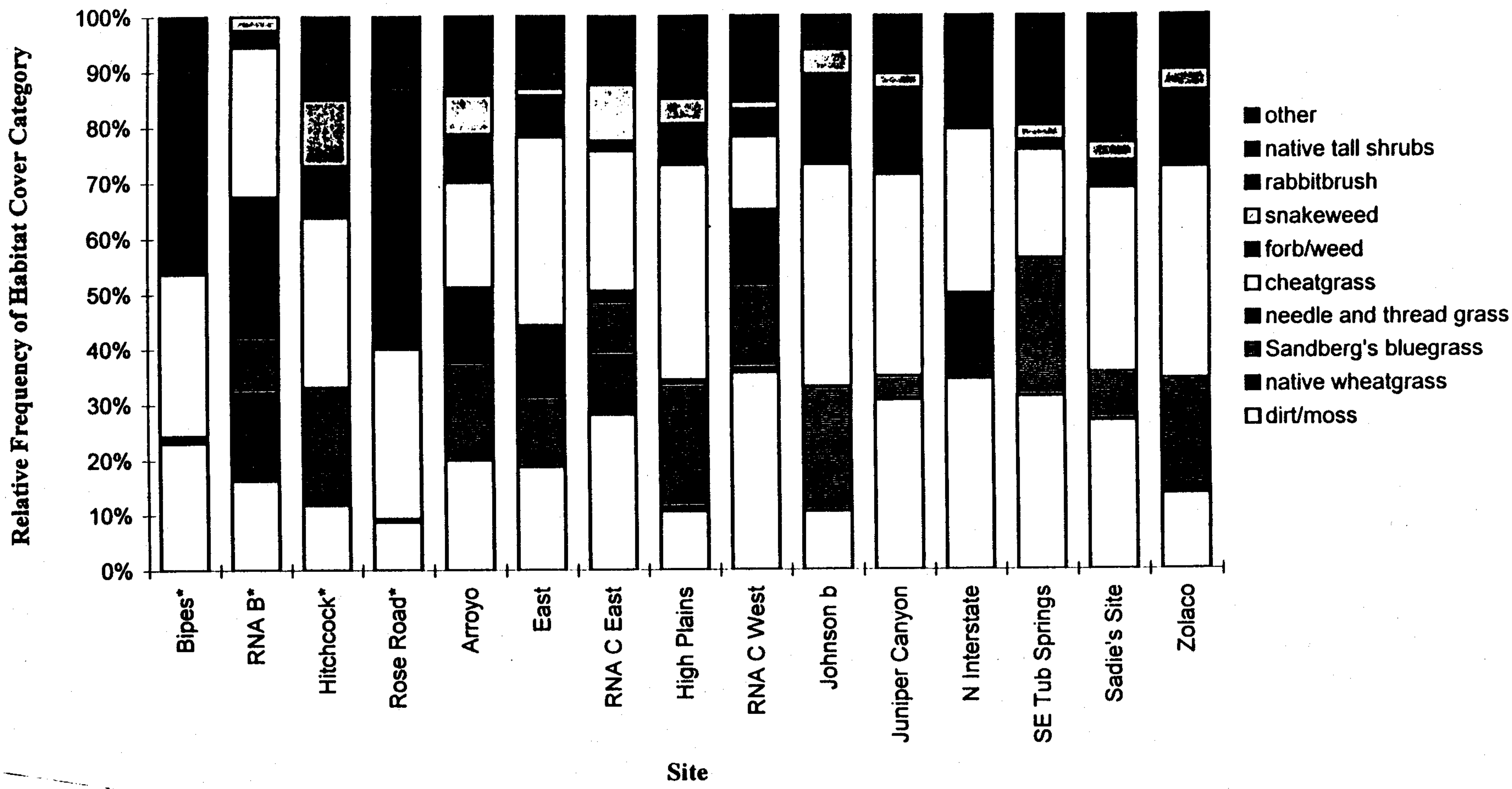



**Figure 16:** Relative frequencies of habitat cover categories observed from 0 - 200m along four transects at each site (* = "inactive" site).

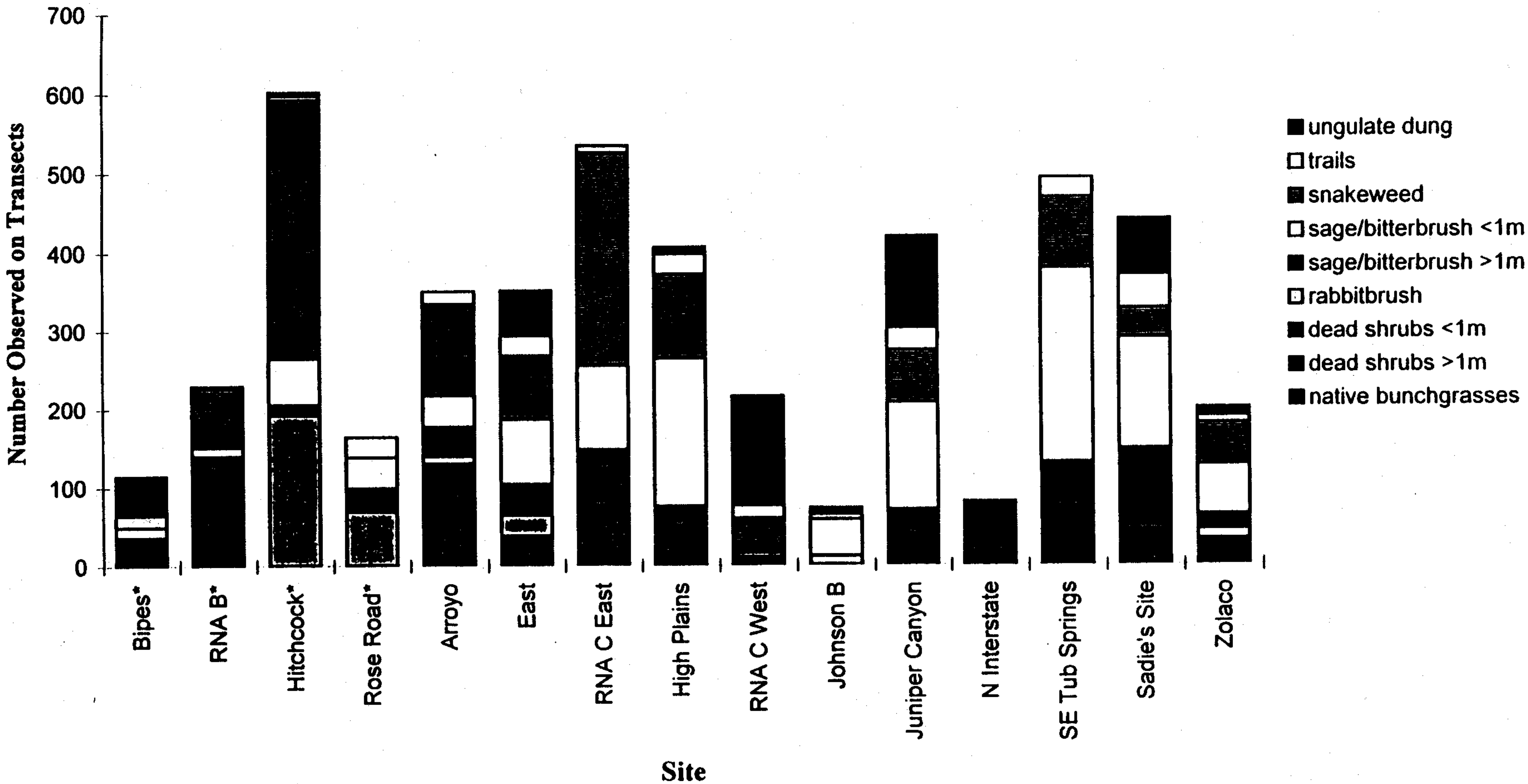



Figure 17: Number of observations of each habitat count variable tallied from 0 - 200m along four transects at each site (* = "inactive" site).

270 per 800m. Large bunchgrasses were counted on 6/11 sites, ranging from 2-106 per 800m.

Two of the four inactive sites, Rose and Bipes transects, were in the bitterbrush/rabbitbrush vegetative community of the northern Boardman NWSTF. Counts of Russian thistle and bitterbrush and cover by **Exotic Weed/Cheat** and **Forb** were higher on these two sites than any of the other 13 surveyed sites. **Forb** cover on the Rose Road transect was inflated by a neighboring alfalfa field. A third site was relatively shrubby, with highest counts of rabbitbrush and snakeweed and cover by **Rabbitbrush** and **Snakeweed**. The fourth site, RNA B, had the highest number of large bunchgrasses, as well as the highest cover by **Bluebunch Wheatgrass** and **Needle and Thread**. This was the only site where the grass-associated western harvest mouse was found.

3. Discussion

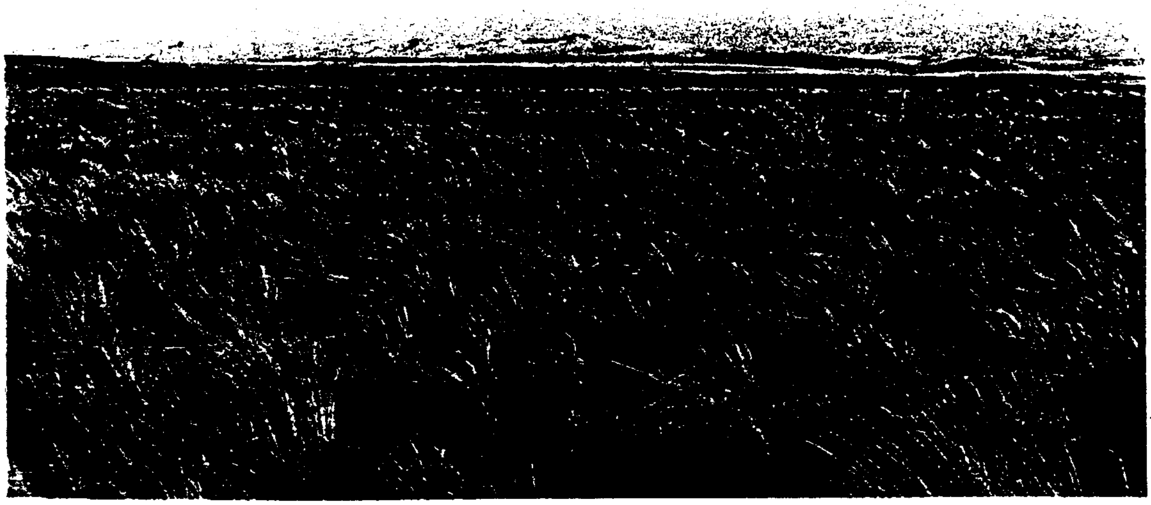
Washington ground squirrels were found in a variety of habitats (Fig. 18-19). As described by Bailey in Howell (1938; see "Habitat Characteristics", above), they were found along steep hillsides (Johnson B, Sadie's, Juniper Canyon, Zolaco), a wash-out/gulch (Arroyo), sagebrush along a river bottom (East), grasslands (RNA C West), dry and sandy areas (N. Interstate), and relatively flat sagebrush covered areas (RNA C East, High Plains, Rancher's Site). They occupied both heavily grazed areas (Zolaco, Juniper Canyon, N. Interstate) and ungrazed areas (Arroyo, RNA C West, RNA C East).

This study was not designed to identify habitat differences between sites occupied and unoccupied by squirrels (i.e. trapping sites were not randomly selected within each section, although sections were selected randomly from the stratified Boardman NWSTF; and sample sizes were unequal). Therefore, comparisons between "active" and "inactive" sites are informational rather than conclusive. The suggestion that Washington ground squirrels do not occupy sandy bitterbrush/rabbitbrush communities should be investigated further. Considering the fossorial habits of ground squirrels and the appeal of bitterbrush seeds to other ground-dwelling shrub-steppe rodents (Jenkins 1988), it may be more likely that the squirrels are avoiding this habitat due to its friable soil rather than its vegetation.

Considering the likely importance of grass seeds and leaves to the squirrel's diet (see "Diet Composition", above), it is not surprising that the results of Betts (1990) indicated that Washington ground squirrels reach highest densities on sites with high grass cover. The present study was not designed to test Betts (1990) conclusions; however, three observations suggest that there may be an upper limit to the amount grass cover preferred by the species. First, the site with highest grass cover (RNA B) was not successfully trapped in 1994. Second, there were no signs of Washington ground squirrel activity on the southwest corner of RNA C (*Agropyron/Stipa/Poa* community, as identified by Kagan 1987). Lastly, no Washington ground squirrels were caught in dense mats of cheatgrass near successfully trapped areas. It would be interesting to test whether the soil characteristics of RNA B and southwest RNA C are amenable to burrowing, as Betts (1990) found Washington ground squirrels associated with soils that were deep, weak, and with little clay.

Whether further investigation reveals that there is truly a threshold for grass cover on sites used by Washington ground squirrels, it is easy to imagine how fields of tall grasses may impede the ability of a squirrel to detect predators. Somewhat like people in dog-haired forest plantations, the sight of Washington ground squirrels may be restricted by the density and height of the grass,

a)



b)

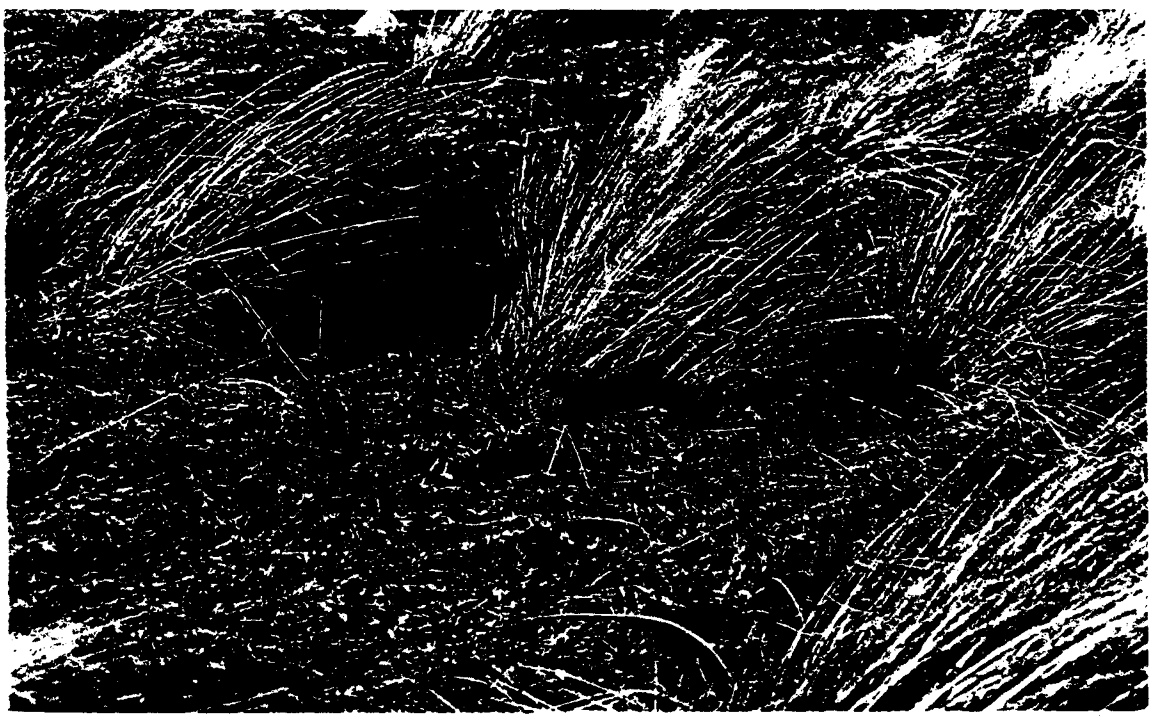
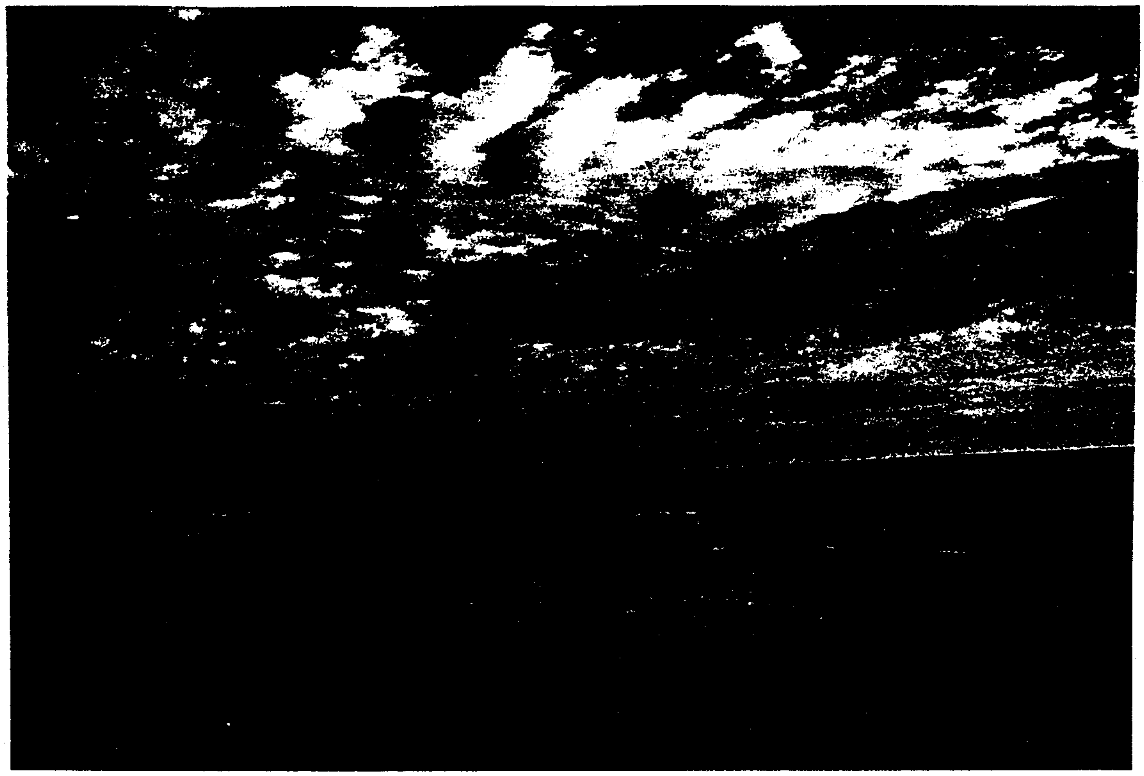


Figure 19a,b: Grassland habitat of the Washington ground squirrel from two perspectives (RNA C East).

a)



b)

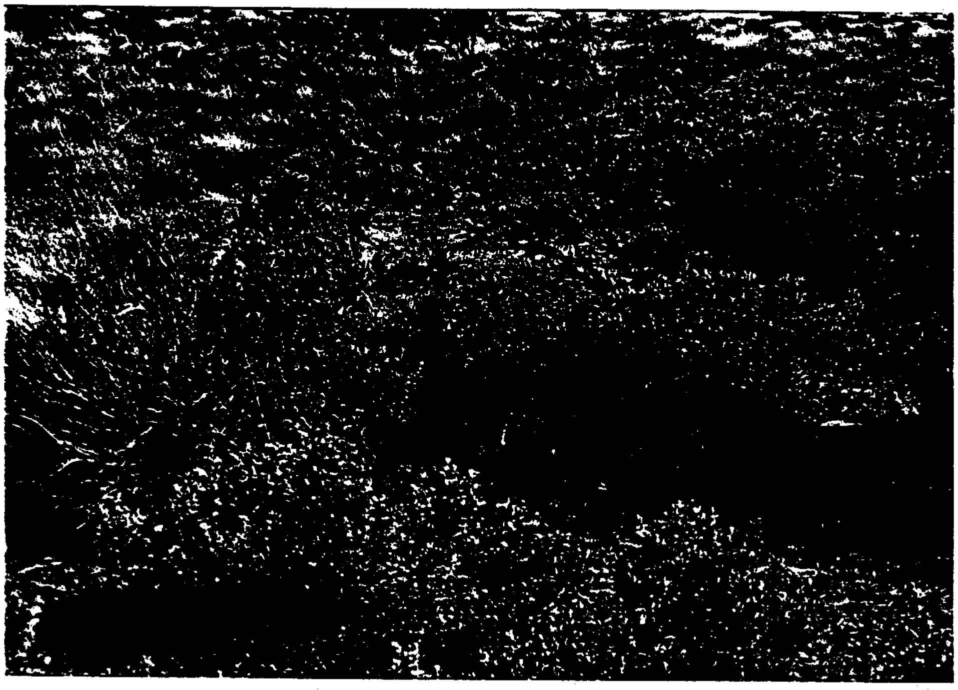


Figure 20a,b: Shrubland habitat of the Washington ground squirrel from two perspectives (Zolaco, a; RNA C East, b).

so that by the time a predator is detected, it is too late. Sagebrush covered areas might similarly be avoided if the shrubs reach a certain density. Unlike grasses, however, squirrels can climb sage to obtain better views. Such behavior was seen on Sadie's transect. Squirrels on hillsides may also have an advantage in detecting predators due to the increased visibility afforded by the slope, at least in the downhill direction. Nonetheless, because Washington ground squirrels were found in such a variety of habitats, predator detection may be an insignificant part of habitat occupancy.

Sharpe et al. (1993) found differences in a detection index among the Snake River BOPA study sites, with the best visibility on burned sagebrush sites. He will be relating visibility to vigilance postures and total time spent in vigilance behavior (*in press*). Time spent in vigilance is sacrificed foraging time, a potentially serious trade-off for animals that need to nearly double their weight in four to five months (MacHutchinson and Harestad 1990). Different requirements for vigilance behavior between habitat types may partially explain differences of parturition, survival, immergence, and other factors related to foraging and weight gain among habitat types that may be observed in future studies of Washington ground squirrels.

## IV. NEEDS FOR FURTHER RESEARCH

Before any management methods can be suggested for the Washington ground squirrel, the basic natural history of the species needs to be identified. Ultimately, understanding which factors limit the species will enable us to design an appropriate conservation strategy. We have begun to monitor trends in ground squirrel abundance at Boardman NWSTF. We have some information on seasonal activity patterns. However, we lack conclusive information concerning the species habitat preferences, space requirements, movements, diet, and basic natural history.

Probably the most important task before us is to clearly identify habitat preferences, or what makes a habitat "unpreferred". The task is difficult because Washington ground squirrels seem somewhat elusive and difficult to detect, despite their diurnal lifestyle. So far, post-hoc examinations of sites occupied by squirrels revealed that the squirrels tolerate a wide variety of habitat characteristics. Does this indicate that the species is able to occupy almost any habitat with diggable soil? Not likely, as indicated earlier (see "Discussion" under "Habitat Evaluation", above). A different survey approach is necessary.

Our efforts to identify habitat preferences have stemmed from areas known to be occupied by squirrels. Alternatively, we could focus on the vegetative communities available to ground squirrels, and decipher which of these are not occupied through a combination of techniques. This study attempted to focus on the vegetative communities available to ground squirrels through stratified sub-sampling of Boardman NWSTF. The inconclusive results may suggest that much of Boardman NWSTF is acceptable habitat to the Washington ground squirrels and/or that more intensive sampling within specific habitat types is necessary to ascertain patterns of habitat occupancy. Within Boardman NWSTF, vegetative communities should be identified and mapped. Within each community type, several (min. n=3) sites should be randomly selected. Sites could be initially surveyed for obvious signs of squirrel presence (i.e. direct sightings, tracks, and alarm calls). If no signs were visible, or if the signs were inconclusive as to the nature of the occupant (a single track may imply that a squirrel traversed the area but was not a resident), livetrapping transects could be placed within each site using random coordinates and angles and trapped to determine presence according to Watts (1994; see "Alternative Monitoring Techniques", above). Contrasts of habitat types and squirrel occupancy outside Boardman NWSTF would be further enlightening.

To obtain the clearest picture of habitat preference, determining mere presence or relative abundance of Washington ground squirrels among habitat types will not suffice. All habitats where squirrels are present are not necessarily "preferred" and high relative abundance does not infer habitat quality (there may be source/sink phenomena, Van Horne 1983). Populations on several different habitat types should be monitored over longer time periods to decipher which types consistently support high and relatively stable densities of Washington ground squirrels.

Whatever way they are determined, having a clearer understanding of the Washington ground squirrel's habitat preferences will aid development of sound management strategies and perhaps enable us to locate new colonies. An equally important research priority is to continue monitoring trends in the abundance of Washington ground squirrels. Such data will likely reveal multi-annual population fluctuations that are related to climate or otherwise. Special precautions (e.g. no disturbance buffers, artificial feeding stations) that may not be necessary during average years may be critical tothe species' survival during years of low abundance.

The next research priority is to ascertain the space requirements and movements of the Washington ground squirrel. Knowing the how much space is generally required for a colony and the patterns and modes of emigration would enable us to design protected areas that are appropriate to the scale required by the species. Species-specific diet information would also be useful, so that land management techniques can be optimized to produce the highest quality, diverse, and stable forage resourcesoin areas occupied by squirrels. Overall, at least some time in all future studies should be allocated to direct observations of squirrels. As was the case in the present study, direct observations lead to knowledge not readily decipherable from standard descriptive or experimental techniques.

## V. PROTECTION AND MANAGEMENT RECOMMENDATIONS

### A. Review of Management Methods for Maintenance of Washington Ground Squirrel Habitat

#### 1. Agriculture

The most pervasive disturbances that affect Washington ground squirrel habitat are agriculture, grazing, and fire. Conversion of native habitat to agriculture obviously limits potential habitat. Most (27) of the 45 colonies located by Carlson et al. (1980) were in uncultivated areas. However, "weedy habitat bordering wheat fields" was the second most common habitat in which squirrels were located (10 colonies). Ground squirrels have an historical reputation for persisting along irrigated pastures (see “Diet Composition”, above). Colonies with access to crops may have a nutritional advantage over those occupying non-irrigated grasslands, especially during droughts. In Idaho, the colonies of Townsend's ground squirrels near irrigated fields were the only ones to reproduce (Smith and Johnson 1985).

The indirect consequences of agricultural development, primarily habitat fragmentation, may be more detrimental to the persistence of Washington ground squirrels than the short-term nutritional benefits provided by irrigated crops. In northeastern Washington, Weddell (1991) found that occupancy of suitable habitats by Columbian ground squirrels was related to the distance of the patch of suitable habitat from the source population, but not to the size of the patch. The squirrels most often settled near their natal colony rather than vacant areas. Therefore, the effect of the loss of source colonies in fragmented habitat was magnified due to the low colonization rate of the species. The localized failure of a large colony might be catastrophic to the entire region.

The dramatic decrease in range of the Washington ground squirrel between 1979-1989 (Betts 1990) not only suggests that suitable habitat for the species may be decreasingly available, but also, that the species may have a low colonization rate. The significance of the relatively protected Boardman NWSTF colonies as dispersal sources is amplified by this scenario. These colonies, although perhaps not the largest in Oregon (Betts 1990), may have regional significance due to their protection. Land management strategies designed to promote ground squirrel persistence may have positive implications for the species throughout the region.

There is some evidence that travel corridors may be important to emigrating ground squirrels. Columbian ground squirrels using cutbanks along river drainages, game trails and other topographic features successfully located new colonies and suitable habitat (Wiggett and Boag 1989a,b). Maintaining corridors of native habitat around wheat fields and roads may enhance dispersal and resettlement of Washington ground squirrels, thereby encouraging genetic exchange between colonies.

One further point under the topic of agricultural conversion of native habitat concerns habitat quality. To maximize production, the most fertile lands of the Columbia Plateau were likely the first to be converted to agriculture. Areas that remain uncultivated, grazed, or developed are probably inferior in some respects. For example, one reason parts of Boardman NWSTF were ungrazed for so long was the lack of water. Recent pipes and wells have extended the areas usable by livestock. This has potentially important consequences for the Washington ground squirrel. The areas left for them to inhabit may be somewhat inferior. Fluctuations in abundance of squirrels on such sites may be more dramatic, as plant communities on less fertile and drier sites are likely less resilient to fluctuations in climate. One can see a dramatic example of this phenomenon within Boardman NWSTF by comparing the height of cheatgrass in different areas (cheatgrass grows taller on better sites).

2. Livestock Grazing

Unlike the prairies of the Great Plains, large herds of grazing ungulates were never part of Columbia Basin ecology. Indigenous plants did not evolve to tolerate grazing pressure, and indigenous herbivores did not evolve in such intense competition for forage resources. Therefore, detrimental effects to indigenous flora and fauna from intensive grazing by livestock is not unexpected.

At least two studies indicate that moderate livestock grazing and ground squirrel persistence may not be directly incompatible. First, Rogers and Gano (1980) did not find a significant difference in abundance of Townsend's ground squirrels, by sex or age class, among grazed and ungrazed areas in southcentral Washington. Secondly, Uresk and Rickard (1976) found that Sandberg's bluegrass, the principle component of the Townsend's, and presumably Washington, ground squirrel diet (see above), was not eaten by cattle (April 9-May 29) despite its prevalence as the second most abundant grass on a shrub-steppe range in southcentral Washington. However, USDA (1937) contradicts this suggestion. The inferior palatability of Sandberg's bluegrass compared to other available forage was similarly recognized, but seasonal consumption of the grass by grazing livestock was reported. Both cattle and sheep will graze on Sandberg's bluegrass until it becomes impalatable in early spring, and again in October, when the leaves green up again. Franklin and Dyrness (1988) report that sheep favor Sandberg's bluegrass over cheatgrass. Furthermore, Carlson et al. (1980) hypothesized that grazing was responsible for premature estivation of Washington ground squirrels, due to drying of habitat through reduction of green grasses on Boardman NWSTF. Exclosure studies have revealed that perennial grasses such as needle and thread grass and bluebunch wheatgrass decrease with grazing pressure (Tueller 1962, in Franklin and Dyrness 1988; Bock et al. 1984).

Under moderate grazing schedules, Sandberg's bluegrass is one of the most resistant to damage from trampling by livestock due to its root structure, a thick and tough mass below the ground surface (USDA 1937). It may temporarily increase with grazing, but will succumb to cheatgrass under heavy schedules (Tueller 1962, in Franklin and Dyrness 1988). Trampling by livestock does disturb the cryptogramic crust, a layer of mosses and lichens that spreads between bunchgrasses on native grasslands of the region (e.g. Brotherson et al. 1983). Disruption of the crust allows invasion by colonizing species. Indigenous colonizing species are often out competed by cheatgrass and other non-indigenous annuals. Grazing animals also spread seeds of non-indigenous annuals by trampling them and dragging them around.

The presence of cheatgrass and other non-indigenous annuals alone is not necessarily detrimental for the Washington ground squirrel, as they reportedly consume many non-indigenous species. However, cheatgrass is less drought resistant, as are nearly all the common non-indigenous annuals of Boardman NWSTF. Whereas non-indigenous annual species can vary by several orders of magnitude depending on climatic conditions, indigenous perennial forbs, bunchgrasses, and shrubs provide a relatively more constant, stable food source (Young et al. 1987). Therefore, ground squirrel populations are likely more stable over time in native plant communities than in non-indigenous annual dominated communities (Townsend's ground squirrel, Yensen et al. 1992).

Heavy disturbance (e.g. from overgrazing) can result in dense mats of cheatgrass. Such areas appear to be avoided by the Washington ground squirrels, as the squirrels were not caught in traps placed in such vegetation. Whether further investigation reveals that Washington ground squirrels truly avoid these areas or that this observation was a product of sampling error, it is easy to imagine how dense mats of cheatgrass may increase the success of predators due to the impeded ability of the squirrels to detect predators (see "Discussion" under "Habitat Evaluation", above). Also, one squirrel was observed crawling on his belly in an amphibian-like manner. This mode of locomotion is likely difficult in dense mats of cheatgrass.

Another important consequence of the replacement of indigenous forbs and grasses with non-indigenous species is a reduction in the diversity of ground squirrel diets. Townsend's and other ground squirrels eat varied diets but usually only a limited number (1-5) of species contribute >10% to the diet (Rogers and Gano 1980, Yensen and Quinney 1992). As argued by Yensen and Quinney (1992), this follows a feeding strategy proposed by Freeland and Janzen (1974) and Hansen and Johnson (1976), where a species may specialize on 2-4 highly nutritional species but eat a wide variety of other species as "poisoning insurance." A limited forage selection could have negative population consequences for generalist herbivores such as the Washington ground squirrel by reducing their ability to counter toxic secondary plant compounds.

Of course, negative effects of overgrazing are not limited to native plants and Washington ground squirrels. Small rodents were more abundant on ungrazed sites on southeastern Arizona rangelands (Bock et al. 1984). Leporid density may also be limited by grazing (MacCracken and Hansen 1989). Grazing may alter bird communities, restricting grassland species to ungrazed or lightly grazed areas (Bock et al. 1984). The effects of grazing on the above species are translated to the reptilian, mammalian, and avian predators depend on them. In conclusion, livestock grazing should be closely monitored on Boardman NWSTF to prevent further deterioration of its rangelands. Benefits of maintaining high quality grasslands would extend to all of the indigenous wildlife species of the range.

3) Fire

As a native grassland inhabitant, the Washington ground squirrel has likely evolved with fire. Fire may have played an historic role in maintaining grasslands in this area. Provided that they were not extensive, low intensity fires probably benefited the squirrel by increasing the available forage. Ground squirrels could easily avoid the direct hazard of most fires by retreating to the deepest chambers of their burrows and take full advantage of the renewed growth of bunchgrasses and forbs in the following spring.

In modern times, fire presents hazards similar to overgrazing in that intensive fires may open an area for invasion by non-indigenous species. Also, the continuity of non-indigenous species (i.e. dense mats of cheatgrass) may amplify the size of a fire. In the relatively open native grasslands, there is more space between plants and less opportunity for fires to spread. Fire can be an important management tool in native grasslands, but should be used cautiously (e.g. with attention to season) to avoid replacement of indigenous by non-indigenous species.

**B. Recommendation of Specific Protection/Management Strategies for the Washington Ground Squirrel**

1) Avoid disturbance (including grazing by livestock and use of pesticides) within a 400m buffer around currently active colonies.

(400m was suggested by responses from a survey to raptor field researchers who were asked to identify the distance between prey (i.e. ground squirrels) and people (several individuals and large equipment) required to have at least 80% of the raptors hunt and kill prey in the area (Suter and Jones 1981). Such buffers may only need to be established when populations are low (i.e. during and after a drought) if we can establish a conclusive link between the current decline in abundance and climatic factors).

2) Use synthetic pyrethroid insecticides (e.g. permethrin) instead of organochlorine, organophosphate, and carbamate compounds when insecticides are required (Grue et al. 1983, Smith and Stratton 1986).

2) Avoid herbicides that target indigenous grasses and forbs (potential forage resources of the Washington ground squirrel).

3) Prevent disturbance of RNA's, including invasion by non-indigenous weedy (e.g. diffuse knapweed) species.

(These areas are critically valuable for their rare plant communities. For ground squirrels, they offer a control site for comparisons with disturbed sites. Knapweed is encroaching on RNA C from the west and south and is threatening indigenous plants and animals that depend on them.)

4) Avoid overgrazing by livestock and spread of noxious weeds on any Boardman NWSTF rangelands.

5) Encourage landowners to leave travel corridors of natural grassland between cultivated fields.

(Washington ground squirrels do occupy weedy habitat surrounding wheat fields. Because Boardman NWSTF is the only protected squirrel site in Oregon, such areas are important to species survival in the state. Isolation and extinction of these colonies may perhaps be prevented by providing native habitat to protect and promote emigration.)

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## VII. SUMMARY ABSTRACT OF THE BIOLOGICAL CHARACTERISTICS OF THE WASHINGTON GROUND SQUIRREL

Washington ground squirrels were historically abundant but discontinuously distributed over most of their range, south and east of the Columbia River on the Columbian Plateau. Colonies have been reported in a variety of habitats, from indigenous grass and shrublands to rocky hillsides and weedy habitat surrounding wheat fields and grain elevators. Although little is known about Washington ground squirrel burrow characteristics, their fossorial habits likely restrict suitable colony locations to areas with friable but stable soils. Recent work has documented a decline in the range of the species, which has been attributed to loss of habitat.

Washington ground squirrels are generally active for 4-5 months. The breeding season generally takes place during February and March, likely depending on the availability of green forage. Actual timing of immergence is probably influenced by low temperatures. Juveniles, 5-11 per litter, are usually visible by late March. Females likely provide most of the parental care. At this time, alarm calls among or between family groups are commonly heard and adult females have been observed perching like sentinels in big sagebrush. Much of the active season is spent replenishing fat reserves. The ground squirrels likely eat new leaves of grass and shrubs in early spring, switching to forbs and seeds as they become available later in the season. By mid to late May, most of the adults begin estivation. Juveniles follow after another month (mid-June). Timing of immergence is likely related to forage and climatic conditions, including both temperature and aridity. Little is known about the structure of the species' hibernacula or over-winter survival rates.

Washington ground squirrels provide an important prey base to many predators of the shrub-steppe habitat, including gopher snakes, ferruginous hawks, Swainson's hawks, and badgers.

## VIII. SUMMARY OF THE 1994 WASHINGTON GROUND SQUIRREL STUDY

1) The hole census method (estimation of the abundance of Washington ground squirrels from the density of holes) was investigated as a potential long-term population monitoring technique and rejected through field observations and discussions with other ground squirrel researchers. The technique was found to be insensitive to large declines in ground squirrel abundance, in part due to the persistence of burrows in some habitat types and the lack of species specificity to burrows. Livetrapping transects were recommended as an alternative method to gather an index of relative Washington ground squirrel abundance over time.

2) Boardman NWSTF was surveyed for signs of Washington ground squirrel inhabitation. Most of the squirrel sightings and successful trapping locations were within the Warden and Sagehill soils of the southern range.

3) Two trapping grids were operated March through June following a sampling scheme used in a 1979 study to gather data on the trends in seasonal activity and abundance of the Washington ground squirrels on Boardman NWSTF. The extremely low number of squirrels caught per grid (eight individuals) contrasted sharply to the earlier study, where 86 individuals were caught per grid (one grid). Despite the discrepancy in abundance between years, the 1994 population was similar to the 1979 study in its slight male bias, lower distance moved between traps for juveniles

than adults, and later immergence of adult females compared to adult males.

4) Several factors point to recent climatic conditions as a factor influencing the decrease in abundance and suggest that ground squirrel abundance may be low again next season: delayed appearance of juveniles, late capture of a pregnant female, a decreased ratio juveniles to adults, increased recapture rates, delayed period of highest captures, lack of substantial weight gain in adults before immergence, early immergence of adults, and lower average weights at immergence.

## IX. SUMMARY ABSTRACT OF THE MANAGEMENT NEEDS AND SPECIFICATIONS FOR THE WASHINGTON GROUND SQUIRREL

Management actions for the Washington ground squirrel should focus on prevention of habitat degradation due to invasion by non-indigenous and noxious weeds. Outside of Boardman NWSTF, areas with ground squirrels should be acquired and protected, and landowners should be encouraged to leave tracts of native vegetation around cultivated fields and landscaped property to provide travel corridors for the species. Meanwhile, the abundance of squirrels should continue to be monitored to ascertain whether the apparent drop in population is related to abnormal climatic conditions. If so, it may be necessary to provide protection to known colonies in the form of "no disturbance" buffers during periods of low animal abundance. If the decrease in abundance is not related to climatic conditions, it may be necessary to take aggressive management steps, including reestablishment of colonies by artificial relocation.

# APPENDIX A

## SPECIAL ANIMAL AND PLANT SPECIES POTENTIALLY OCCURING AT BOARDMAN NWSTF*

| Taxa | Scientific Name | Common Name | ODFW/ USFWS Status** | ONHP List # *** |
|---|---|---|---|---|
| **Species with occurrence records from the Columbia Basin physiographic province, including specific records from Morrow County:** | | | | |
| Amphibian | *Rana pipiens* | (northern) leopard frog | SV | 2 |
| Reptile | *Crysemys picta* | painted turtle | SC | 3 |
| Bird | *Amphispiza bilineata* | black throated sparrow | FWS 3C | 3 |
| Bird | *Athene cunicularia* | burrowing owl | SC | 3 |
| Bird | *Buteo regalis* | ferruginous hawk | FWS C2, SC | 3 |
| Bird | *Buteo swainsoni* | Swainson's hawk | FWS 3C, SV | 3 |
| Bird | *Glaucidium gnoma* | northern pygmy owl | SU | 3 |
| Bird | *Lanius ludovicianus* | loggerhead shrike | FWS C2, SU | 3 |
| Bird | *Haliaeetus leucocephalus* | bald eagle | FWS LT, LT | 1 |
| Bird | *Numenius americanus* | long-billed curlew | 3C | 4 |
| Bird | *Riparia riparia* | bank swallow | SU | 3 |
| Bird | *Sialia mexicana* | western bluebird | SV | 4 |
| Mammal | *Canis lupis* | gray wolf | FWS LE, LE | 2-extinct |
| Mammal | *Lepus townsendii* | white-tailed jackrabbit | FWS C2, LT | 2 |
| Mammal | *Spermophilus washingtoni* | Washington ground squirrel | SC | 2 |
| Plant | *Allium pleianthum* Wats. | many-flowered onion | -- | 3 |
| Plant | *Allium robinsonii* Hend. | Robinson's onion | -- | 2-extinct |
| Plant | *Astragalus collunus* Dougl. ex Hook. var. *laurentii* (Rydb.) Barn. | Laurence's milk-vetch | FWS C2, C | 1 |
| Plant | *Astragalus diaphanus* Dougl. var. *diaphanus* | transparent milk-vetch | -- | 4 |
| Plant | *Astragalus sclerocarpus* Gray | stalked-pod milk-vetch | -- | 4 |
| Plant | *Astragauls succumbens* Dougl. | Columbia milk-vetch | -- | 4 |
| Plant | *Lesquerella douglasii* Wats. | Columbia bladderpod | -- | 3 |
| Moss | *Aloina bifrons* (De Not.) Delg. | none | -- | 2 |
| Moss | *Bryoerythrophyllum columbianaum* (Herm. & Lawt.) Zand. | none | -- | 2 |

*Extracted from: Oregon Natural Heritage Program (1993)

## APPENDIX A *CONT.*

| Taxa | Scientific Name | Common Name | ODFW/ USFWS Status** | ONHP List #*** |
|---|---|---|---|---|
| **Species with occurrence records from the Columbia Basin, but without specific records for Morrow County:** | | | | |
| Amphibian | *Bufo boreas* | western toad | CV | 3 |
| Reptile | *Contia tenius* | sharptail snake | SV | 4 |
| Bird | *Ammodramus savannarum* | grasshopper sparrow | SU | 3 |
| Bird | *Melanerpes lewis* | Lewis' woodpecker | SC | 3 |
| Bird | *Grus canadensis tabida* | greater sandhill crane | SV | 4 |
| Bird | *Tympanuchus phasianellus columbianus* | Columbian sharp-tailed grouse | FWS C2 | 1-extinct |
| Mammal | *Brachylagus idahoensis* | pygmy rabbit | FWS C2, SV | 2 |
| Mammal | *Felis lynx canadensis* | North American lynx | FWS C2 | 2 |
| Mammal | *Gulo gulo luteus* | California wolverine | FWS C2, LT | 2 |
| Mammal | *Plecotus townsendii townsendii* | Pacific wesetern big-eared bat | FWS C2, SC | 2 |
| Plant | *Allium macrum* Wats. | rock onion | -- | 4 |
| Plant | *Arenaria franklinii* Dougl. ex Hook var. *thompsonii* Peck | Thompson's sandwort | FWS 3B, C | 1-extinct |
| Plant | *Astragalus kentrophyta* Gray var. *douglasii* Barn. | Douglas' milk-vetch | FWS 3A, C | 1-X |
| Plant | *Balsamorhiza rosea* Nels. & Macbr. | rosy balsamroot | -- | 2-extinct |
| Plant | *Camissonia pygmaea* (Dougl.) Raven | dwarf evening primrose | -- | 1 |
| Plant | *Cryptantha leucophaea* (Dougl.) Pays. | gray cryptantha | -- | |
| Plant | *Lipocarpha aristulata* (Cov.) G.C. Tucker | aristulate lipocarpha | -- | 3 |
| Plant | *Lipocarpha occidentalis* (Gray) G.C. Tucker | western lipocarpha | -- | 3 |
| Plant | *Mimulus evanescens* Meinke *unpubl.* | disappearing monkeyflower | -- | 1 |
| Plant | *Mimulus jungermannioides* Suksd. | hepatic monkeyflower | C | 1 |
| Plant | *Penstemon deustus* var. *variabilis* (Suksd.) Cronq. | Variable hot-rock penstemon | -- | 3 |

# APPENDIX A *CONT.*

| Taxa | Scientific Name | Common Name | ODFW/ USFWS Status** | ONHP List #*** |
|---|---|---|---|---|
| **Species with occurrence records from Morrow County, but without specific records from the Coulumbia Basin (Blue, and Wallowa Mountains physiographic province, southwestern Morrow County):** | | | | |
| Bird | *Accipiter gentilis* | northern goshawk | FWS C2, SC | 3 |
| Bird | *Catharus fuscescens* | veery | -- | 4 |
| Bird | *Picoides albolarvatus* | white-headed woodpecker | SC | 3 |
| Bird | *Picoides arcticus* | black-backed woodpecker | SC | 4 |
| Bird | *Setophaga ruticilla* | American redstart | -- | 4 |
| Bird | *Sitta pygmaea* | pigmy nuthatch | SV | 4 |
| Bird | *Sphyrapicus thyroideus* | Williamson's sapsucker | SU | 4 |
| **Species without occurrence records from either Morrow County or the Columbia Basin, which may occur at Boardman NWSTF (based on habitat associations):** | | | | |
| Mammal | *Sorex prebei* | Preble's shrew | FWS C2 | 4 |

*Extracted from: Oregon Natural Heritage Program (1993)

**See ONHP (1993) for definitions of ODFW and USFWS sensitive species categories. Generally, the ODFW categories are: SC (critical, listing as threatened/endangered is pending), SV (vulnerable), SP (peripheral or naturally rare), and SU (undetermined status). The USFWS categories are LE (Listed Endangered), LT (Listed Threatened), PE (Proposed Endangered), PT (Proposed Threatened), C1 (Category 1 Candidate, sufficient information is available to propose taxa as threatened or endangered), C2 (Category 2 Candidate, additional information needed before taxa is proposed as endangered or threatened), C2* (Possibly Extinct Category 2 Candidate), 3A (Extinct Taxa), 3B (Taxonomic Problems, the taxa doesn't meet the USFWS definition of "species"), and 3C (taxa previously thought to be threatened which have proven to be more secure).

*** The ONHP Listing indicates that the taxa is:

- List 1 considered extinct or threatened by extinction throughout its entire range
- List 2 considered extinct or threatened by extinction in Oregon
- List 3 suspected to be threatened/endangered in Oregon but more information is needed to determine its status
- List 4 not currently threatened/endangered but are of concern (i.e. rare or declining species but currently secure)

# APPENDIX B1

## A LIST OF COMMON ANS SCIENTIFIC NAMES* OF VASCULAR PLANTS OCCURRING ON BOARDMAN NWSTF

| Family | Scientific Name | Common Name |
|---|---|---|
| Asteraceae (Sunflower) | *Centaurea diffusa* Lam. | diffuse knapweed |
| Boraginaceae (Borage) | *Amsinckia lycopsoides* (Lehm.) | tarweed fiddleneck |
| | *Plagiobothrys tennellus* (Nutt.) Gray | slender popcorn flower |
| Cactaceae (Cactus) | *Opuntia polycantha* Haw. | prickly pear cactus |
| Carophyllaceae (Pink) | *Holosteum umbellatum* L. | jagged chikweed |
| Compositae (Composite) | *Achillea millefolium* L. | yarrow |
| | *Artemisia tridentata* Nutt. | big sagebrush |
| | *Antennaria dimorpha* (Nutt.) T. & G. | low pussy-toes |
| | *Balsamorhiza deltoidea* Nutt. | northwest balsamroot |
| | *Chaenactis douglasii* var. *achilleaefolia* (H. & A.) A. Nels. | false-yarrow |
| | *Chrysothamnus nauseosus* (Pall.) Britt. | gray rabbitbrush |
| | *Chrysothamnus viscidiflorus* (Hook.) Nutt. | green rabbitbrush |
| | *Crepis acuminata* Nutt. | long-leaf hawksbeard |
| | *Crepis atrabarba* Heller | slender hawksbeard |
| | *Crocidium multicaule* Hook. | gold stars |
| | *Erigeron filifolius* Nutt. | thread-leaf fleabane |
| | *Erigeron linearis* (Hook.) Piper | yellow desert daisy |
| | *Gutierrezia sarothrae* (Pursh) Britte & Rusby) | snakeweed, matchbrush |
| | *Hemizonia pugens* var. *septentrionalis* (Keck) Cronq. | common spikeweed |
| | *Hieracium cynoglossoides Arv.-Touv.* | hounds-tongue hawkweed |
| | *Layia glandulosa* (Hook.) H. & A. | white tidy tips |
| | *Madia glomerata* Hook. | cluster tarweed |
| | *Wyethia amplexicaulis* Nutt. | northern wyethia |
| | *Tragopogon dubius* Scop. | yellow salsify |
| Chenopodiaceae (Goosefoot) | *Salsola kali* L. | Russian tumbleweed |
| | *Sarcobatus vermiculatus* (Hook.) Torr. | black greasewood |
| Cruciferae (Mustard) | *Descurainia pinnata* (Walt.) Britt. | tansymustard |
| | *Draba verna* L. | spring whitlow grass |
| | *Erysimum asperum* (Nutt.) D.C. | rough wallflower |
| | *Sisymbrium altissimum* L. | tumble mustard |
| Cupressaceae (Cypress) | *Juniperus occidentalis* Hook. | western juniper |

## APPENDIX B1 *CONT.*

| Family | Scientific Name | Common Name |
|---|---|---|
| Geraniaceae (Geranium) | *Erodium cicutarium* (L.) L'Her. | redstem filaree, storksbill |
| Hydrophyllaceae (Waterleaf) | *Phacelia linearis* (Pursh) Holz. | thread-leaf phacelia |
| | *Verbascum thapsus* L. | common mullein |
| Liliaceae (Lily) | *Brodiaea douglasii* Wats. | Douglas' brodiaea |
| | *Calochortus macrocarpus* Dougl. | green-banded mariposa lily |
| | *Fritillaria pudica* (Pursh) Spreng. | yellow bells |
| | *Zigadenus venenosus* Wats. | panicled death-camas |
| Linaceae (Flax) | *Linum perenne* L. | wild flax |
| Leguminosae (Pea) | *Astragalus filipes* Torr. | thread-stalk locoweed |
| | *Astragalus lentiginosus* Dougl. | speckle-pod milk-vetch |
| | *Astragalus purshii* Dougl. | wolly-pod milk-vetch |
| | *Astragalus sclerocarpus* Gray | The Dalles milk-vetch |
| | *Astragalus succembens* Dougl. | Columbia milk-vetch |
| | *Psoralea lanceolata* Pursh | lance-leaf scurf-pea |
| | *Lupinus spp.* L. | lupine |
| Malvaceae (Mallow) | *Sphaeralcea munroana* (Dougl.) Spach | orange globe mallow |
| Onagraceae (Evening Primrose) | *Oenothera pallida* Lindl. | pale evening primrose |
| Poaceae (Grass) | *Agropyron cristatum* (L.) Gaertn. | crested wheatgrass |
| | *Agropyron dasytachyum* (Hook.) Scribn. | downy wheatgrass |
| | *Agropyron spicatum* (Pursh) Scribn. & Smith | bluebunch wheatgrass |
| | *Bromus tectorum* (L.) | downy brome, cheatgrass |
| | *Elymus cinereus* Scribn. & Smith | yellow wild rye |
| | *Elymus flavescens* Scribn. & Merr. | giant wild rye |
| | *Festuca bromoides* L. | barren fescue |
| | *Festuca idahoensis* Elmer | Idaho fescue |
| | *Festuca microstachys* Nutt. | Nuttall's fescue |
| | *Festuca octoflora* Walt. | six-weeks fescue |
| | *Koeleria cristata* Pers. | junegrass |
| | *Oryzopsis hymenoides* (R. & S.) Ricker | Indian ricegrass |
| | *Poa nevadensis* Vasey | Nevada bluegrass |
| | *Poa secunda* Vasey | Sandberg's bluegrass |
| | *Sitanion hystrix* (Nutt.) Smith | bottlebrush squirrel tail |
| | *Stipa comata* Trin. & Rupr. | needle and thread grass |
| | *Stipa thurberiana* Piper | Thurber needle grass |

# APPENDIX B1 *CONT.*

| Family | Scientific Name | Common Name |
|---|---|---|
| Polemoniaceae (Phlox) | *Gilia minutiflora* Benth. | small-flowered gilia |
| | *Phlox longifolia* Nutt. | long-leaf phlox |
| Polygonaceae (Buckwheat) | *Eriogonum heracleoides* (Nutt.) | Wyeth eriogonum |
| | *Rumex venosus* Pursh | veiny dock |
| Ranunculaceae (Buttercup) | *Delphinium nuttallianum* Pritz. | upland larkspur |
| | *Ranunculus testiculatus* Crantz | bur buttercup |
| Rosaceae (Rose) | *Purshia tridentata* Pursh | bitterbrush |
| Santalaceae (Sandalwood) | *Comandra umbellata* (L.) Nutt. | bastard toad-flax |
| Saxifragaceae (Saxifrage) | *Lithophragma bulbifera* Rydb. | bulblet prairie star |
| Scrophulariaceae (Figwort) | *Penstemon acuminatus* Dougl. | sand dune penstemon |
| Umbelliferae (Parsley) | *Lomatium leptocarpum* (T. & G.) Coult. & Rose | bicolor biscuit root |
| | *Lomatium cous (Wats.)* Coult. & Rose | Cous biscuit root |
| | *Lomatium macrocarpum* (Nutt.) Coult. & Rose | gray-leaf desert parsley, biscuit root |
| | *Cymopterus terebinthinus* (Hook.) T. & G. | Indian-parsnip |

*Plant taxonomy follows Hitchcock and Cronquist (1973)

# APPENDIX B2

## A LIST OF NONVASCULAR PLANTS OCCURRING ON BOARDMAN NWSTF

### Mosses

*Aloina pilifera* (De Not.) Crum & Steere
*Bryum* sp.
*Ceratodon purpureus* (Hedw.) Brid.
*Didymodon australasii* (Hook. in Grev.) Zander
*D. brachyphyllus* (Sull. in Whippl.) Zander
*Encalypta* cf. *rhaptocarpa* Schwaegr.
*Funaria hygrometrica* Hedw.
*Grimmia montana* B.S.G.
*Phascum cuspidatum* (Hedw.)
*Pseudocrossidium revolutum* (Brid. in Schrad.) Zander
*Pterygoneurum ovatum* (Hedw.) Dix.
*Tortula brevipes* (Lesq.) Broth.
*T. princeps* De Not.
*T. ruralis* (Hedw.) Gaertn., Meyer & Scherb. var. hirsuta (Vent.) Paris

Identified by: John A. Christy, for The Nature Conservancy; 15 April 1978; T2-4N, R 24&25 E, elev. 137-244m, collected from "seven or eight localities where we stopped during a traverse of the Bombing Range"

### Lichens

*Acarospora schleicheri* (Ach.) Mass.
*Cladonia fimbriata* (L.) Fr.
*Cladonia pyxidata* (L.) Hoffm.
*Cladonia coniocraea* (Florke) Spreng.
*Collema tenax* (Sw.) Ach.
*Diploschistes scruposus* (Schreb.) Norm.
*Dermatocarpon hepaticum*
*Lecanora muralis*
*Leptogium californicum* Tuck
*Leptogium lichenoides* (L.) Zahlbr.
*Nostoc* (the algal symbiont of *Leptogium* and *Collema* species)
*Polychidium albociliatum* (Desm) Zahlbr.
*Psora luridella*

### Liverworts

*Cephaloziella divaricata* (Fran) Schiffn.

Most (except those species listed without authors, which are from Kagan (1987)) identified by: Amy Rossman, for The Nature Conservancy; 28 September 1978

# APPENDIX C

SCIENTIFIC AND COMMON NAMES OF REPTILES, BIRDS, AND MAMMALS* KNOWN TO OCCUR AND POTENTIALLY OCCURRING ON BOARDMAN NWSTF

| Order | Family | Scientific Name | Common Name | Seen in 1994? |
|---|---|---|---|---|
| CLASS REPTILA | | | | |
| SQUAMATA | Iguanidae | *Sceloporus occidentalis* | western fence lizard | Y |
| | | *Uta stansburiana* | side-blotched lizard | N |
| | | *Sceloporus graciosus* | sagebrush lizard | N |
| | | *Phrynosoma douglassi* | short-horned lizard | Y |
| | Scincidae | *Eumeces skiltonianus* | western skink | N |
| | Boidae | *Charina bottae* | rubber boa | N |
| | Colubridae | *Coluber constrictor* | yellow bellied racer | Y |
| | | *Hypsiglena torquata* | night snake | N |
| | | *Masticophis taeniatus* | striped whipsnake | N |
| | | *Pituophis melanoleucus* | gopher snake | Y |
| | | *Thamnophis sirtalis fitchi* | valley garter snake | N |
| | | *Thamnophilus elegans* | terrestrial garter snake | N |
| | Viperidae | *Crotalus viridis* | western rattle snake | N |
| CLASS AVES | | | | |
| ANSERIFORMES | Anatidae | *Anas crecca* | green-winged teal | N |
| | | *Anas platyrhynochos* | mallard | N |
| | | *Branta canadensis* | Canada goose | N |
| FALCONIFORMES | Accipitridae | *Aquila chrysaetos* | golden eagle | Y |
| | | *Buteo jamaicensis* | red-tailed hawk | N |
| | | *Buteo lagopus* | rough-legged hawk | Y |
| | | *Buteo regalis* | ferruginous hawk | Y |
| | | *Buteo swainsoni* | Swainson's hawk | Y |
| | | *Haliaeetus leucocephalus* | bald eagle | Y |
| | | *Circus cyaneus* | northern harrier | Y |
| | Cathartidae | *Cathartes aura* | turkey vulture | Y |
| | Falconidae | *Falco mexicanus* | prairie falcon | Y |
| | | *Falco sparverius* | American kestrel | Y |
| GALLIFORMES | Phasianidae | *Alectoris chukar* | chukar | N |
| | | *Callipepla californica* | California quail | Y |
| | | *Perdix perdix* | gray partridge | Y |
| | | *Phasianus colchicus* | ring-necked pheasant | Y |
| CHARADRIIFORMES | Charadriidae | *Charadrius vociferus* | killdeer | Y |

# APPENDIX C *CONT.*

| Order | Family | Scientific Name | Common Name | Seen in 1994? |
|---|---|---|---|---|
| **CLASS AVES (Cont.)** | | | | |
| CHARADRIIFORMES | Laridae (Cont.) | *Larus delawarensis* | ring-billed gull | Y |
| (Cont.) | Scolopacidae | *Numenius americanus* | long-billed curlew | Y |
| COLUMBIFORMES | Columbidae | *Zenaida macroura* | mourning dove | Y |
| STRINGIFORMES | Strigidae | *Athene cunicularia* | burrowing owl | Y |
| | | *Asio otus* | long-eared owl | Y |
| | | *Asio flammeus* | short-eared owl | N |
| | Tytonidae | *Tyto alba* | barn owl | Y |
| CAPRIMULGIFORMES | Caprimulgidae | *Chordeiles minor* | common nighthawk | Y |
| PASSERIFORMES | Alaudidae | *Eremophila alpestris* | horned lark | Y |
| | Corvidae | *Corvus corax* | common raven | Y |
| | | *Corvus brachyrhynocos* | American crow | Y |
| | | *Pica pica* | black-billed magpie | Y |
| | Fringillidae | *Amphispiza belli* | sage sparrow | N |
| | | *Amphispiza bilineata* | black-throated sparrow | Y |
| | | *Annodramu savannarum* | grasshopper sparrow | Y |
| | | *Chondestes grammacus* | lark sparrow | Y |
| | | *Carpodacus mexicanus* | house finch | Y |
| | | *Passerculus sandwichensis* | savannah sparrow | Y |
| | | *Pipilo erythrophthalmus* | rufous-sided towhee | Y |
| | | *Zonotrichia leucophrys* | white-crowned sparrow | N |
| | Hirundinidae | *Hirundo rustica* | barn swallow | Y |
| | Icteridae | *Euphagus cyanocephalus* | Brewer's black bird | Y |
| | | *Icterus bullockii* | northern oriole | Y |
| | | *Sturnella neglecta* | western meadowlark | Y |
| | Lanidae | *Lanius excubitor* | northern shrike | Y |
| | | *Lanius ludovicianus* | loggerhead shrike | Y |
| | Mimidae | *Oreoscoptes montanus* | sage thrasher | Y |
| | Motacillidae | *Anthus spinoletta* | water pipet | N |
| | Picidae | *Colaptes cafer* | northern flicker | Y |
| | Sturnidae | *Sturnus vulgaris* | European starling | Y |
| | Troglodytidae | *Salpinctes obsoletus* | rock wren | Y |
| | Turdidae | *Sialia currucoides* | mountain bluebird | Y |
| | | *Turdus migratorius* | American robin | Y |

## APPENDIX C *CONT.*

| Order | Family | Scientific Name | Common Name | Seen in 1994? |
|---|---|---|---|---|
| CLASS AVES (Cont.) | | | | |
| PASSERIFORMES (Cont.) | Tyrannidae | *Empidonax difficilis* | western flycatcher | Y |
| | | *Sayornis saya* | Say's phoebe | Y |
| CLASS MAMMALIA | | | | |
| INSECTIVORA | Soricidae | *Sorex merriami* | Merriam's shrew | N |
| | | *Sorex preblei* | Preble's shrew | N |
| | | *Sorex vagrans* | vagrant shrew | N |
| LAGOMORPHA | Leporidae | *Lepus californicus* | black-tailed jack rabbit | Y |
| | | *Lepus townsendii* | white-tailed jack rabbit | N |
| | | *Brachylagus idahoensis* | pygmy rabbit | N |
| | | *Sylvilagus nuttalli* | mountain cottontail | Y |
| RODENTIA | Erethizontidae | *Erethizon dorsatum* | common porcupine | N |
| | Geomyidae | *Thomomys talpoides* | northern pocket gopher | Y |
| | Heteromyidae | *Dipodomys ordii* | Ord's kangaroo rat | Y |
| | | *Perognathus parvus* | Great Basin pocket mouse | Y |
| | Muridae | *Reithrodontomys megalotis* | western harvest mouse | Y |
| | | *Lagarus curtatus* | sagebrush vole | N |
| | | *Mus musculus* | house mouse | Y |
| | | *Peromyscus maniculatus* | deer mouse | Y |
| | | *Onychomys leucogaster* | northern grasshopper mouse | Y |
| | Sciuridae | *Spermophilus washingtoni* | Washington ground squirrel | Y |
| CARNIVORA | Canidae | *Canis latrans* | coyote | Y |
| | Felidae | *Lynx rufous* | bobcat | N |
| | Mustelidae | *Mustela frenata* | long-tailed weasel | N |
| | | *Spilogale gracilis* | western spotted skunk | N |
| | | *Taxidea taxus* | American badger | Y |
| ARTIODACTYLA | Cervidae | *Odocoileus hemonius* | mule deer | Y |

*Taxonomy follows Nussbaum et al. (1983, reptiles), Peterson (1961, avians), and Jones et al. (1992, mammals).

# APPENDIX D

## LIST OF WASHINGTON GROUND SQUIRREL SIGHTINGS AND TRAPPING LOCATIONS ON BOARDMAN NWSTF

| | Site Name | Location (TRS) | Squirrels Present? | Traps Used? | Sign of Presence | First Obs. Date | Notes on site, etc. |
|---|---|---|---|---|---|---|---|
| 1 | Rose Road | T4N R24E S25 | Uncertain | Y | holes | 4/13/94 | site suggested by J.Anderson (SCS) on basis of suspicious holes; 16 traps open 8 days during 4/13-22 |
| 2 | Bipes | T4N R25E S31 | Uncertain | Y | holes | 5/9/94 | suspicious holes; 16 traps open 6 days during 5/9-17 |
| 3 | N. Interstate | T3N R25E S20 | Present | Y | holes, tracks | 4/27/94 | suspicious holes; 9 traps open 6 days during 4/27-5/4; discontinued due to interference from cattle |
| 4 | Jim's Grid B | T2N R25E S5-8 | Present | N | sight | 4/25/94 | squirrels sighted frequently; not trapped due to constant cattle interference |
| 5 | RNA C West | T2N R25E S8 | Present | Grid | holes | 3/15/94 | squirrels observed; grid placed (4/5) and trapped 4-5 days/wk through 6/23 |
| 6 | S. RNA C West | T2N R25E S8 | Present | Y | holes | 6/3/94 | suspicious holes; 8 traps open 12 days during 6/1-6/23 |
| 7 | Arroyo | T2N R25E S8 | Present | Y | holes, tracks | 4/22/94 | suspicious holes; sight monitored in 1993 by Russell; 12 traps open 12 days during 4/22-5/13 |
| 8 | Arroyo South | T2N R25E S8 | Present | None | sight | 5/13/94 | squirrel crossed road |
| 9 | Zolaco North | T2N R25E S9 | Present | Y | holes | 6/16/94 | suspicous holes; 2-5 traps open 10 days during 6/1-17 |
| 10 | Zolaco | T2N R25E S16 | Present | Y | holes | 6/3/94 | suspicous holes; 4-8 traps open 17 days during 6/1-7/1 |

# APPENDIX D *CONT.*

| | Site Name | Location (TRS) | Squirrels Present? | Traps Used? | Sign of Presence | First Obs. Date | Notes on site, etc. |
|---|---|---|---|---|---|---|---|
| 11 | Johnson B | T2N R25E S16 | Present | Y | sight | 6/4/94 | squirrels sighted; first, 3 traps open 10 days during 3/28-4/14, then 7 traps open 17 days 6/1-30 |
| 12 | Hitchcock | T2N R25E S21 | Possible | Y | holes, tracks | 4/12/94 | tracks observed in mud, suspicious holes; 18 traps open for 13 days during 3/28-4/13 |
| 13 | Sadie's | T2N R25E S22 | Present | Y | sight | 3/20/94 | squirrels sighted and heard, trapped with 10 traps for 6 days during 4/19-26; attempted 13 traps to south for 9 days 3/28-4/8 |
| 14 | High Plains | T2N R25E S28 | Present | Y | sight | 2/16/94 | first squirrel sighting; later trapped with 13 traps for 19 days during 3/28-4/25 |
| 15 | Sheep Pasture | T2N R25E S28 | Present | Y | sight | 3/19/94 | saw squirrel on two occasions; only trapped for three days in early April before sheep pasture became active |
| 16 | E. Rodent Junction | T2N R25E S28-14 | Present | N | sight | 2/17/94 | squirrel crossed road; not trapped due to sheep interference |
| 17 | East | T2N R25E S12 | Present | Y | sight, holes | 6/28/94 | too late in season to trap; squirrels observed here by C.T. Shattuck; eventually used 12 traps for five days during 6/29-7/1 |
| 18 | SE Tub Springs | T2N R25E S11 | Present | N | sight, holes | 5/11/94 | recommended by ranchers; one squirrel and tracks observed |

## APPENDIX D *CONT.*

| | Site Name | Location (TRS) | Squirrels Present? | Traps Used? | Sign of Presence | First Obs. Date | Notes on site, etc. |
|---|---|---|---|---|---|---|---|
| 19 | Juniper Canyon (Cow Trough) | T2N R25E S15 | Present | Y | tracks, sight | 4/19/94 | 3 traps for 5 days (too much cow and sheep interference for longer trapping) but frequent sightings here |
| 20 | Johnson A | T2N R25E S9-10 | Possible | Y | tracks | 3/17/94 | tracks visible along road, squirrels sighted in vicinity in 1993 |
| 21 | Tub Springs | T2N R25E S10 | Present | N | sight, holes | 4/12/94 | too much cow and sheep interference for trapping; sighted three times |
| 22 | RNA C East | T2N R25E S3 | Present | Grid | holes, sight | 3/5/94 | holes and squirrel sighted; trapped min. 4-5 days/week with 64 traps (grid) from 3/10-6/4 |
| 23 | RNA B | T3N R25E S26 | Possible | Grid | tracks | 2/26/94 | tracks in snow along road; 64 traps (grid) opened for 14 days during 3/10-3/24 |
| 24 | Hey Road | T2N R25E S2 | Possible | N | tracks | 3/17/94 | tracks from holes along road |
| 25 | W. Juniper Canyon | T2N R25E S21 | Possible | Y | tracks | 2/11/94 | tracks in side of road, trapped here and NW 200m with 3 traps, four days during 3/29-4/4 |
| 26 | Sand Dune | T2N R25E S3 | Possible | N | tracks | 5/94 | tracks over sand dune, no squirrels sighted |
| 27 | Betts* #164 | T3N R25E S6,7 | Present | N | holes | 5/10/87 | no squirrels sighted |
| 28 | Betts #165 A | T3N R25E S17,18 | Present | N | sight | 5/10/87 | squirrels sighted |
| 29 | Betts #165 B | T3N R25E S19 | Present | N | sight | 5/10/87 | squirrels sighted |
| 30 | Betts #166 A | T3N R25E S29 | Present | N | burrows | 5/10/87 | no squirrels sighted |
| 31 | Betts #166 B | T3N R25E S32 | Present | N | burrows | 5/10/87 | no squirrels sighted |
| 32 | Betts #167 | T2N R25E S3 | Present | N | burrows | 5/10/87 | no squirrels sighted |
| 33 | Betts #168 | T2N R25E S8 | Present | N | sight | 5/10/87 | squirrels sighted |

## APPENDIX D *CONT.*

| | Site Name | Location (TRS) | Squirrels Present? | Traps Used? | Sign of Presence | First Obs. Date | Notes on site, etc. |
|---|---|---|---|---|---|---|---|
| 34 | S. Water Trailer | T2 N R25E S8? | Present | N | sight | 5/12/94 | squirrel crossed road 1 mi. south of water trailer on Interstate Rd. |

*From Betts (1990).

## APPENDIX D.  Other Wildlife Studies

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**Wildlife species mentioned in text, that presently occur, potentially occur, or have occurred in the past at NWSTF Boardman.**

| Species | Scientific Name |
|---|---|
| **Amphibians** | |
| Great Basin spadefoot toad | *Scaphiopus intermontanus* |
| **Reptiles** | |
| Common garter snake [1] | *Thamnophis sirtalis* |
| Gopher snake | *Pituophis melanoleucus* |
| Night snake [1] | *Hypsiglena torquata* |
| Northern sagebrush lizard | *Scleroporus graciosus* |
| Racer | *Coluber constrictor* |
| Rubber boa [1] | *Charina bottae* |
| Short-horned lizard | *Phrynosoma douglassi* |
| Side-blotched lizard | *Uta stansburiana* |
| Striped whipsnake [1] | *Masticophis taeniatus* |
| Western fence lizard | *Scleroporus occidentalis* |
| Western rattlesnake | *Crotalus viridis* |
| Western skink [1] | *Eumeces skiltonianus* |
| Western terrestrial garter snake [1] | *Thamnophis elegans* |
| **Birds** | |
| American crow | *Corvus brachyrhynchos* |
| American goldfinch | *Carduelis tristis* |
| American kestrel | *Falco sparverius* |
| American robin | *Turdus migratorius* |
| Bald eagle [1] | *Haliaeetus leucocephalus* |
| Barn owl | *Tyto alba* |
| Barn swallow | *Hirundo rustica* |
| Black-billed magpie | *Pica pica* |
| Black-crowned night heron | *Nycticorax nycticorax* |
| Black-throated sparrow | *Amphispiza bilineata* |
| Blue-winged teal | *Anas discors* |
| Brown-headed cowbird | *Molothrus ater* |
| Brewer's blackbird | *Euphagus cyanocephalus* |
| Brewer's sparrow | *Spizella breweri* |
| Bullock's oriole | *Icterus bullockii* |
| Burrowing owl | *Athene cunicularia* |
| California gull | *Larus californicus* |
| California quail | *Callipepla californica* |
| Caspian tern | *Sterna caspia* |
| Chipping sparrow | *Spizella passerina* |
| Chukar | *Alectoris chukar* |
| Cliff swallow | *Hirundo pyrrhonota* |
| Common nighthawk | *Chordeiles minor* |
| Common poorwill | *Phalaenoptilus nuttallii* |
| Common raven | *Corvus corax* |
| Cooper's hawk | *Accipiter cooperii* |
| Dark-eyed junco | *Junco hyemalis* |
| Eastern kingbird | *Tyrannus tyrannus* |
| European starling | *Sturnus vulgaris* |
| Ferruginous hawk | *Buteo regalis* |
| Fox sparrow | *Passerella iliaca* |
| Golden-crowned kinglet | *Regulus satrapa* |
| Golden eagle | *Aquila chrysaetos* |

**Wildlife species mentioned in text, that presently occur, potentially occur, or have occurred in the past at NWSTF Boardman.**

| Species | Scientific Name |
|---|---|
| Grasshopper sparrow | *Ammodramus savannarum* |
| Gray flycatcher | *Empidonax wrightii* |
| Gray partridge | *Perdix perdix* |
| Horned lark | *Eremophila alpestris* |
| House sparrow | *Passer domesticus* |
| Killdeer | *Charadrius vociferus* |
| Lark sparrow | *Chondestes grammacus* |
| Lewis's woodpecker | *Melanerpes lewis* |
| Loggerhead shrike | *Lanius ludovicianus* |
| Long-billed curlew | *Numenius americanus* |
| Long-eared owl | *Asio otus* |
| Macgillivray's warbler | *Oporornis tolmiei* |
| Mallard | *Anas platyrhynchos* |
| Merlin | *Falco columbarius* |
| Mountain bluebird | *Sialia currucoides* |
| Mourning dove | *Zenaida macroura* |
| Northern flicker | *Colaptes auratus* |
| Northern harrier | *Circus cyaneus* |
| Northern pintail | *Anas acuta* |
| Northern rough-legged hawk | *Buteo lagopus* |
| Northern rough-winged swallow | *Stelgidopteryx serripennis* |
| Orange-crowned warbler | *Vermivora celata* |
| Peregrine falcon [1] | *Falco peregrinus* |
| Prairie falcon | *Falco mexicanus* |
| Red-tailed hawk | *Buteo jamaicensis* |
| Red-winged blackbird | *Agelaius phoeniceus* |
| Ring-billed gull | *Larus delawarensis* |
| Ring-necked pheasant | *Phasianus colchicus* |
| Rock wren | *Salpinctes obsoletus* |
| Sage grouse [2] | *Centrocercus urophasianus* |
| Sage sparrow | *Amphispiza belli* |
| Sage thrasher | *Oreoscoptes montanus* |
| Savannah sparrow | *Passerculus sandwichensis* |
| Say's phoebe | *Sayornis saya* |
| Sharp-shinned hawk | *Accipiter striatus* |
| Sharp-tailed grouse [2] | *Tympanuchus phasianellus columbianus* |
| Short-eared owl | *Asio flammeus* |
| Snowy owl | *Nyctea scandiaca* |
| Spotted sandpiper | *Actitis macularia* |
| Spotted towhee | *Pipilo maculatus* |
| Swainson's hawk | *Buteo swainsoni* |
| Townsend's solitaire | *Myadestes townsendi* |
| Turkey vulture | *Cathartes aura* |
| Upland sandpiper | *Bartramia longicauda* |
| Vesper sparrow | *Pooecetes gramineus* |
| Violet-green swallow | *Tachycineta thalassina* |
| Western kingbird | *Tyrannus verticalis* |
| Western meadowlark | *Sturnella neglecta* |
| Western sandpiper | *Calidris mauri* |
| Western tanager | *Piranga rubra* |

**Wildlife species mentioned in text, that presently occur, potentially occur, or have occurred in the past at NWSTF Boardman.**

| Species | Scientific Name |
|---|---|
| White-crowned sparrow | *Zonotrichia leucophrys* |
| Wilson's warbler | *Wilsonia pusilla* |
| Yellow-headed blackbird | *Xanthocephalus xanthocephalus* |
| **Mammals** | |
| Badger | *Taxidea taxus* |
| Belding's ground squirrel [1] | *Urocitellus [Spermophilus] beldingi* |
| Big brown bat [1] | *Eptesicus fuscus* |
| Bison [2] | *Bison bison* |
| Black-tailed jackrabbit | *Lepus californicus* |
| Bobcat [1] | *Lynx rufus* |
| Bushy-tailed wood rat [1] | *Neotoma cinerea* |
| Columbian ground squirrel [1] | *Urocitellus [Spermophilus] columbianus* |
| Coyote | *Canis latrans* |
| Deer mouse | *Peromyscus maniculatus* |
| Elk | *Cervus elaphus* |
| Golden-mantled ground squirrel [1] | *Callospermophilus [Spermophilus] lateralis* |
| Great Basin pocket mouse | *Perognathus parvus* |
| House mouse | *Mus musculus* |
| Little brown myotis [1] | *Myotis lucifugus* |
| Long-tailed weasel | *Mustela frenata* |
| Merriam's shrew [1] | *Sorex merriami* |
| Montane vole | *Microtus montanus* |
| Mountain lion [1] | *Felis concolor* |
| Mule deer | *Odocoileus hemionus* |
| Northern grasshopper mouse | *Onychomys leucogaster* |
| Northern pocket gopher | *Thomomys talpoides* |
| Norway rat [1] | *Rattus norvegicus* |
| Nuttall's cottontail | *Sylvilagus nuttallii* |
| Ord's kangaroo rat | *Dipodomys ordii* |
| Little pocket mouse [1] | *Perognathus longimembris* |
| Porcupine | *Erethizon dorsatum* |
| Pronghorn [2] | *Antilocarpa americana* |
| Pygmy rabbit [1] | *Brachylagus idahoensis* |
| Raccoon [1] | *Procyon lotor* |
| Red fox | *Vulpes vulpes* |
| Sagebrush vole | *Lemmiscus curtatus* |
| Silver-haired bat [1] | *Lasionycteris noctivagrans* |
| Townsend's ground squirrel [1] | *Urocitellus [Spermophilus] townsendii* |
| Vagrant shrew | *Sorex vagrans* |
| Washington ground squirrel | *Urocitellus [Spermophilus] washingtoni* |
| Western harvest mouse | *Reithrodontomys megalotis* |
| White-tailed jackrabbit | *Lepus townsendii* |
| Wolf [2] | *Canis lupus* |

[1] Species that hypothetically could occur at NWSTF Boardman, but it unlikely in most cases.
[2] Species with historical ranges overlapping NWSTF Boardman.

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*Note*

# Behavioral Accommodation of Nesting Hawks to Wind Turbines

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**ABSTRACT** The most direct effects of wind energy development on birds are rotor blade strikes and collisions with wind turbines. Probability of a blade strike is affected by the rates at which a bird visits the rotor swept zone (RSZ), and mitigated by the behaviors it uses to avoid being struck. Between 2011 and 2013, we studied the occurrence and nature of avoidance responses of 3 nesting ferruginous hawks (*Buteo regalis*), 5 Swainson's hawks (*B. swainsoni*), and 2 red-tailed hawks (*B. jamaicensis*) to turbines built within their territories. Two of 10 breeding males we tracked with satellite telemetry were turbine-collision fatalities, one during the study and the other in the following year. Collectively, nesting hawks displayed no macro-avoidance of turbine projects and flew adjacent to or within RSZs at high rates ($\bar{x} = 0.8$ visits/hr, 1.3 min/visit; $n = 387$ visits during 434 hr of observation) synchronized with morning and afternoon peaks in foraging activity. Passes through rotors accounted for 9.8% of responses. The turbine that hawks approached most closely from collective encounters on each territory accounted for an average of 29% of all visits to RSZs and visitation was greater than expected at turbines <0.8 km from nests ($P < 0.001$). As rotor speed increased, the frequency that hawks in RSZs flew between turbine rows increased relative to other avoidance behaviors and hawks that were potentially distracted (i.e., hunting or aggressive chasing) increased avoidance flights over and between turbines. The ability of hawks to employ evasive behaviors mitigated blade collision but allowed for close, hourly interaction with turbines that increased risk of collision. Where nesting populations of hawks are at risk, particularly ferruginous hawks, pre-construction siting of wind turbines needs to account for nest locations and expected high rates of hawk visitation to turbines <800 m from nests. On existing projects collision risk can be reduced through operational shutdown of turbines in this zone during 2 daily peaks in hawk foraging in the vicinity where hawks nest, but a greater effectiveness can be achieved by shutdown of specific turbines associated with highest regular use. 

**KEY WORDS** avoidance behavior, *Buteo jamaicensis*, *Buteo regalis*, *Buteo swainsoni*, collision fatality, wind power development, wind turbine.

Wind energy development has the potential to affect raptors through collision injury or fatality, displacement from habitat, and increased energetic expenditure from avoidance (Fielding et al. 2006, Johnston et al. 2014). Displacement occurs when birds avoid wind power development at a large scale, such as shifting locations to avoid entire projects (May 2015). This type of macro-avoidance may be measured by comparing changes in raptor abundance before and after project development (Walker et al. 2005, Martínez et al. 2010, Garvin et al. 2011, Johnston et al. 2014). Meso-avoidance occurs when raptors avoid individual wind turbines or rows of turbines through anticipatory evasion or impulsive evasion (May 2015), and is measured by changes in behavior and flight response (Chamberlain et al. 2006, Smallwood et al. 2009, Katzner et al. 2012). Micro-avoidance occurs when birds avoid an imminent strike from a rotor blade or a collision with a turbine through reflexive, escape behavior (Barrios and Rodríguez 2004, May 2015). Avoidance responses of birds to turbines adjacent to and within the rotor swept zone (RSZ), particularly flights over and through the rotors, are important to our understanding of collision risk (Smales 2017).

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When wind turbines are constructed within territories defended by nesting raptors, their nest-centric behavior (Watson et al. 2014*a*, *b*; Millsap et al. 2015) may put them in proximity to turbines, resulting in increased frequency of encounters and risk of mortality (Balotari-Chiebao et al. 2015, Hötker et al. 2017). Whether hawks abandon territories because of wind development (i.e., macro-avoidance), and how they respond to turbines and rotors (e.g., meso- and micro-avoidance) are of critical importance because they affect territory occupancy, adult survival, and therefore nesting outcome. Mortality and survival rates of adult raptors exert the strongest influence on direction and rate of population growth relative to other population parameters (Hunt 1998). Thus, measures to reduce loss of nesting adult raptors from turbine fatalities are especially important in declining or unstable populations of listed species (Carrete et al. 2009).

Best management practices for siting wind turbine projects requires site- and species-specific knowledge of raptor avoidance mechanisms (May 2015). Cataloguing responses of nesting raptors to turbines with respect to the nest location, time of day or season, and nesting outcome may best be accomplished by focal monitoring of individuals (Gaibani and Csermely 2007) aided by markers or telemetry (Nygård et al. 2011, Hötker et al. 2017). Such monitoring can elucidate patterns of activities and modes of flight that are relevant to collision risk such as territorial displays and aggression, and predatory behavior (Gaibani and Csermely 2007, Smallwood et al. 2009, Dahl et al. 2013).

The ferruginous hawk (*Buteo regalis*) is listed as threatened in Washington (Washington Department of Fish and Wildlife [WDFW] 1996) and critically sensitive in the Columbia Plateau in Oregon (Oregon Department of Fish and Wildlife [ODFW] 2016). The nesting population of this species, along with that of Swainson's (*B. swainsoni*) and red-tailed hawks (*B. jamaicensis*), is distributed in the range of major wind energy projects in the Columbia Basin in Washington and Oregon (Conley et al. 2010). We evaluated encounters of telemetered, nesting buteos (i.e., hawks) with wind turbines. Our purpose was to conduct an observational study to better understand whether and how hawks behaviorally accommodate turbines. Specific objectives were to 1) document and characterize fatal interactions of breeding hawks with turbines; 2) summarize hawk visitation rates to the RSZ by number and duration and test for relationships to distance from nest and time of day; 3) analyze the interactive relationships between turbine speed, hawk behavior, and their flight mode and compare behaviors and flight modes to those of untagged hawks in the observation areas; and 4) evaluate avoidance mechanisms used by hawks in RSZs on the basis of whether they were likely to be distracted or undistracted based on their behavior.

## STUDY AREA

We studied hawk behavior between 2011 and 2013 in northern Oregon and southern Washington (Fig. 1). The area has established or developing wind farms and an assemblage of nesting hawks. This portion of the Columbia Plateau is characterized by semi-arid climate, with cool and wet winters, and dry, hot summers. Little habitat in the area remains undisturbed with large sections of dry-land and irrigated agriculture interspersed with native rangeland that is used primarily for grazing cattle and sheep. Sagebrush (*Artemisia* spp.) mixed with annual grasses is found on hillsides that are too steep or rocky to be farmed. Cheatgrass (*Bromus tectorum*) invasion is prevalent in highly disturbed areas or where range fires have been intense. Topography is variable throughout this area with the developed cropland giving way to steep hillsides associated with the Columbia

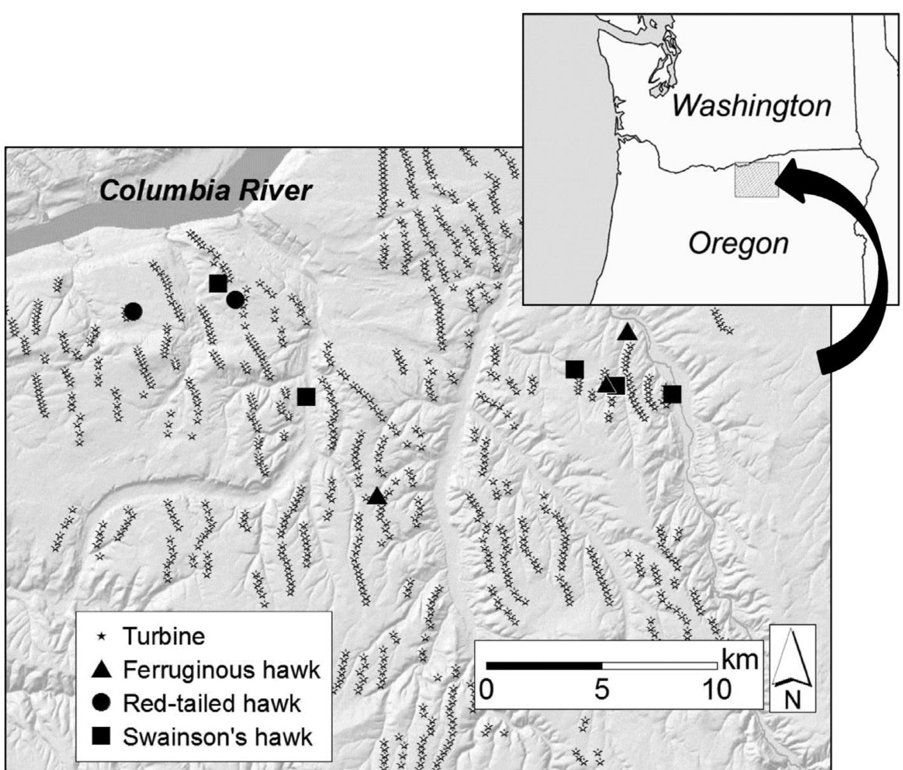


**Figure 1.** Study area and nest locations of adult ferruginous, red-tailed, and Swainson's hawks captured and monitored to assess encounters with wind turbines, northern Oregon and southern Washington, USA, 2011–2013.

River and its large tributaries. Elevation ranges from 100 m to 300 m.

We identified nest locations of hawks from existing, unpublished databases (S. P. Cherry, ODFW; K. Kronner, Northwest Wildlife Consultants; P. S. Kolar, Boise State University). Nesting habitats of ferruginous hawks included significant areas of shrubsteppe or native grasses often on talus slopes and hills that were too steep to cultivate. Others were found on relatively level ground between canyons where hawks often nested in western juniper (*Juniperus occidentalis*). Swainson's hawks most often nested in exotic or native homestead trees adjacent to agricultural land. Red-tailed hawks nested in a wide gradient of native and agricultural habitats and built nests in trees and cliffs. Northern pocket gophers (*Thomomys talpoides*), snakes (gopher snake [*Pituofis catenifer*] and racer [*Coluber constrictor*]), and grasshoppers (notable apote [*Apote notablis*] and *Melanoplus* spp.) are some of the prey items consumed by nesting hawks in the study area (J. W. Watson, Washington Department of Fish and Wildlife, unpublished data).

Wind turbine construction in the study area began in mid-2000s and our study overlapped about 350 turbines (Fig. 1) involving 6 different projects (Pebble Springs, Willow Creek, Wheatfield, Rattlesnake Road, Leaning Juniper, and Shepherd's Flat). Turbines were horizontal axis models built by General Electric (model SLE, Fairfield, CT, USA) and Suzlon (model S88, Magarpatta City, India), with rotor diameters ranging from 77 m to 88 m, and hub heights between 80 m and 100 m. Turbines were spaced apart at an average of $220 \pm 4$ m (SE) and positioned either in rows on flat ground or clustered on the highest ground atop ridgelines where topography was variable (Fig. 1). Infrastructure necessary to operate wind farms included power lines, substations, access roads, and turbine pads.

## METHODS

### Data Collection

From 2011 to 2013 we studied hawks nesting on 10 territories (Fig. 1). We planned exclusive study of ferruginous hawks but because of limited numbers of breeding pairs of this species within the project area, we also sampled Swainson's hawks and red-tailed hawks. Thus, we pooled data for all species such that our results describe co-generic behavior of nesting hawks.

Nests on all territories were located <0.8 km from the nearest turbine. Except for 2 nests, we telemetered adult males with satellite transmitters as part of concurrent research on hawk space use (J. W. Watson, unpublished data), but for this study we used telemetry only to facilitate identification of territorial individuals and recovery of collision fatalities. Transmitters were backpack-mounted, 22-g or 30-g platform transmitter terminals (PTTs) with global positioning system capability (Microwave Telemetry, Columbia, MD, USA). We captured hawks with live great horned owl (*Bubo virginianus*) lures and dho gaza nets (Bloom et al. 1992). We identified males from morphometric measurements (Harmata 1981, Sarasola and Negro 2004, Donohue and Dufty 2006).

During the breeding season, beginning the last week of May, through the third week of July, an observer visually tracked the radio-tagged hawk on a selected territory as it moved from the nest out to turbines. The observer used a vehicle to move to the best viewpoint that allowed for detailed observation of behaviors using a spotting scope. We conducted training sessions with observers to provide consistency in interpretation of hawk behavior and flight modes, and to improve estimation of distances when they flew in proximity to turbines. We initiated focal sampling (Lehner 1979) between 0600 and 1200 and conducted sampling for 2–4 hours (seasonal average of 42 hours observed/nest). To balance observations among territories between morning and afternoon periods, the observer monitored a different territory from 1200 to 1800. We monitored movements of hawks continually with respect to surrounding turbines and the observer commenced documentation of hawk behavior when 1 or both of the paired birds flew near a turbine RSZ. The RSZ was the 3-dimensional sphere encompassing the 75–100-m-wide rotor plane, depending on turbine size, plus a 20-m buffer beyond the turbine tips to include potential effects of wind disturbance (wake and turbulence) on hawk flight (Manville 2016). We used turbine blade length as the standard for ocular estimates of hawk location with respect to the RSZ. We did not quantify precision of ocular locations of hawks with respect to the RSZ. However, hawks flying through the rotor-swept area were relatively easy to locate in relation to the rotor tip and the turbine nacelle, and any imprecision that resulted in a mis-classification of hawk location was more likely for birds flying near the outer extent of the RSZ.

During each observation period when either adult hawk entered the RSZ, we recorded their behaviors, flight modes, reactions, and duration in RSZ in seconds. We categorized hawk behavior (hunt-pursue prey, gain lift, in transit, chase other raptor, mixed), flight mode (soar, kite, flap-glide, mixed), and reaction (through blades, reverse direction, over turbine, between turbines, parallel to turbine row, under rotor, mixed), and classified rotor speed based on revolutions per minute (fast cut out = 15–20, moderate = 6–14, slow cut in = ≤5, none). Flight behavior defined as in transit was directional, powered flight when hawks were not involved in pursuit of prey or agonistic behavior. The avoidance reaction parallel to row was when hawks moved around the face of the turbine and between turbine rows, and between turbines was movement around the side of a turbine. The mixed category represented multiple behaviors, flight modes, or reactions that could not be assigned to specific categories. We referenced flight postures described in Dunne et al. (1988) and Liguori (2011) to classify modes of flight. We mapped hawk flight patterns in relation to turbines and turbine rows during each event and referenced specific turbines identified by codes stamped at the base of the turbine towers.

During each observation period we also documented behavior, flight mode, and reaction of untagged hawks in RSZs observed incidentally during focal observations. Behaviors of untagged hawks in the generic hawk population (i.e., including all ages and any breeding status) were potentially different from behaviors of territorial hawks. The generic hawk population is often sampled for wind-power impact assessment analyses (Hoover and Morrison 2005, Katzner et al. 2016). For comparisons of tagged and untagged hawks we assumed that there was no effect of telemetry backpacks on flight of territorial hawks (Barron et al. 2010). For capture and telemetry of hawks, we adhered to animal care and use guidelines of the Washington Department of Fish and Wildlife and protocols designated within the federal capture and banding permit.

### Analysis

We pooled visitation data for untagged nesting females tracked from nests to turbines (<10% of observations) with marked males for analyses. We used a chi-square goodness-of-fit test to determine whether the total number of hawk visits to RSZs differed at increasing distances from nests (<0.4 km, 0.4–0.8 km, and >0.8 km). To evaluate hourly visitation patterns in RSZs, we used a chi-square goodness-of-fit to compare visitation rates (number/hour) with expected visitation rates based on observation time during each hourly interval. We also used chi-square contingency tests to evaluate differences in total numbers of behaviors and flight modes documented for tagged, nesting adults and the generic population of untagged hawks.

To parametrize hawk avoidance responses to turbines within the risk zone, we conducted probabilistic analyses of flight mode and reaction as functions of behavior and turbine speed. We performed initial model selection by fitting log-linear models of all pairwise interactions of flight mode, behavior, and turbine speed, and by graphical exploration of mosaic plots. We used JAGS 3.4 (Plummer 2003) to estimate the probabilities of kiting or soaring relative to flap-glide flight modes and all reaction types relative to mixed reactions. We initiated Markov chain Monte Carlo (MCMC) chains to fit the models at different starting values and, after discarding initial samples as burn in and thinning, we allowed chains to run such that we retained 1,200 and 1,500 independent draws from the posterior for the flight mode and reaction model, respectively. We used multinomial distributions for response variables with rates modeled as a linear function using a logit link. We placed diffused priors on all free parameters in both models. We ran interaction models of all pairwise comparisons as well as the additive full-independence and saturated models, and identified the best model based on the lowest residual deviance and scores of the Akaike's and Bayesian Information Criterion (AIC and BIC). For modeling reaction, we reduced behaviors to a 2-level variable, distracted (hunt-pursue prey and chase raptor) and undistracted (gain lift and in transit), to reflect potential differences in vulnerability of hawks to turbine collision. When raptors are capturing prey or chasing intruders their focal attention may intensify (O'Rourke et al. 2010*a*, *b*; Martin 2011) and these 2 behaviors have been suggested as a proximate cause for raptor collisions (Hunt 2002, Barrios and Rodríguez 2004, Smallwood et al. 2009, Dahl et al. 2013). We conducted all data exploration and analysis of model output in R-3.1.0 (R Core Team 2017).

## RESULTS

We conducted focal observations of hawks nesting near wind turbines on 3 territories of ferruginous hawks, 5 territories of Swainson's hawk, and 2 territories of red-tailed hawks (Fig. 1). One adult male Swainson's hawk was struck and killed by a turbine 0.5 km from the nest following an observation session, and the female abandoned the eggs during incubation. Failure of 3 other nests in the year they were observed (1 each ferruginous, Swainson's, and red-tailed hawk) did not result from turbine collision fatality of adult hawks. On 1 ferruginous hawk territory, the year after our study the adult male was struck and killed by a turbine 325 m from the nest.

During 434 hours in 120 sessions, we observed nesting hawks flying in RSZs (i.e., visits) 387 times ($\bar{x} = 0.8 \pm 0.4$ [SD] visits/hour, range = 0.2–1.4). Hawks spent 511.7 minutes in RSZs ($\bar{x} = 1.3 \pm 1.1$ minute/visit, range = 0.01–3.1). Number of hawk visits to RSZs was different than expected based on distances of turbines to nests ($\chi^2_2 = 143.57$, $P < 0.001$). Visitation was greater than expected at turbines <0.8 km from nests, accounting for 80% of all hawk visits to RSZs, and less than expected at turbines >0.8 km from nests (Fig. 2). Hawks visited from 1 to 20 different turbines/territory that were located within 1 to 3 turbine rows. The turbine that hawks approached most closely on each territory accounted for an average of $29 \pm 22$ [SD] % of all visits to RSZs.

Hawks flew into turbine RSZs at different frequencies throughout the day ($\chi^2_{15} = 29.03$, $P = 0.016$). Based on total observation time for each hourly period, there were more visits between 0900 and 1100 (standardized residual = 3.5), and fewer than expected from 0700 through 0800 (standardized residual = −2.2), and from 1500 to 1700 (standardized residual = −1.4).

Nesting hawks visiting the RSZs most often engaged in mixed behaviors, followed by in transit, hunt-capture prey,

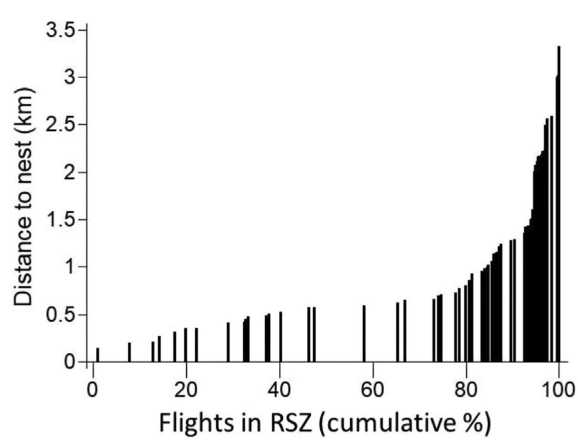


**Figure 2.** Cumulative percentage of flights of adult hawks in wind turbine rotor swept zones (RSZ; $n = 387$) relative to the distance between wind turbines and their nests. We collected data in the upper Columbia Basin, USA, 2011–2013.

gain lift, and chase (Table 1). Behaviors compared by total number ranked similarly to behaviors based on total duration, except hawks spent a higher percentage of time hunting or capturing prey near turbines and less time in transit. Nesting hawks used mixed modes of flight most often in RSZs, but flap-glide flight was individually the most common flight mode by frequency and time (Table 1). Reaction of nesting hawks to turbines when they flew in RSZs included passes through rotors, which accounted for 9.8% of all avoidance responses, and flights near the tips of rotors at the peripheries of RSZs (parallel to row, between turbines, over turbine), which accounted for 77.2% of reactions (Table 1).

We recorded 125 observations of untagged hawks in RSZs (Table 1). Behavior types differed between nesting hawks and untagged hawks based on the number of flights recorded within RSZs ($\chi^2_4 = 19.65$, $P < 0.001$), with fewer untagged hawks in transit (standardized residual $= -3.1$) and more hunting or capturing prey (standardized residual $= 1.9$) relative to other behaviors. Flight mode also differed ($\chi^2_3 = 24.13$, $P < 0.001$) with fewer untagged hawks in flap-glide flight (standardized residual $= -3.3$) relative to other modes of flight. Avoidance response frequencies were different for nesting and untagged hawks ($\chi^2_5 = 39.62$, $P < 0.001$), with more untagged hawks displaying mixed responses (standardized residual $= 4.39$), and fewer flying through turbine blades (standardized residual $= -2.7$).

For nesting hawks, the best 3-way interaction model of flight mode, behavior, and turbine speed identified flight mode as a function of behavior and turbine speed (model 7, Table 2). Based on model ranking ($\Delta\text{AIC} = 9.5$ for the second-best model), there was no evidence to suggest hawk flight behavior further correlated with turbine speed except as conditioned on flight mode (i.e., interaction). When we fit model 7 using flap-glide flight mode as the reference level, hawks showed intuitive use of flight modes among behaviors (Fig. 3). For example, hawks increasingly soared relative to flapping and gliding when they gained lift and hunted, but probability of hawks using soaring flight was comparatively low when they were in transit or chasing other raptors. Hawks were shown to kite more frequently when they hunted prey compared to when they were soaring or flapping and gliding, but there was a comparatively low probability of hawks kiting when chasing raptors or flying in transit. Among flight modes, turbine speed only affected the odds of hawks kiting, which increased 11% at moderate to fast turbine speeds ($P = 0.020$).

Hawks responded to turbines ($n = 387$) with similar tendencies whether they were classified as distracted or undistracted; the most common response was flying parallel to turbine rows, followed by flights between and over individual turbines (Fig. 4). However, there were subtle differences in avoidance responses at different turbine rotor speeds for hawks that were distracted versus undistracted. When hawks were undistracted, they reduced flights through turbine blades as rotor speed increased and they increased flights parallel to turbine rows, relative to when turbines were not moving (Fig. 4). When hawks were distracted and encountered turbines, they reduced flights between and over turbines as rotor speed increased, increasingly reversed direction when encountering moving turbine blades (i.e., except for still blades), and increased flights parallel to turbine rows.

**Table 1.** Behaviors, flight modes, and reactions of hawks in wind turbine rotor swept zones ($\leq$20 m from turbine blades) in the upper Columbia Basin, USA. We radio-tagged nesting, adult hawks ($n = 10$) and tracked them focally during 434 hours of observation, and recorded observations of unmarked hawks of mixed age and breeding status incidentally.

| | | Nesting adult hawks | | | | Hawks of mixed age and status | |
|---|---|---|---|---|---|---|---|
| **Variable** | **Category** | **Number** | **%** | **Duration (min)** | **%** | **Number** | **%** |
| Behavior | | | | | | | |
| | In transit | 113 | 29.2 | 63.0 | 12.3 | 14 | 11.2 |
| | Hunt-capture prey | 94 | 24.3 | 121.1 | 23.7 | 45 | 36.0 |
| | Gain lift | 36 | 9.3 | 27.7 | 5.4 | 11 | 8.8 |
| | Chase raptor | 8 | 2.1 | 10.4 | 2.0 | 1 | 0.8 |
| | Mixed behaviors[a] | 136 | 35.1 | 289.6 | 56.6 | 54 | 43.2 |
| Flight mode | | | | | | | |
| | Flap-glide | 138 | 35.7 | 119.6 | 23.4 | 18 | 14.4 |
| | Soar | 81 | 20.9 | 52.2 | 10.2 | 30 | 24.0 |
| | Kite | 23 | 5.9 | 43.2 | 8.4 | 17 | 13.6 |
| | Mixed flight[a] | 145 | 37.5 | 296.7 | 58.0 | 60 | 48.0 |
| Reaction | | | | | | | |
| | Parallel to row | 176 | 45.5 | 208.7 | 40.8 | 54 | 43.2 |
| | Between turbines[b] | 100 | 25.8 | 138.6 | 27.1 | 19 | 15.2 |
| | Through blades | 38 | 9.8 | 48.8 | 9.5 | 1 | 0.8 |
| | Over turbine[c] | 23 | 5.9 | 14.9 | 2.9 | 7 | 5.6 |
| | Reverse direction | 16 | 4.1 | 17.9 | 3.5 | 10 | 8.0 |
| | Mixed reaction[a] | 34 | 8.8 | 82.9 | 16.2 | 34 | 27.2 |

[a] Mixed category includes >1 behavior, flight mode, or reaction.
[b] Includes flights around ends of turbine row.
[c] At tips of rotor above the nacelle.

**Table 2.** Relationships between mode of hawk flight (F), hawk behavior (B), and turbine speed (TS) fit with log-linear interaction models of all pairwise comparisons as well as the additive full-independence model (model 1) and saturated model (9). We identified model 7 as the best model based on the lowest residual deviance and scores of the Akaike and Bayesian Information Criterion (AIC and BIC). Hawks were studied in the upper Columbia Basin, USA, 2011–2013.

| Model | Residual df | Residual deviance | *P*-value[a] | AIC | BIC |
|---|---|---|---|---|---|
| (1) F + TS + B | 39 | 158.75 | <0.001 | 328.92 | 345.76 |
| (2) F + TS × B | 30 | 146.47 | <0.001 | 334.64 | 368.32 |
| (3) F × B + TS | 33 | 108.95 | <0.001 | 291.12 | 319.19 |
| (4) F × TS + B | 33 | 79.61 | <0.001 | 261.78 | 289.85 |
| (5) B × (F + TS) | 24 | 96.67 | <0.001 | 296.84 | 341.75 |
| (6) TS × (F + B) | 24 | 67.34 | <0.001 | 267.51 | 312.42 |
| (7) F × (B + TS) | 27 | 29.82 | 0.32 | 223.99 | 263.28 |
| (8) F × (B + TS) + B × TS | 18 | 21.30 | 0.26 | 233.47 | 289.61 |
| (9) F × TS × B | | | | 248.17 | 377.99 |

[a] Likelihood ratio test of model to null model (9).

# DISCUSSION

Some nesting hawks accommodated turbines built within their territories through avoidance behaviors when they flew near them daily. We documented adult collision mortality at 2 of 10 territories but based on the high frequency and time spent in the RSZ fatalities would have been higher had hawks not engaged in active avoidance of turbines and rotor blades. Because we conducted our study on hawk home ranges with existing turbines, these behaviors may represent a subset of more tolerant hawks. Less tolerant individuals may be permanently displaced (i.e., display macro-avoidance) after turbine construction (Garvin et al. 2011). Long-term monitoring of territory occupancy by hawks on our study area is needed to assess the degree that nesting hawks failed to re-occupy their nesting territories compared to pre-construction occupancy, and whether new, replacement adults are deterred by turbines. No nesting hawks that we monitored demonstrated macro-avoidance within the breeding season, such as foraging exclusively on areas outside of wind developments. Thus, there was no evidence to suggest turbine-related displacement of adult hawks contributed to reduced reproduction of hawks that was previously documented on our study area (Kolar and Bechard 2016).

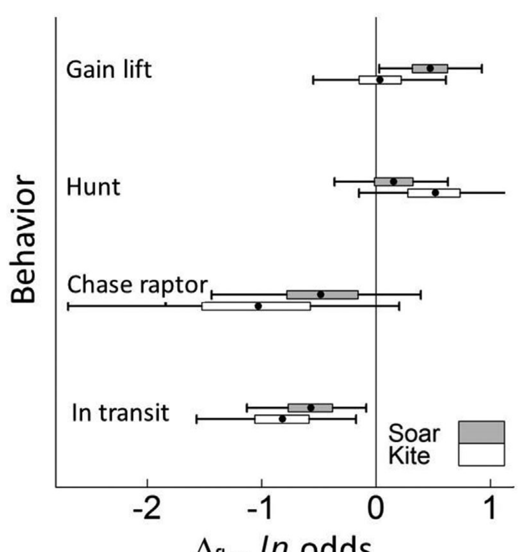


**Figure 3.** Estimated differences in natural log odds of soaring and kiting by adult hawks in the upper Columbia Basin, USA, 2011–2013 relative to flap-glide flight by behavior. Dots represent the median value of 1,200 independent Markov chain Monte Carlo draws from the posterior distribution. Bars range between the first and third quartiles and whiskers represent the 95% credible interval.

High rates of visitation within turbine RSZs (nearly hourly, and for >1 minute duration on average) was synchronized with morning and afternoon peaks when hawks naturally increase foraging activity (Smith and Murphy 1973, Wakeley 1974). Greater turbine interaction of hawks with turbines within 800 m from nests was not unexpected because of the area of hawk use is usually centered on the nest. Based on concurrent research, disproportionate activity near specific turbines within that zone was likely because of micro-site conditions that hawks favored for prey acquisition and flight (J. W. Watson, unpublished data), such has been illustrated for red-tailed hawks with regard to terrain features (Smallwood et al. 2017). Daily flight of hawks near some turbines was not dissimilar from what we might expect near other elevated structures on the home range (e.g., perch trees, transmission towers) but of course differed because of their unique lethality. Ironically, the ability of some hawks to behaviorally accommodate turbines, through their use of evasive or reflexive escape maneuvers as they fly through rotors or at the tips of blades, is what places them at increased risk of injury or fatal collision. At least 2 previous studies also documented frequent fine-scale interactions of hawks with turbines and corroborate their lack of broad-scale avoidance. Smallwood et al. (2009) reported that among 15 species of birds, ferruginous hawks exhibited the highest intensity of activity ≤50 m from turbines, with red-tailed hawks ranked third. Garvin et al. (2011) also documented close flights of red-tailed hawks to turbines (i.e., <100 m).

Flights through moving rotors and kiting around the turbine likely presented the highest collision risk to hawks, and were affected by turbine speed (and thus windspeed). Flights through rotors constituted a high percentage (10%) of all avoidance flights. They occurred at higher blade speeds when hawks were in behaviors we identified as distracting (hunting and chasing), as opposed to flights through slower rotors when they were not distracted. We observed a few

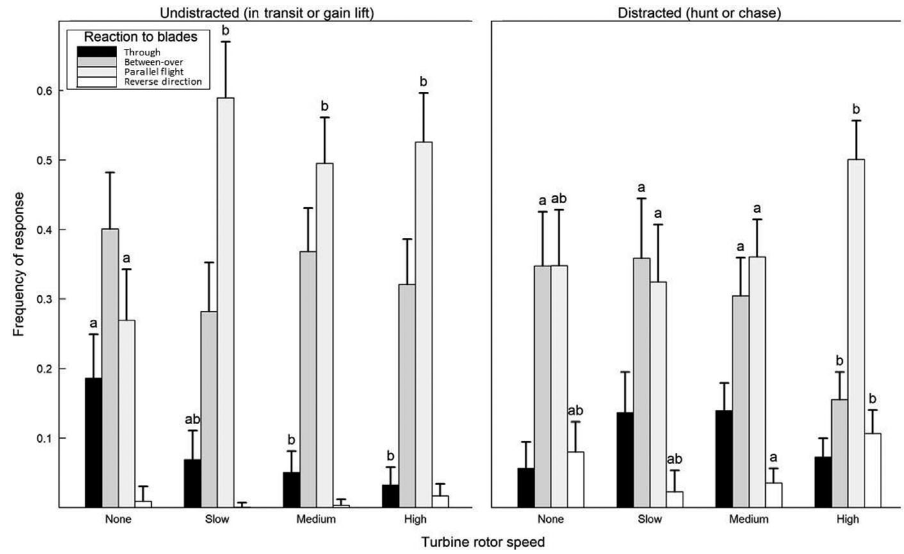


**Figure 4.** Proportion of hawk reactions that can be considered as increasing degree of avoidance (flying directly through the rotor swept zone [RSZ], between 2 zones or over an RSZ, flying in parallel to the turbine row or RSZ and reversing direction upon encounter with the zone) at increasing turbine speeds and when undistracted (left panel) or distracted (right panel) defined by activity in the upper Columbia Basin, USA, 2011–2013. Estimates and standard deviations are from 1,200 independent Markov chain Monte Carlo draws from the posterior distribution. Bars that do not share a letter designate a smaller than 5% overlap between respective posterior distributions, and unlabeled bars share similar distributions. Proportion of mixed response are not shown; therefore reactions do not sum to 1.

instances where profiled hawks abruptly tipped in apparent response to imminent blade strike in what were likely reflexive, escape responses (May 2015). However, because of interpretive uncertainty we did not attempt to classify escape behaviors separately from small-scale anticipatory or impulsive evasive maneuvers for flights through blades (May 2015). The predominance of kiting flight as a hunting behavior at the blade tips, particularly with increased odds at increased turbine speed, identified this activity as particularly dangerous, also noted for red-tailed hawks by Hoover and Morrison (2005). Kiting hawks tended to drift or reposition several meters so when they hunted up-wind of turbines it put them in their rearward blind spot (O'Rourke et al. 2010*a*, *b*). Kiting hawks are probably vulnerable in the forward direction as well because birds probably employ their wide lateral vision for detection of conspecifics and foraging opportunities, which may be more important than looking ahead in their narrow binocular field in open airspace (Martin 2011).

Less risk was associated with avoidance responses where hawks reversed direction or soared in the RSZ. We interpret the increased tendency of hawks to reverse direction and engage in mixed flights when distracted as evidence for impulsive evasion as compared to anticipatory evasion (May 2015) when hawks flew parallel to, between, or over turbines along familiar paths (Hull and Muir 2013). Birds have restrictions on reflexive adjustment of flight speed relative to their rate of gain of visual information so they may use prediction during use of lateral vision during flight (Martin 2011). It is unclear whether the sound of the blade sweep played a role in hawk avoidance responses within the RSZ; although within the range of avian hearing, higher wind speeds may increasingly mask noise generated by turbine blades (Dooling 2002). Even though soaring to gain lift was also a common activity, it was not as risky as kiting flight because it did not increase with windspeed and was often initiated in windless conditions. Also, hawks infrequently engaged in hunting or aggressive chases from soaring flight. This was in contrast to griffon vultures (*Gyps fulvus*) where soaring flight was a very risky flight mode on low wind days when vultures were brought closer to turbine blades to gain lift (Barrios and Rodríguez 2004). Nesting hawks in the RSZ infrequently chased other raptors and thus potential risk due to territory defense was low. Wind development near raptor populations that have high social interaction among mixed aged classes, such as eagles (*Haliaeetus* spp.), may result in an associated higher risk of turbine collision (Dahl et al. 2013). Red-tailed hawks were the most abundant adult and immature hawks observed on our study area (J. W. Watson, personal observation).

Our comparison between nesting adults and mixed class individuals found significant differences in flight modes, behavior, and avoidance responses, suggesting behavior of nesting hawks in the RSZ should not be inferred from a population of mixed ages and breeding status. We do not believe radio-tags on nesting hawks confounded behavioral comparisons. We saw no evidence of impaired movement of radio-tagged adults, nor increased aggression toward them by other birds, as has been suggested as an effect on radio-tagged raptors (Stahlecker et al. 2015). Barron et al. (2010) comprehensively examined transmitter effects on birds and concluded there was no evidence that transmitters affect the flying ability of birds. Few turbine interaction studies have addressed adult raptor avoidance behavior specifically (Carrete et al. 2009, Dahl et al. 2013), and most studies have been of migrant or local raptor behavior and interactions with turbines based on mixed age classes (Hoover and Morrison 2005, Smallwood et al. 2009, Garvin et al. 2011, Katzner et al. 2012) or raptor populations that include breeding adults (Barrios and Rodríguez 2004, Hull and Muir 2013). The relevance of these differences is best illustrated by our finding that nesting adults flew through turbine blades with significantly greater frequency than for the general hawk population. Breeding adult raptors have unique ecological constraints on spatial use resulting from territoriality, and nest-centric behavior, that develop an intimate familiarity with local range characteristics because of repetitive flight and use of traditional foraging locations. Thus, how hawks respond to turbines built within their home ranges and rates of visitation are expectedly different than hawks with less-limiting life requirements because of their age, breeding status, or stage of annual cycle (Marques et al. 2014). Migrant raptors, for example, are brought in conflict with wind development by their search for favorable flight conditions where wind turbines may interfere with preferred airspace (Ainslie et al 2014, Johnston et al. 2014, Cabrera-Cruz and Villegas-Patraca 2016). Acquiring prey is a priority for non-breeding and wintering raptors and where prey are concentrated near wind turbines, raptors may be at risk (Smallwood et al. 2007, 2009; Hunt et al. 2017).

Our examination of hawk avoidance rates and responses to wind turbines that was specific to nesting, adult hawks has important implications for their conservation. Ferruginous hawks and Swainson's hawks are species modeled as being at high risk for breeding population declines from wind energy development (Beston et al. 2016). For declining avian species, extinction risk is exacerbated by factors that increase mortality of reproductive adults, including raptors that have relatively large body size, produce few offspring, and have long life expectancy (Owens and Bennett 2000). Ecological traps (Robertson and Hutto 2006) like wind turbines and utility poles that kill adult raptors (Dwyer 2009, Hunt and Watson 2016) may hasten decline of threatened populations because of effects of additive mortality (Carrete et al. 2009, Longcore and Smith 2013, Hunt et al. 2017). Also, adult raptor survival is more important to growth of avian populations than survival of other age classes (Sæther and Bakke 2000, Tack 2016), as demonstrated for ferruginous hawks (Watson and Pierce 2003, Collins and Reynolds 2005).

## MANAGEMENT IMPLICATIONS

Behavioral accommodation of nesting hawks to existing turbines indicates measures to minimize effects from proposed wind development should be framed with an expectation for high rates and daily visitation of hawks to turbine RSZs $<800$ m from nests. Modeling to estimate collision probability should use avoidance rates associated with specific activities for adult hawks. Specific turbines accounted for $\leq 43\%$ of hawk flights into the RSZs, so measures to reduce collision risk for nesting hawks ideally need to include pre-construction identification of locations within home ranges where turbines should not be built based on site-specific hawk use or terrain features (Smallwood et al. 2017). On developed projects, powering down regularly visited turbines during bimodal, daily hunting periods or in high wind conditions that promote kiting behavior may be the most direct way to reduce risk to buteo hawks. Curtailment may be particularly important where ferruginous hawks are listed or a species of concern.

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# HOME RANGES, MOVEMENT PATTERNS, AND PREY OF ADULT BUTEOS WITHIN WIND DEVELOPMENT PROJECTS IN THE COLUMBIA BASIN

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The ability to assess ecological processes and their relationships to anthropogenic changes in the environment often depends on understanding a species spatial use of that environment. An individual's space use over the annual cycle is largely determined by their life stage, season, and breeding status. At a local level, an animal's regular movements between essential resources define its home range (Burt 1943), that can best understood as a snapshot of dynamic processes between an animal and its environment that it maintains as a cognitive map (Powell and Mitchell 2012). For raptors, home ranges typically encompass nest substrates, topography promoting flight, prey concentrations, and are associated with relatively low disturbance (Newton 1979). Although sizes of range contours are dynamic because resources on home ranges vary by time and space, individuals within a regional population for a given species or taxon may have similarly-sized ranges because of consistent distribution of prey (Marzluff et al. 1997, Leary et al. 1989, Peery 2000, Watson 2002), perches, and nest substrates (Watson 2002, Hamer et al. 2007, Kudo et al. 2005) in the landscape. Thus, estimable range characteristics may provide a useful template for predicting general spatial use, and intensity of use, for these raptors in unstudied, similar habitats (Suter and Joness 1981, Camp et al. 1997, Millar 2002).

At middle, temperate latitudes throughout the year raptor populations typically include resident breeders, floating adults, migrant adults, and immature nonbreeders. In shrubsteppe regions, soaring hawks, including ferruginous hawks (*Buteo regalis*), Swainson's hawks (*B. swainsoni*), and red-tailed hawks (*B. jamaicensis*) nest sympatrically, but particular populations of each species may have variable seasonal movements and migration (Martell et al. 1998, Kochert et al. 2011, Bloom et al. 2015, Watson et al. *in press*). A species-specific understanding of these movements and home range dimensions is important in the Columbia Basin where large numbers of these species nest and where wind power development has expanded dramatically in the past 15 years (Conley 2009).

Here, we evaluate movement patterns and home range characteristics of sympatrically nesting ferruginous, red-tailed, and Swainson's hawks in a landscape experiencing recent wind power development. Our specific objectives were to: 1) summarize residency status and duration, home range and core area size, and territory fidelity of telemetered adult hawks; 2) determine the proportion of home ranges contained within fixed buffers from nests to provide management templates for predicting extent of unstudied ranges; and 3) identify prey of nesting hawks.

**STUDY AREA**

The study was conducted in south-central Washington and north-central Oregon, within the Columbia Plateau Ecoregion. The main study area encompassed about 5400 km$^2$ that included existing and proposed wind development projects (Fig. 1). We included a project outside the study area near Vantage where we captured and tracked one hawk (Fig. 1). Anthropogenic habitat alterations associated with wind power development includes strings of turbines that bisect all habitats but often follow ridgelines and the gravel roads used to access them, electrical infrastructure, and low-intensity vehicle traffic associated with turbine maintenance. Grassland

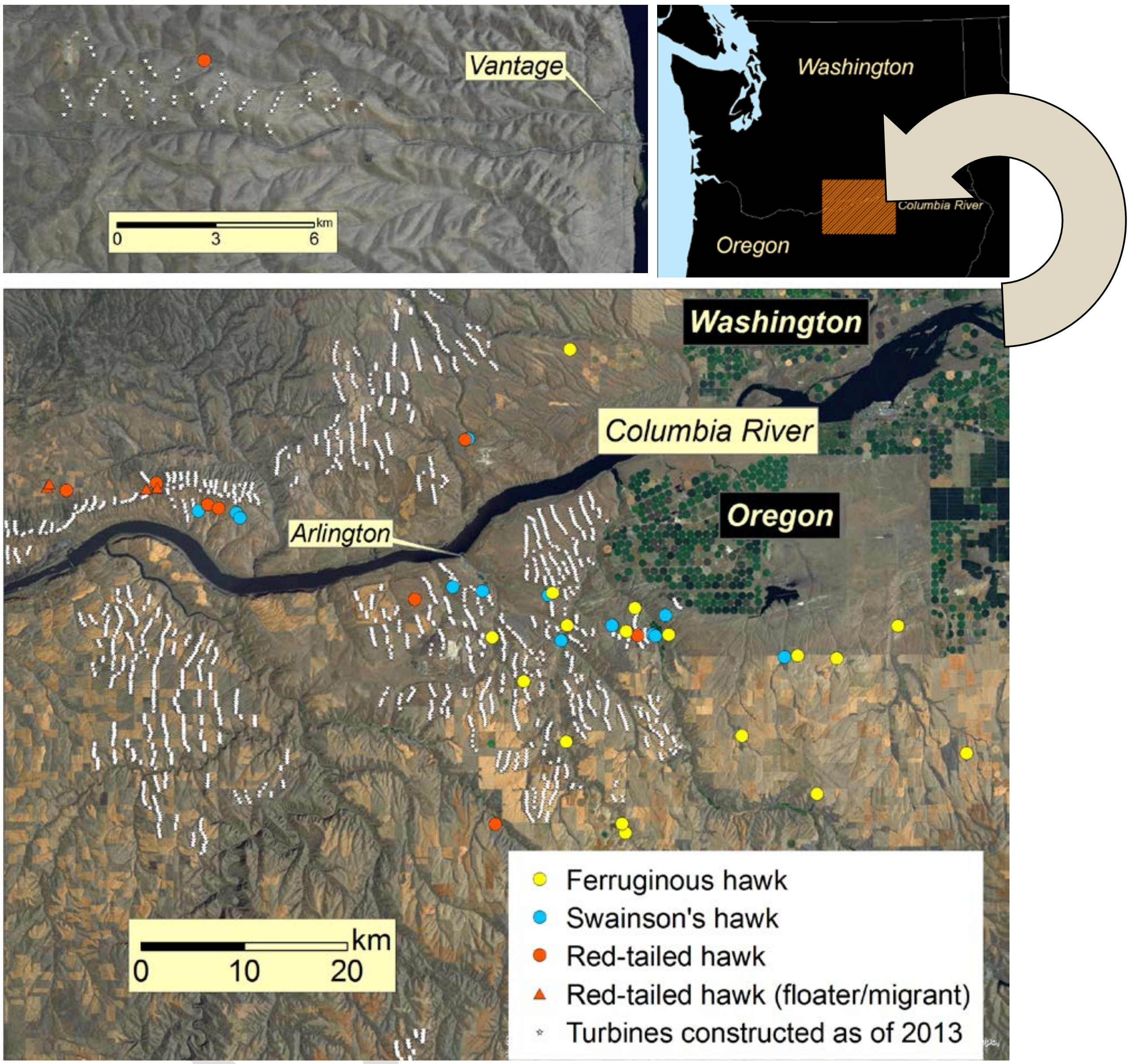


Fig.1. Territory locations of 39 adult hawks (circles), and capture locations of 4 adult, non-territorial hawks (triangles) monitored with global positioning telemetry to better understand their associations with wind power development in the Columbia Plateau Ecoregion, 2007-2014. One study territory was located near the Vantage wind power project in central Washington (upper left).

habitats show considerable topographic variation throughout the study area with the steepest hillsides associated with the Columbia River and large tributaries that feed the river. Little habitat remains undisturbed; large sections of dry-land and irrigated agriculture are interspersed with rangeland that is used primarily for cattle and sheep grazing. Sagebrush (*Artemisia* spp.)

and rabbitbrush (*Chrysothamnus tectorum*) is mixed among annual grasses or in remnant patches along with lithosol soils. Cheatgrass is prevalent in heavily grazed pastures and intensively burned areas. Large expanses of native habitats include the Boardman Conservation Area and NWSTF Boardman managed by the Nature Conservancy and Department of Defense, respectively.

Nesting habitats of ferruginous hawks include significant areas of shrubsteppe or native grasses often on talus slopes and hills that are too steep to cultivate. Others occupy relatively level landscapes between canyons where hawks often nest in western juniper (*Juniperus occidentalis*). Red-tailed hawks nest in some of the same areas, but also frequent more open stands of windbreak trees in mixed cropland and native habitats. Swainson's hawks frequently nest in exotic or native homestead trees adjacent to agricultural land.

## METHODS

### Capture and telemetry

We captured and radio-tagged adult hawks that were perched near nests we identified as being within historic territories. We targeted a sample of about 45 birds, sampled approximately equally between those nesting within or adjacent to wind projects, and those outside of wind projects, based on the need to satisfy other research objectives (Chapter 2). Some historic nest locations were provided by researchers or surveyors conducting simultaneous studies (K., Kronner, Northwest Wildlife Consultants, S. Cherry, Oregon Department of Fish and Wildlife, P. Kolar, Boise State University, pers. comm.). We emphasized the capture of ferruginous hawks because of the interest in this species due to its Threatened status in Washington and Critically Sensitive designation in Oregon, but early in the study we began targeting similar numbers of the other two buteo species in order to have adequate samples for investigating hawk and wind turbine interactions. In each spring, beginning in 2007, we road-trapped hawks using bal-chatris baited with mice or gerbils, or trapped hawks on territories with break-away dho gaza nets and a live great horned owl (*Bubo virginianus*) lure (Bloom et al. 2007). We captured one adult on each territory, and emphasized capturing males because male raptors potentially range more widely than females, at least during incubation and brooding (Collopy 1984, Howell and Chapman 1997), but we also telemetered females. We attached 30-g satellite PTTs (platform transmitter terminals) with GPS location capability using "X" configured backpacks and teflon ribbon to all species, but also used 22-g PTTs on male Swainson's hawks to maintain a transmitter/body mass ratio of <3% (Fig. 2). Thirty gram PTTs were programmed for transmitting hourly locations for 21 hours per day, but actual transmissions were often less due to less than optimal battery charging and perching locations of birds that affect satellite-to-PTT communication. Twenty-two gram PTTs were programmed to broadcast every 4 h for 20 h/da for optimal transmission of five locations daily. Data retrieval was accomplished via computer access to ARGOS satellite data servers. Manufacturer specified error for GPS fixes was ±22 m (T. Rollins, Microwave Telemetry Inc., personal communication).

**Home Range**

Nesting attempts and productivity were assessed annually for monitored hawks and their mates by ground surveys between April and May, and June and July, respectively. Nesting pairs laid eggs and were either successful or unsuccessful fledging young [see Steenhof and Newton (2007) for definitions]. Non-nesting hawks were either territorial non-breeders, floaters, that were not associated with nesting territories (Hunt 1998), or migrants passing through the study

Fig. 2. Telemetered adult male ferruginous hawk (left) and Swainson's hawk (right) monitored during the wind turbine study, Washington and Oregon.

area. Throughout the study status of individual hawks could change annually from territorial nesters to territorial non-nesters or vice versa (we included territorial birds that lost their mates as non-nesters), but status of floaters and non-regional migrants did not change during the study.

We estimated home range characteristics for territorial, breeding hawks and non-breeding hawks. Home range was defined by the period between spring capture date and the last fixes prior to post-breeding departure from the range. For hawks monitored >1 yr, initiation of the breeding season, and thus estimates of breeding home range, began with the hawk's arrival on its previous breeding range. Arrival on ranges was abrupt and distinct for all ferruginous hawks and Swainson's hawks, which were complete migrants, but red-tailed hawks were partial migrants and a few remained in the Pacific Northwest year-round. Most of these red-tailed hawks dispersed away from the ranges at the same time complete migrants migrated, so we defined their home ranges for the period prior to their regional dispersal.

We used the Brownian bridge movement model (BBMM) to delineate ranges (Horne et al. 2007) based on flight locations (i.e., speed sensor >0 kph) and perch locations (i.e., speed sensor = 0 kph). This method allowed us to estimate utilization distributions (UDs) that included hawk flight paths in range estimation because it involved the probability of the bird being at any point between 2 locations based on elapsed time between fixes. We calculated UDs and 99%, 95%, and 50% isopleths from consecutive locations separated by ≤2 hours using the R statistical package (R Version 2.15.1, www.r-project.org, accessed 7 Jul 2012) and the ADEHABITAT package (http://cran.r-project.org/package=adehabitat, accessed 7 Jul 2012). We chose this interval to include the minimal transmission time for programmed transmitters (e.g., 1-hr for 30-g PTTs, 3-hr for 22-g PTTs) and exclude longer periods of missed fixes. We recorded the number of isolated isopleths at each level as a measure of range fragmentation. Plotting of ranges and movements was accomplished with a Geographic Information System (ESRI 2011).

We pooled range estimates for hawks in year of their capture when range occupancy was partial with those estimated from complete breeding seasons because range size (95% BBMM isopleths) was not correlated with occupancy duration for any species ($P > 0.10$). Due to small sample size, we did not analyze effects of sex, whether eggs were laid, or nest success on home range size.

We overlaid circular buffers, centered at used nests and with radii 0.8, 1.6, 2.4, 3.2 km, and at 5 km (Swainson's and red-tailed hawks) and 10 km (ferruginous hawks) to measure overlap with 99%, 95%, and 50% isopleths for annual ranges. Progressively increasing overlap of buffers with ranges, as they increased in size, provided a measure of the utility of using fixed buffers for territory protection.

**Prey**

In 2011, pellets and prey were collected opportunistically in and around 47 Buteo nests representing the three species in the study area during another investigation (Kolar and Behcard 2016). From each sample we derived the minimum number of individuals down to the most specific taxa possible through identification of mammal and bird skulls and jaw fragments and paired jaws of Orthopertans (Elbroch 2006). Fur, feathers, and reptile scales (Moore et al. 1974; Scott and McFarland 2010) from prey and pellets were considered to represent the same individual, whereas counts of pooled skulls and jaws allowed for identification of >1 individual. Frequencies of prey species in diets were quantified to provide an assessment of relative use among Buteo species and not a comprehensive picture of dietary breadth and prey biomass contribution that could be gleaned with coordinated video or visual data collection of hawk feeding behavior.

**RESULTS**

From 2007-2014 we captured, radioed, and monitored 44 adult buteos including 17 ferruginous hawks, 14 Swainson's hawks, and 13 red-tailed hawks (Fig. 1 and Appendix Table 1). All ferruginous and Swainson's hawks were nesting the first season they were captured, but five red-tailed hawks did not nest including four floaters, and one northern migrant (Fig. 3). For nesting hawks that migrated from ranges during the non-breeding period, ferruginous and red-tailed hawks had similar arrival dates and were the first hawks on the study area, but red-tailed hawks tended to be the last species to leave the study area (Table 1). All migratory hawks monitored ≥1 yr ($n$ = 6 ferruginous, 7 Swainson's, and 2 red-tailed hawks) returned to the study area in subsequent years.

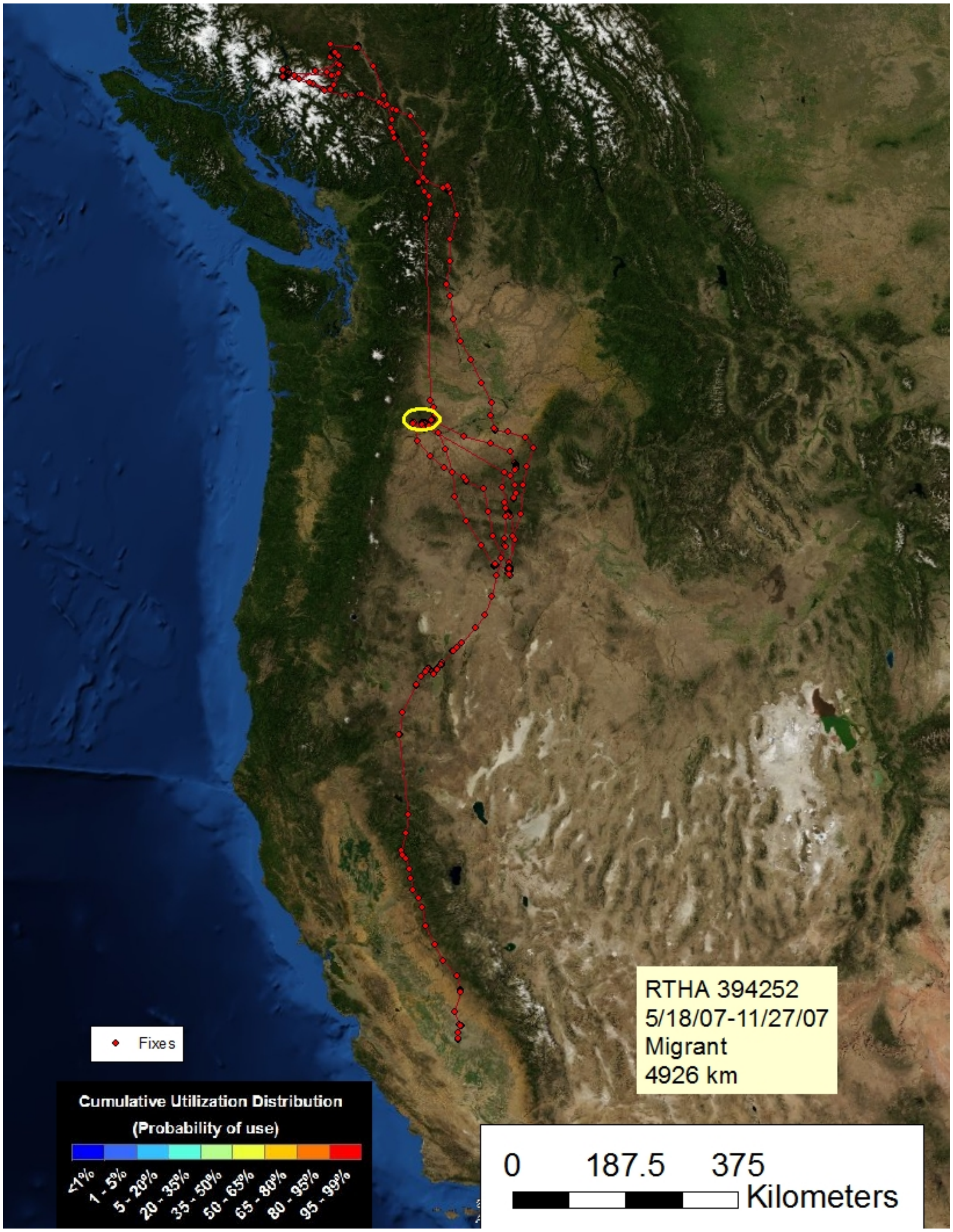


Fig. 3. Movements of migrant red-tailed hawk from the study area (oval) to southern Canada in spring, and California in fall.

Table 1. Arrival and departure dates of telemetered buteos nesting in the Columbia Basin, 2007-2014.

| Species | Arrival | | | Departure | | |
|---|---|---|---|---|---|---|
| | Median | Range | *n* | Median | Range | *n* |
| Ferruginous hawk | 22 Feb | 27 Jan-30 Mar | 14 | 17 Jul | 21 Jun-27 Oct | 28 |
| Red-tailed hawk | 18 Feb | 10 Jan-29 Mar | 8 | 2 Oct | 21 Jun-18 Nov | 17 |
| Swainson's hawk | 23 Apr | 13 Apr-16 May | 15 | 12 Aug | 11 Jul-26 Aug | 29 |

Home ranges of nesting hawks were most often characterized by one core area (i.e., 50% contour) centered on the nest, whereas floating hawks had fragmented ranges with multiple core areas (Fig 4). We estimated annual home ranges from over 234 thousand fixes for each season 43 resident hawks were monitored. With the exception of one male ferruginous hawk that nested on a different adjacent territory each of five breeding seasons (i.e., FEHA 90734) hawks monitored multiple years used the same or alternative nests within the same territory. Ferruginous hawk home ranges (95% and 99% isopleths), and 50% core areas were the largest of the three buteos, >33% larger than ranges of Swainson's hawks, and 15 times larger than ranges of red-tailed hawks (Table 2). This was in spite of the fact that on average red-tailed hawks were monitored for the longest period and ranges were determined from the highest number of fixes (Table 2). We documented one nest switch between a telemetered ferruginous hawk and Swainson's hawk in consecutive years that provided site-specific contrast in spatial use with a smaller and less fragmented fix distribution for the latter species (Fig. 5).

Range fragmentation ($\bar{x}$ no. islands ± SE) was highest for ferruginous hawks for 99%, 95%, and 50% isopleths (5.7 ± 1.5, 4.7 ± 1.1, and 1.5 ± 0.3, respectively) compared to red-tailed hawks (1.3 ± 0.2, 1.9 ± 0.5, and 1.1 ± 0.1, respectively) and Swainson's hawks (1.3 ± 0.2, 1.5 ±

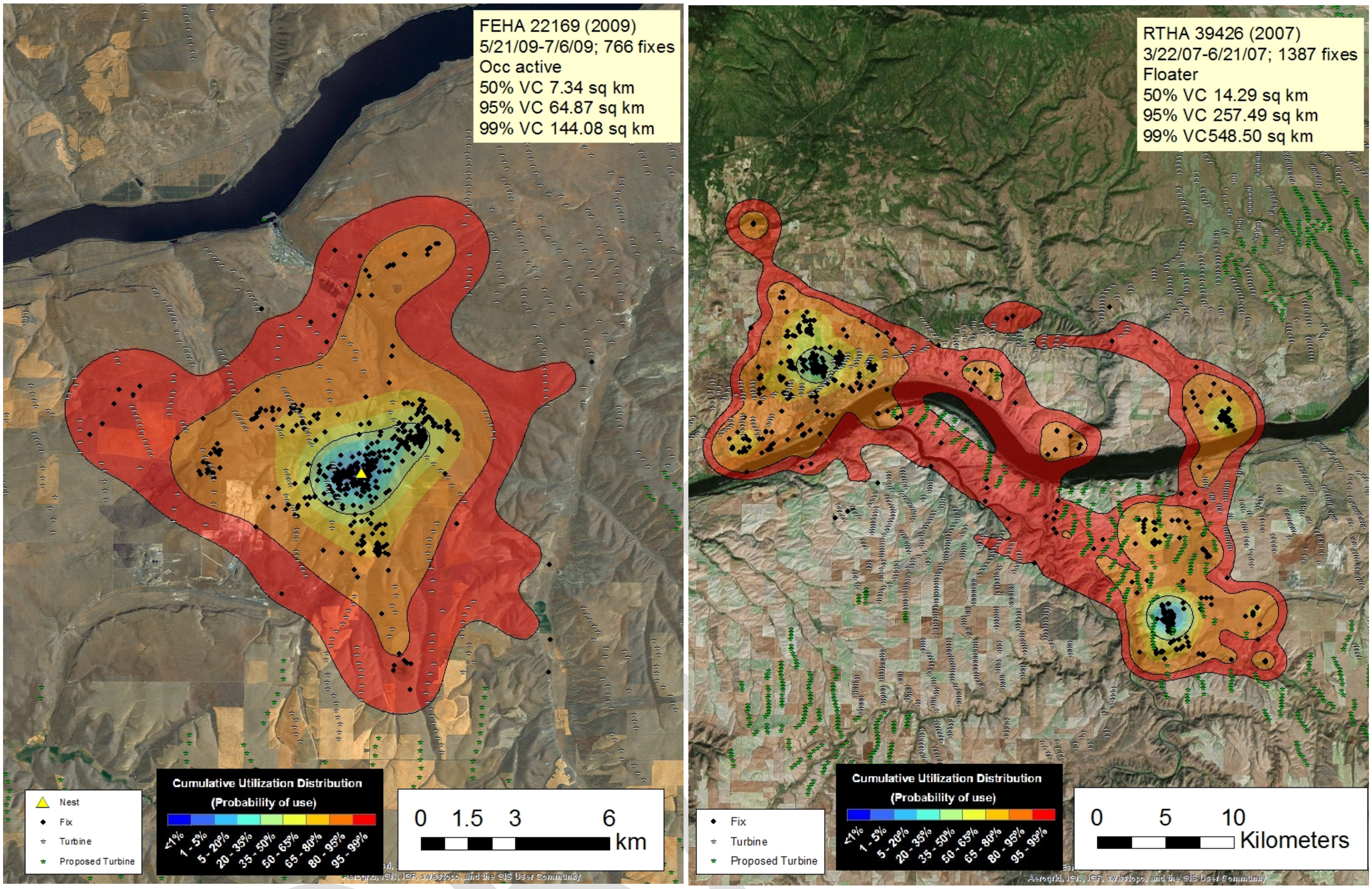


Fig. 4. Examples of home ranges during the breeding season for a nesting ferruginous hawk and single core area centered on the nest (left), and floating adult red-tailed hawk (right) with multiple core areas. Ranges were determined by the Brownian Bridge Movement Model.

Table 2. Home range size ($km^2$) and occupancy duration ($\bar{x} \pm$ SE) of territorial hawks monitored by satellite telemetry during the breeding season in the Columbia Basin, 2007-2014. Ranges were estimated using the Brownian Bridge Movement Model.

| Species | 99% Isopleth | 95% isopleth | 50% isopleth | No. territories | No. days | No. fixes |
|---|---|---|---|---|---|---|
| Ferruginous hawk | 703.3 ± 194.1 | 314.5 ± 93.8 | 32.3 ± 12.1 | 33 | 100.2 ± 9.0 | 1588.9 ± 151.3 |
| Red-tailed hawk | 52.2 ± 24.5 | 20.7 ± 8.0 | 1.9 ± 0.6 | 16 | 197.0 ± 16.4 | 1904.1 ± 248.1 |
| Swainson's hawk | 343.8 ± 133.8 | 193.3 ± 82.1 | 22.8 ± 10.5 | 33 | 86.8 ± 5.6 | 608.2 ± 80.4 |

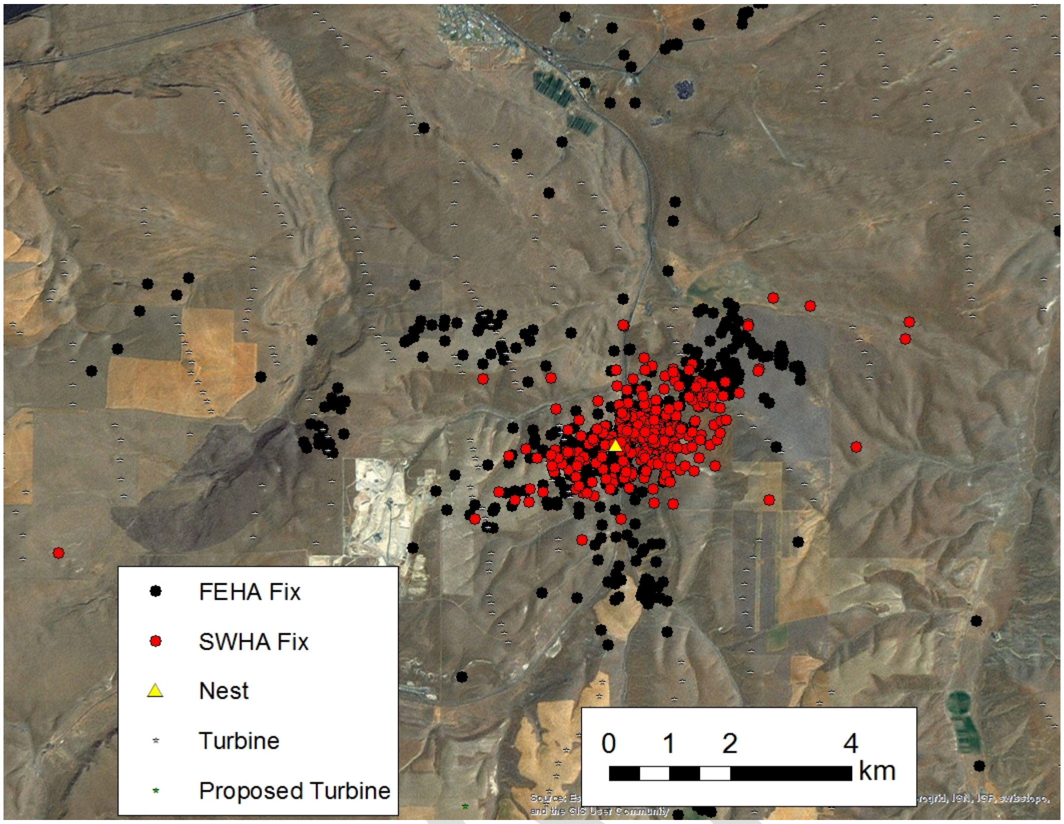


Fig. 5. GPS fix distribution for an adult male ferruginous hawk (*n* = 766; 5/21/09-7/6/09) and adult male Swainson's hawk (*n* = 427; 5/31/10-8/12/10) using the same nest in consecutive years.

0.2, and 1.3 ± 0.2), respectively. Mean home range size estimated by the fixed kernel method were larger for each species and followed the same order as Brownian Bridge ranges (Table 3).

Table 3. Size (km$^2$) of breeding home range kernels ($\bar{x}$ ± SE) of territorial hawks monitored by satellite telemetry in the Columbia Basin, 2007-2014.

| Species | 99% kernel | 95% kernel | 50% kernel |
|---|---|---|---|
| Ferruginous hawk | 969.9 ± 290.2 | 503.1 ± 171.1 | 74.2 ± 30.7 |
| Red-tailed hawk | 124.5 ± 78.4 | 61.1 ± 36.0 | 6.2 ± 3.2 |
| Swainson's hawk | 671.6 ± 292.6 | 383.4 ± 177.5 | 67.4 ± 37.5 |

On average, buffers 2.4 km (1.5 mi) from Swainson's and red-tailed hawk nests, and 3.2 km (2 mi) from ferruginous hawk nests encompassed >85% of 50% core ranges for each species (Fig. 6). On average, a 10-km nest buffer encompassed 75% of the 95% home range of a ferruginous hawk, whereas a 2.4-km nest buffer encompassed 80% of the 95% home range of a red-tailed hawk, and a 5-km nest buffer encompassed 81% of the 95% home range of a Swainson's hawk (Fig. 6). At each buffer distance, buffers encompassed a smaller percentage of home range estimated by 99% isopleths compared to 95% isopleths (≤16 % difference).

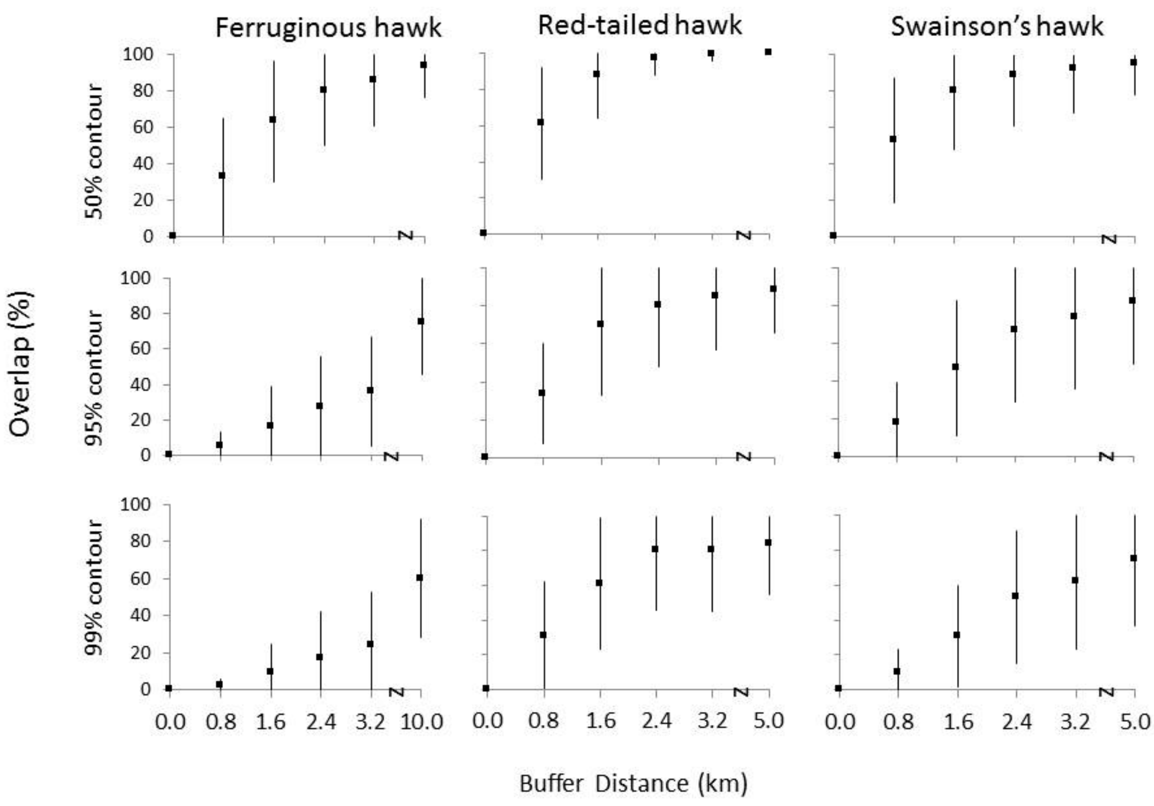


Fig. 6. Percentage of breeding home range contours of hawks encompassed by circular buffers at 0.8 km increments radiating from used nests. Home ranges were estimated by the Brownian Movement Model. Mean percentages and associated standard deviations are shown at each increment.

We identified 29 prey species or species groups in 394 whole pellets and pellet fragments from nests of 6 ferruginous hawks, 13 red-tailed hawk nests, and 28 Swainson's hawk nests (Table 4). Northern pocket gophers (*Thomomys talpoides*) were the most prevalent prey in ferruginous hawk pellets (60%) followed by snakes (21%). Frequencies of these prey items were reversed in red-tailed hawk pellets (24% and 40%, respectively), and birds (13%) were also important to red-tailed hawks. Considerably more diverse prey was represented in Swainson's hawk pellets, with insects accounting for 86% of prey by frequency, principally grasshoppers.

**DISCUSSION**

Influence of anthropogenic factors on our study area set the context for interpreting the buteo home range attributes that we assessed. These factors included habitat composition, consisting of mixed agriculture, ranching, and native habitats in varies degrees of degradation, and expanding wind power development variously present on the subject raptor ranges. In that context, adult buteos that we monitored multiple years displayed a high degree of breeding range fidelity, although they occasionally switched nests within these ranges, including hawks that were complete migrants (ferruginous and Swainson's hawks) and partial migrants (red-tailed hawks). Breeding range fidelity of individuals is the foundation for long-term population stability, such as has been demonstrated for these species east of our study area (Kennedy et al. 2014) and for the red-tailed and Swainson's hawk population southwest of our study (Janes 2003). Recent research found ferruginous hawks throughout their distribution had high breeding range philopatry (Watson et al. *in press*) and were not widely nomadic (Woffinden and Murphy 1989). Range fidelity is important to document because after build-out of wind projects the

Table 4. Diet of hawks in the wind power development study area identified from analysis of pellets collected in and around 6 ferruginous hawk nests (77 pellets and fragments), 13 red-tailed hawk nests (54 pellets and fragments), and 28 Swainson's hawk nests (263 pellets and fragments) in 2011.

| **Prey Species or Group** | **Ferruginous Hawk** | | **Red-tailed Hawk** | | **Swainson's Hawk** | |
|---|---|---|---|---|---|---|
| | **No.** | **%** | **No.** | **%** | **No.** | **%** |
| N. Pocket Gopher (*Thomomys talpoides*) | 73 | 60.3 | 22 | 23.7 | 110 | 5.9 |
| Deer Mouse (*Peromyscus maniculatus*) | 0 | 0.0 | 3 | 3.2 | 2 | 0.1 |
| MontaneVole (*Microtus montanus*) | 0 | 0.0 | 0 | 0.0 | 7 | 0.4 |
| Jumping Mouse (*Zapus princeps*) | 0 | 0.0 | 0 | 0.0 | 6 | 0.3 |
| Great Basin Pocket Mouse (*Perognathus parvus*) | 0 | 0.0 | 0 | 0.0 | 4 | 0.2 |
| Unidentified Small Mammal | 4 | 3.3 | 8 | 8.6 | 40 | 2.1 |
| Mountain Cottontail (*Sylvilagus nutallii*) | 1 | 0.8 | 3 | 3.2 | 5 | 0.3 |
| White-tailed Jackrabbit (*Lepus townsendii*) | 1 | 0.8 | 0 | 0.0 | 0 | 0.0 |
| Black-tailed Jackrabbit (*Lepus californicus*) | 1 | 0.8 | 0 | 0.0 | 0 | 0.0 |
| Coyote (*Canis latrans*) | 1 | 0.8 | 0 | 0.0 | 0 | 0.0 |
| Unidentified Large Mammal | 0 | 0.0 | 0 | 0.0 | 3 | 0.2 |
| **Total Mammal** | **81** | **66.9** | **36** | **38.7** | **177** | **9.5** |
| Black-billed Magpie (*Pica hudsonia*) | 0 | 0.0 | 4 | 4.3 | 0 | 0.0 |
| Stellar'sJay (*Cyanocitta Stelleri*) | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 |
| Western Meadowlark (*Sturnella neglecta*) | 3 | 2.5 | 0 | 0.0 | 2 | 0.1 |
| Horned Lark (*Eremophial alpestris*) | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 |
| Bewick's Wren (*Thryomanesbewickii*) | 1 | 0.8 | 0 | 0.0 | 0 | 0.0 |
| Unidentified Passerine | 2 | 1.7 | 7 | 7.5 | 14 | 0.8 |
| Long-billed Curlew (*Numenius americanus*) | 0 | 0.0 | 1 | 1.1 | 1 | 0.1 |
| Killdeer (*Charadrius vociferous*) | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 |
| Gray Partridge (*Perdix perdix*) | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 |
| Unidentified bird egg | 1 | 0.8 | 0 | 0.0 | 0 | 0.0 |
| **Total Bird** | **7** | **5.8** | **12** | **12.9** | **21** | **1.1** |
| Gopher Snake (*Pituofis catenifer*) | 1 | 0.8 | 1 | 1.1 | 4 | 0.2 |
| Racer (*Coluber constrictor*) | 0 | 0.0 | 1 | 1.1 | 1 | 0.1 |
| Unidentified Snake | 24 | 19.8 | 35 | 37.6 | 43 | 2.3 |
| **Total Reptile** | **25** | **20.7** | **37** | **39.8** | **48** | **2.6** |
| Burying Beetle *Nicrophorini* spp. | 0 | 0.0 | 0 | 0.0 | 5 | 0.3 |
| Unidentified Beetles Coleoptera | 4 | 3.3 | 2 | 2.2 | 48 | 2.6 |
| Grasshopper *Apote notablis* and *Melanoplus* spp. | 4 | 3.3 | 6 | 6.5 | 1558 | 83.4 |
| Field Cricket (*Gryllus pennsylvanicus*) | 0 | 0.0 | 0 | 0.0 | 10 | 0.5 |
| Jerusalem Cricket (*Stenopelmatus fuscus*) | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 |
| **Total Insect** | **8** | **6.6** | **8** | **8.6** | **1602** | **85.7** |
| **Total Prey** | **121** | **100.0** | **93** | **100.0** | **1868** | **98.9** |

species composition of this buteo community may change, and breeding density may ultimately decline as a result of direct and indirect effects of wind power development (Farfán, et al. 2009, Garvin et al. 2011, Campedelli et al. 2013) (Fig. 7). Home range size and fragmentation that we measured reflected species differences in response to existing turbines that we examine in chapters 2 and 3. Ferruginous hawks may be negatively impacted to anthropogenic changes from energy development (Coates et al. 2014), although in some circumstances ferruginous hawks in oil and gas developments benefit by nesting on tanks and towers associated with energy infrastructure (Keough et al. 2014, Wallace 2014, Watson et. al. 2014a). Other factors may affect buteo community such as species differences in aggressive behavior, perch requirements, and ability to adapt to habitat change (Bechard et al. 1990, Restani 1991, Janes 1994, Coates et al. 2014).

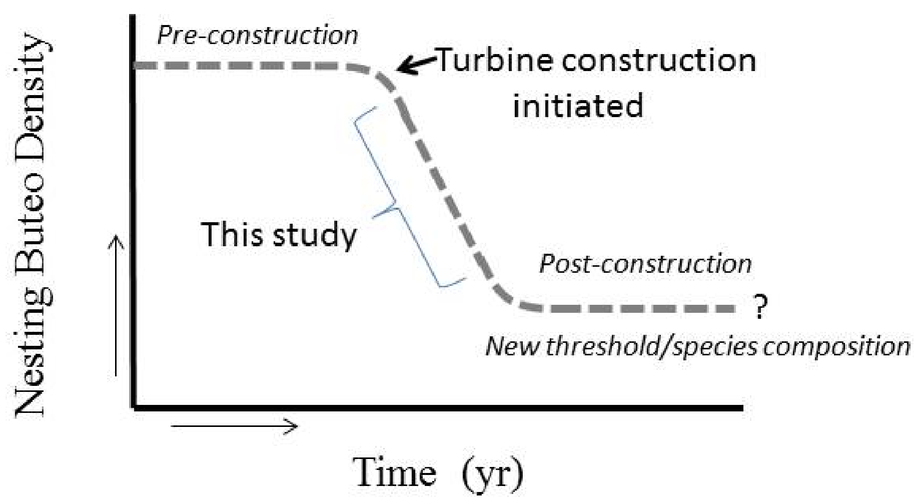


Fig. 7. Potential change in nesting density of buteos in the study area after build-out of turbines.

Home range size, and intensity of areas used within raptor home ranges are strongly influenced by whether raptors nest in a given season, and whether they fledge young (Marzluff et al. 1997, Haworth et al. 2010, Watson et al. 2014b). Non-nesters and raptors that fail to raise young may have substantially larger ranges with core areas away from the nest compared to those that rear young to fledging. We were able to exclude non-nesting hawks from our home range estimates, but included all nesting hawks including those that were unsuccessful nesters in home range estimates because classification was confounded by apparent late failures, and the fact that some adults (particularly ferruginous hawks) expanded ranges substantially during brood-rearing at both unsuccessful and successful nests. Perhaps more to the point, management application of buffers for nesting hawks (Fig. 6) should reflect resource needs of nesting pairs regardless of nest success. Studies that assess anthropogenic effects of development on raptors are often "nest-centric" and may focus almost entirely on potential impacts on avian activities conducted on or near the nest, including incubation, brooding, and feeding (e.g., 50% contours, Fig. 6). For raptors that exhibit high site fidelity it is important to manage essential range components (Watson et al. 2014b) and establish buffers based on entire ranges (e.g., 95% isopleths, Fig. 6).

Based on previous research we suspect distribution of prey was an important influence on buteo home range characteristics on the study area (Marzluff et al. 1997, Leary et al. 1998, Watson 2002), but because we didn't measure prey abundance or distribution we could only assess the effects of prey indirectly through our diet analysis and comparisons to other studies. Also, our diet analysis was not intended to address diet breadth and overlap that might be gleaned from a more comprehensive investigation of feeding observations to reduce potential bias of pellet analysis alone that could benefit from observation or video camera data (Giovanni et al. 2007, Keeley 2009). Ferruginous hawks that used comparatively huge, fragmented ranges would be expected for a species that is closely associated, if not obligated, to native grasslands and shrublands (Bechard and Schmutz 1995) especially where these habitats are interspersed with monoculture cropland (Leary et al. 1998, Coates et al. 2014). Their consumption of pocket gophers was not unexpected based on their predominance in ferruginous hawk diets (Bechard and Schmutz 1995) and their association with both native habitats (Dechant et al. 2002) and irrigated edges of cropland (Zelenak and Rotella 1997, Leary et al. 1998). We believe the clustered distribution of fixes and range fragmentation on exterior portions of some ferruginous hawk ranges reflected their hunting of pocket gophers near cropland several kilometers distant from nests (Thurow et al. 1980, Leary 1998), and possibly scattered ground squirrel colonies. Home ranges of ferruginous hawks in high density ground squirrel habitat in Canada were 20 times smaller than in our study area (Watson et al. 2014a). We didn't find ground squirrel skulls in pellets, suggesting they were not eaten often, but they may have been represented in unidentified remains. Intensive diet studies using video cameras have shown that ground squirrels are often bolted as whole prey by ferruginous hawks (W. Keeley, C. Nordell, pers. comm.) so squirrels skulls would be expected in pellets that we examined had they been eaten in large numbers. Nesting ferruginous hawks in southeast Oregon fed almost exclusively on ground squirrels (Lardy 1980), and ferruginous hawk densities, but not red-tailed hawk or Swainson's hawk densities, were significantly associated with squirrel densities in Alberta (Downey et al. 2004).

Swainson's hawks that averaged 69% of the body mass of ferruginous hawks on the study area (unpubl. data), had home ranges about two-thirds the size of average ferruginous hawk ranges. This is consistent with the positive correlation between body mass and home range size in holarctic raptors (Peery 2000). Diverse prey that features grasshoppers is typical in many regions where this species nests (Thurow et al. 1980, England et al. 1997). Body mass of red-tailed hawks averaged 83% of that for ferruginous hawks yet their home ranges were very compact and averaged 12% the size of ferruginous hawk ranges. Our analysis suggested diet of red-tailed hawks that included snakes and birds was perhaps more diverse than that of ferruginous hawks, and compact home ranges of red-tailed hawks may have resulted in part from generic diet and social dominance in the raptor guild (Restani 1991) especially in core areas of ranges (Janes 1984, 1994). Home range size of buteos described in most previous studies were exponentially smaller and difficult to compare to our results because they used conventional ground-based telemetry (Janes 1984, Andersen and Rongstad 1989, McAnnis 1990, Andersen et al. 1990, Anderson 1995, Babcock 1995, Leary 1998). We attribute an unknown, but significant portion of these differences to advances in technology because GPS has dramatically improved fix frequency and accuracy, reduced bias of sampled fixes, and improved comprehensive, seasonal and multi-year analyses.

## CONSERVATION IMPLICATIONS

This study provides a rare opportunity to evaluate long-term effects of wind power development on a buteo population that includes ferruginous hawks. We strongly recommend comprehensive re-evaluation of buteo species and occupancy rates in the study area by 2020 using pre-development information to document post-construction changes in nesting density and species composition with particular emphasis on effects on the ferruginous hawk population. Home range and prey use of remaining pairs will provide an understanding of habitat qualities that continue to support occupancy in spite of anthropogenic changes.

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**APPENDIX** Table 1. Capture and monitoring summary of adult buteos studied in Washington and Oregon, 2007-2015.

| PTT ID | Species/sex | Territory | Turbine/non-turbine [a] | Inclusive Monitoring Dates | Total No. GPS fixes | Outcome |
|---|---|---|---|---|---|---|
| 394193 | FEHA/m | Hale Road | NT | 6/12/08-8/25/08 | 1,219 | Fatality on post-breeding range (WY), golden eagle predation |
| 80630 | FEHA/m | Upper 8-mi | NT | 5/20/08-10/25/08 | 1,235 | PTT failed |
| 90734 | FEHA/m | Halverson | NT | 5/19/09-10/14/12 | 17,404 | PTT expired |
| 22169 | FEHA/m | Railroad | T | 5/21/09-12/24/09 | 3,163 | PTT stationary winter range (CA); unknown |
| 96278 | FEHA/f | Willow | T | 5/26/10-2/4/2011 | 3,863 | Fatality on winter range (AZ), shot |
| 96279 | FEHA/m | Jordan Gd | NT | 5/27/10-1/18/13 | 12,896 | Abrupt loss of signal |
| 394182 | FEHA/m | Immigrant | NT | 5/28/10-10/20/10 | 2,204 | Abrupt loss of signal |
| 96280 | FEHA/m | TNC | T | 5/30/10-3/20/16 | 835 | Fatality on winter range (CA), undetermined |
| 96281 | FEHA/f | Boardman | NT | 5/31/10-4/25/13 | 15,612 | Fatality on breeding range, shot |
| 96283 | FEHA/m | Kemp Road | NT | 5/18/11-10/30/11 | 2,403 | Fatality on breeding range, shot |
| 96285 | FEHA/m | Lindstrom Lane | NT | 5/20/11-10/03/11 | 2,207 | Fatality on post-breeding range (WY), suspected West Nile Virus |
| 96284 | FEHA/m | Willow N | T | 5/25/11-7/24/14 | 17,267 | Fatality in migration (WA); undetermined cause of death |
| 96286 | FEHA/m | Burned Juniper | NT | 5/25/11-8/10/11 | 1,273 | Fatality on post-breeding range (WY), suspected West Nile Virus |
| 96287 | FEHA/m | Boardman CA | NT | 5/27/11-12/23/14 | 18,067 | Fatality in migration (WA); undetermined cause of death |
| 962782 | FEHA/m | 4-mi Gravel Pit | T | 6/1/11-9/21/11 | 1,833 | Fatality on post-breeding range (WY), suspected West Nile Virus |
| 280182 | FEHA/m | Montague | T | 6/3/11-7/8/2013 | 10,432 | Fatality on breeding range, possible coyote predation |
| 962783 | FEHA/m | Pebble Springs | T | 5/24/12-2/1/13 | 3,159 | Fatality on winter range (CA), broken wing |
| 39425 | RTHA/f | Hoctor Rd Central | T | 3/21/07-5/1/07 | 574 | Fatality on breeding range, shot (floater) |
| 39426 | RTHA/m | Hoctor Rd Central | T | 3/22/07-9/5/10 | 12,377 | PTT expired (floater) |
| 39427 | RTHA/m | Hoctor Rd. West | T | 3/22/07-11/30/09 | 7,684 | PTT expired (resident) |
| 55378 | RTHA/m | Hoctor Rd.East | T | 3/24/07-2/13/08 | 1,290 | Fatality on winter range (CA), shot (floater) |
| 39418 | RTHA/f | Goodenoe Rd. | T | 5/18/07-10/9/07 | 1,470 | Abrupt loss of signal (resident) |
| 394252 | RTHA/f | Hoctor Rd. West | T | 5/18/07-11/27/07 | 1,095 | Abrupt loss of signal (migrant) |
| 553773 | RTHA/m | Goodenoe Rd. | T | 3/12/08-9/21/08 | 1,485 | Abrupt loss of signal (resident) |
| 33242 | RTHA/f | Hoctor Rd. East | T | 3/27/09-5/28/10 | 4,645 | Fatality on breeding range, turbine strike (resident) |
| 478452 | RTHA/f | Juniper Canyon | NT | 5/21/09-12/21/09 | 767 | PTT intermittent, expired (resident) |
| 356442 | RTHA/m | Willow | T | 5/19/10-2/22/11 | 1,330 | Fatality on winter range (CA), shot (resident) |
| 55379 | RTHA/m | Olex | NT | 1/27/11-6/21/15 | 14,121 | Fatality on breeding range (WA), undetermined |
| 394254 | RTHA/m | Rattlesnake | T | 5/23/12-3/14/13 | 1,835 | Fatality on winter range (MX), unknown (resident) |
| 409333 | RTHA/f | Vantage | T | 3/14/13-8/5/16 | 6,407 | Active (resident) |
| 39415 | SWHA/f | Goodnoe W | T | 5/5/07-1/15/08 | 3,184 | Stationary on winter range (Argentina), unknown fate |
| 84200 | SWHA/f | Goodnoe E | T | 4/29/08-7/31/08 | 302 | Bird removed PTT |
| 90728 | SWHA/f | J. Canyon | NT | 4/28/09-5/2/15 | 12,382 | Stationary on breeding range, unknown fate |
| 90729 | SWHA/m | Goodnoe E | T | 4/29/09-5/29/12 | 1,451 | PTT expired |

[a]≥1 wind turbine within 99% home range volume contour.

Table 1. Cont'd.

| PTT ID | Species/sex | Territory | Turbine/non-turbine [a] | Inclusive Monitoring Dates | Total No. GPS Fixes | Status |
|---|---|---|---|---|---|---|
| 90730 | SWHA/m | Cecil | T | 5/22/09-11/28/09 | 1,046 | Stationary on winter range (Argentina), unknown fate |
| 90731 | SWHA/m | Willow | T | 5/22/09-11/8/10 | 3,273 | Stationary on winter range (Argentina), unknown fate |
| 553782 | SWHA/m | Immigrant | NT | 5/28/10-5/8/13 | 6,369 | PTT expired |
| 80633 | SWHA/m | LJI entrance | T | 5/31/10-6/27/10 | 157 | Fatality on breeding range; vehicle collision |
| 394152 | SWHA/m | Railroad | T | 5/31/10-7/11/2013 | 6,446 | Fatality on breeding range, possible coyote predation |
| 33238 | SWHA/m | Pebble | T | 6/12/10-5/3/15 | 10,366 | PTT expired |
| 80634 | SWHA/m | Rattlesnake | T | 6/23/10-3/5/13 | 487 | PTT tranmssions intermittent |
| 394253 | SWHA/m | Willow | T | 4/27/11-5/31/11 | 641 | Fatality on breeding range; turbine strike |
| 96282 | SWHA/m | Willow West | T | 5/12/11-11/26/2013 | 13,982 | PTT expired |
| 356443 | SWHA/f | Eight Mile | T | 7/6/12-1/17/13 | 2,765 | Abrupt loss of signal (resident) |

# Monitoring sagebrush wildlife at Boardman Naval Weapons Systems Training Facility, 2009

Modification AO001
Cooperative Agreement No. N44255-08-2-002

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Figure 2b. Locations of Sage Sparrow nesting territories in the southwestern portion of Boardman NWSTF, 2009. The polygons indicate minimum convex polygons around three territories (NWSTF1, NWSTF2, and NWSTF3). The three points west of NWSTF3 probably represent a transient male detected on only one day in early April, well within the normal migratory period of Sage Sparrows.

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## Introduction

Since the late 1980s, operational, grazing, and agricultural changes have taken place at the Boardman NWSTF. Grazing and agricultural leases have not been granted since 2001 and bombing and other ground-intensive uses by military operations have ceased. Extensive fires have swept portions of the installation; nearly the entire facility has been burned in large fires over the last two years. Changes to habitats of sensitive species and species of concern have subsequently occurred, but it is unknown if these changes are beneficial or detrimental, as there is no monitoring program in place on the facility. Currently, the installation's rangelands are managed for wildlife, soil stability, and fire suppression, while remaining in a ready state should military operations increase. Navy natural resource managers require new data to begin a baseline for measuring habitat and species changes at the installation, and also to provide information that can help better manage the natural resources of Boardman NWSTF.

## Methods

We measured occurrence of four sagebrush-preferring species in areas of the NWSTF historically used by those four species (Figure 1 and 1a). The species are Sage Sparrow, Loggerhead Shrike, Burrowing Owl, and Sagebrush Lizard. We conducted targeted surveys in the remaining upland sagebrush habitat and in areas historically used by nesting Burrowing Owls to determine species abundance and habitat utilization. Once areas inhabited by the species were found, we conducted complete area searches, covering all areas thoroughly three to twelve times between late March and 29 May 2009 to document locations of the three bird species.

Both Sage Sparrows and Loggerhead Shrikes utilize the upland sagebrush habitat. We used the Targeted Species Sampling Protocol (TASP) described in Humple and Holmes (2001) to map territories of sparrows and shrikes. The TASP protocol is an adaptive sampling technique modified from the "strip adaptive cluster sampling" described by Thompson (1992) that incorporates flush-mapping on three days to delimit territories. In summary, sampling is conducted with 1 or 2 observers, starting within a half hour of sunrise and lasting 4-5 hours, weather permitting. Observers walk parallel transects at approximately 75-100 m apart, depending on terrain. When a target species is encountered, no less than 20 minutes is spent attempting to track the individual. If territorial behavior (e.g. singing) is observed, the territory boundaries are delimited using a flush mapping protocol (Reed 1985). After mapping, a wire flag with a unique number identifying the territory is placed in the perceived center of the territory. After a territory is marked, all adjacent areas (four areas the size of the original territory) are searched for other conspecific territorial birds. The 20-minute flush-mapping and territory marking is repeated until no territorial birds are located in adjacent areas. At this time observers return to the original encounter and resume walking the predetermined transect.

We used the TASP protocol to identify territories of Sage Sparrows and Loggerhead Shrikes. We monitored confirmed Sage Sparrow territories by searching for evidence of breeding and used behavioral cues to estimate production of offspring. We found and monitored every 3-5 days nests of Loggerhead Shrikes using methods described in Martin and Geupel (1993). Loggerhead Shrike nests were located at various stages using behavioral cues and systematic searches. We carefully checked nests to minimize human-induced nest mortality, until the outcome (fledge or failure) was determined. We searched all territories of shrikes for re-nests after each nest fledged failed.

We mapped incidental observations of Sagebrush Lizards, because we were not confident that transect methods were effective enough at detecting lizards. We felt that current methods could grossly under-estimate the number of lizards present because of the difficulties of detecting that species during walking-transect surveys.

Areas historically used by Burrowing Owls on the NWSTF were surveyed for evidence of nesting owls. Owls were located as they flushed from burrows or signs of activity at burrows were discovered (e.g., Rich 1986, Green and Anthony 1989). In addition to searching all areas with current sagebrush cover, we visited all sites known to have had breeding owls during extensive surveys by Humple and Holmes (2001) to determine how many of those sites still had breeding owls.

**Vegetation communities within bird territories**

We assessed habitat type and condition at all Sage Sparrow territories, Loggerhead Shrike nests and Burrowing Owl nest burrows.

The vegetation within confirmed territories was described by plant community type and ecological condition class as described in Elseroad (2002). Plant community type is based on the dominant native perennial species present. Communities are named after the dominant tree and/or shrub (when present) followed by up to two dominant native grass species. An exception is made if gray rabbitbrush (*Chrysothamnus nauseosus*) is the dominant native shrub. Gray rabbitbrush is only used to classify a community if no other native shrubs or grasses are present. In areas that are severely degraded such that no native perennial shrub or grass species exist, exotic grass species are used for plant community classification. The ecological condition of each plant community is determined by assessing the abundance and vigor of the native perennial bunchgrasses. The five condition classes are:

1) High: Understory plant community dominated by native perennial bunchgrasses. Bunchgrasses abundant and robust, soil crust intact. Very few if any exotic species present.
2) Medium high: Understory plant community dominated by native perennial bunchgrasses. *Bromus tectorum* and other exotic species present but in very low amounts or only in small isolated patches.
3) Medium: Native perennial bunchgrasses present, but *Bromus tectorum* and other exotic species are widespread throughout the community.
4) Medium low: Community dominated by *Bromus tectorum*, other exotic species, and disturbance-adapted native species such as rabbitbrush. *Poa sandbergii* is often the only native perennial bunchgrass present.

5) Low: Community dominated by *Bromus tectorum* and other exotic species. Few if any native species present (although rabbitbrush may be a dominant species) and no native perennial bunchgrasses present.

**Place names commonly referred to in this report.**

Within Boardman NWSTF, most remaining sagebrush is confined to the southern reaches of the site. An area in the southwest is west of the single lane road that runs north-south nearly the entire length of Boardman called the *Interstate*. In the southeastern section, most remaining habitat is located around a large canyon that runs north-south called *Juniper Canyon*. At the northern end of Juniper Canyon five roads intersect. *Hey Road* runs to the northeast from that intersection and passes through an area with several Sage Sparrow territories. We called that habitat area the Hey Road area. South of Hey Road 2 km the *Oregon Trail* passes east-west through Boardman NWSTF. A few territories of birds were located along that trail, so we referred to those areas as the Oregon Trail territories.

# Results and Discussion

**Sage Sparrows**

*Nesting territory locations*. We detected 8 territories of Sage Sparrows during 2009, mostly clustered in the southeastern portion of the range and in the southwest near the border with the Boardman Conservation Area (Figure 2a, 2b). These are the same areas where most of the remaining tall sagebrush patches occur. A few scattered detections of a singing individual outside of the main territories mapped in Figure 2b were of a bird found only once, suggesting that it was a transient during early spring and chose not to establish on the NWSTF.

*Habitat types and condition*. Sage Sparrows were restricted to sagebrush plant communities with grass communities dominated by *Poa* grasses (Table 1). Sites were generally categorized as being of medium to medium-high ecological condition in the Juniper Canyon and Hey Road area, and of medium-low quality in the western cluster of territories near the Boardman Conservation Area boundary.

*Nesting success*. We discovered one Sage Sparrow nest that had 3 eggs on 16 Apr 2009 and probably fledged 3 young sometime between 27 Apr and 1 May 2009. We encountered juveniles on 15 occasions, for a total of approximately 12 individuals. Some juveniles were encountered more than once, but most were not. Because individual birds were not captured and color-banded, it is not possible to know with certainty how many individual young were produced nor in which territories the young were produced because young birds move around the landscape after leaving the nest. Nevertheless, the numbers of sightings of juveniles of this inconspicuous species suggest that production of young at NWSTF was fairly good in 2009. During weekly surveys of territories, we found juveniles in 7 of the 8 territories (Table 2). When juveniles were encountered, we normally found one or two individuals within a territory, mostly in early May. We did not detect any juveniles in the Oregon Trail territory.

*Populations.* We found a total of 8 Sage Sparrow territories in the NWSTF. Depending on interpretation of the territory mapping in the eastern cluster of territories, the number of territories could be as high as ten. However, a more conservative interpretation is that 8 territories were discovered. Given that we completely searched all remaining sagebrush habitats and sites historically used by Sage Sparrows before the recent fires, we feel confident that our area searches revealed all or nearly all the existing territories. Thus, it is probably most accurate to suggest that there were approximately 8 territories of Sage Sparrows in these sections of the NWSTF during 2009.

**Loggerhead Shrikes**

*Nesting territory locations.* We searched extensively for territories of Loggerhead Shrikes and located 19, all confined to the southern portions of the NWSTF (Figure 3a). Seventeen territories were in the southeastern section, mostly in Juniper Canyon and two were in the southwestern section near the boundary with the Boardman Conservation Area (Figure 3b). We found the nest in all but one of the shrike territories. Two territories had two or three nesting attempts, whereas most territories appeared to have a single nesting attempt.

*Habitat types and condition.* Most Loggerhead Shrike territories were located in areas of tall sagebrush, with scattered junipers, and were classified as having vegetation communities in medium or higher ecological condition (Table 3).

*Nesting success.* We measured 388 days that nests were active (exposure days in Table 4) and detected 9 failures out of 20 observed nest attempts. The daily predation rate at nests was 0.023. The Mayfield estimate of proportion of nests succeeding at producing at least one young was 46.1% (± 0.7 SD). We estimated that at least 31 young were fledged from the nests we observed. Four nests were still active when we terminated fieldwork, so some of those late nests might also have fledged young.

*Populations.* We found 19 territories in the NWSTF and feel confident that our complete area searches discovered all or nearly all the breeding shrikes in the areas we searched. The species is quite conspicuous in open habitats like those present at NWSTF. Populations were highest in Juniper Canyon, where there were 17 territories within an 8 $km^2$ area. On the west side, near the Boardman Conservation Area, there were 2 territories within a 2 $km^2$ area.

**Burrowing Owls**

*Nest locations.* We searched all sites where Burrowing Owls were historically reported to have nested (Humple and Holmes 2001). We found 6 nesting locations during 2009 (Figures 4a, 4b, 4c) widely scattered across the NWSTF, except for two sites closer together near the Interstate in the west-central portion of the site. None were discovered in the sagebrush areas where Sage Sparrows and Loggerhead Shrikes were breeding, despite complete area searches of those habitats.

*Habitat types and condition.* Nest burrows were located in grassland areas of low to medium-low quality. Many of these sites contained areas of cheatgrass, but most had a mixture of grass species and little or no shrub component (Table 5).

**Sagebrush Lizards**

*Sighting locations*. We observed Sagebrush Lizards at 100 locations during 2009 (Figures 5a, 5b, 5c). We do not know the population density of the species on NWSTF because of the challenges of detecting the species during formal surveys. Yet, the number of incidental detections suggests that NWSTF is an important provider of habitat for the species. Most detections were concentrated within remaining sagebrush habitats in the areas of Juniper Canyon, Hey Road and west of the Interstate near the border with the Boardman Conservation Area.

**Areas of concern and overall coincidence of sensitive species**

Figure 6 illustrates areas where occurrences of sensitive species (Burrowing Owls, Loggerhead Shrikes, Sage Sparrows, and Sagebrush Lizards) overlap on NWSTF. The highest densities of sightings and of breeding areas of these species occurred in the area of Juniper Canyon, Hey Road, and west of the Interstate near the border with the Boardman Conservation Area.

## Personnel

Surveys were carried out by James Brennan, Jasmine Graves, Aaron Holmes, Melissa Reynolds, Douglas Robinson, and Teresa Wicks. Randy Moore produced the GIS-based maps. Adam Kotaich and Betty Millard assisted with data entry, data management, and data proofing. The work was facilitated by Leslie Nelson of The Nature Conservancy and Lyle Knudsen of the U.S. Navy.

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Table 1. Habitat types and conditions within nesting territories of Sage Sparrows at Boardman NWSTF, 2009.

| **NWSTF Territory** | **Plant community type** | **Ecological condition** |
|---|---|---|
| 1 | ARTR-POSA | ML |
| 2 | ARTR-POSA | ML |
| 3 | ARTR-POSA | ML |
| O1 | ARTR-POSA | M |
| S1 | ARTR-POSA | M |
| H1 | ARTR-POSA | M |
| H2 | ARTR-POSA | MH |
| H3 | ARTR-POSA | MH |

Abbreviations: Plants—ARTR (*Artemesia tridentata*), POSA (*Poa sandbergii*); Ecological conditions—L = low; M=medium; H=high; MH=medium-high; ML=medium-low; M-ML=medium to medium-low; M-MH=medium to medium-high.

Table 2. Detection of offspring in territories of Sage Sparrows at Boardman NWSTF, 2009.

| NWSTF Territory | Fledglings detected? | Minimum number of fledglings |
|---|---|---|
| 1 | Yes | 2 |
| 2 | Yes | 2 |
| 3 | Yes | 2 |
| O1 | No | 0 |
| S1 | Yes | 1 |
| H1 | Yes | 2 |
| H2 | Yes | 2 |
| H3 | Yes | 1 |

Table 3. Habitat types and conditions within nesting territories of Loggerhead Shrikes at Boardman NWSTF, 2009.

| Territory | Nest attempt | Plant community type | Ecological condition |
|---|---|---|---|
| 1 | A | ARTR-POSA | M |
| 2 | A | ARTR-POSA | MH |
| 3 | A | ARTR-POSA | M |
| 3 | B | ARTR-CHVI | ML |
| 4 | A | ARTR-POSA | M |
| 5 | A | ARTR-POSA | M - ML |
| 6 | A | JUOC-ARTR | M - MH |
| 7 | A | JUOC-ARTR | M |
| 7 | B | ARTR-JUOC | M |
| 8 | A | JUOC-ARTR | M |
| 9 | A | ARTR-POSA | M |
| 10 | A | ARTR-BRTE | L |
| 11 | A | ARTR-ELLA | MH |
| 12 | A | JUOC-ARTR | M |
| 13 | A | ARTR-CHVI | L |
| 14 | A | ARTR-POSA | ML |
| 15 | A | JUOC-ARTR | M |
| 16 | A | JUOC-ARTR | M |
| 18 | A | ARTR-CHVI | M |
| 19 | A | ARTR-POSA | M |

Abbreviations: Plants—ARTR (*Artemesia tridentata*) , BRTE (*Bromus tectorum*), CHVI (*Chrysothamnus viscidiflorus*), ELLA (*Eleocharis lanceolata*) , JUOC (*Juniperus occidentalis*), POSA (*Poa sandbergii*) ; Ecological conditions—L = low; M=medium; H=high; MH=medium-high; ML=medium-low; M-ML=medium to medium-low; M-MH=medium to medium-high.

Table 4. Estimated nesting success of Loggerhead Shrikes at Boardman NWSTF, 2009.

| Territory | Nest attempt | Exposure days | Fail (1) or fledge/unknown (0) | Number kids fledged | Notes |
|---|---|---|---|---|---|
| 1 | A | 40 | 0 | 6 | |
| 2 | A | 24 | 0 | 5 | |
| 3 | A | 3 | 1 | 0 | |
| 3 | B | 8 | 1 | 0 | |
| 4 | A | 39 | 0 | 3 | |
| 5 | A | 20 | 1 | 0 | |
| 6 | A | 31 | 1 | 0 | |
| 7 | A | 10 | 1 | 0 | |
| 7 | B | 22 | 0 | Unknown | |
| 8 | A | 38 | 0 | 5 | |
| 9 | A | 24 | 1 | 0 | |
| 10 | A | 4 | 1 | 0 | |
| 11 | A | 33 | 0 | 6 | |
| 12 | A | 33 | 0 | 6 | |
| 13 | A | 3 | 1 | 0 | |
| 14 | A | 8 | 1 | 0 | |
| 15 | A | 26 | 0 | Unknown | |
| 16 | A | 10 | 0 | Unknown | May be 2$^{nd}$ attempt of territory 2, 5, or 14 |
| 18 | A | 8 | 0 | Unknown | |
| 19 | A | 4 | 0 | Unknown | May be 3$^{rd}$ attempt of territory 3 |
| Totals | | 388 | | 31 + | |

Table 5. Habitat types and conditions at Burrowing Owl burrows at Boardman NWSTF, 2009. Owl nests are numbered in a clockwise rotation based on position in Figure 3a where the central nest near Boardman Headquarters is number 1, the next nest clockwise is 2, etcetera.

| **NWSTF Territory** | **Plant community type** | **Ecological condition** |
|---|---|---|
| 1 | BRTE-POSA | L |
| 2 | POSA-BRTE | ML |
| 3 | POSA-BRTE | ML |
| 4 | BRTE-POSA | L |
| 5 | BRTE-POSA | L |
| 6 | BRTE-POSA | L |

Abbreviations: Plants—BRTE (*Bromus tectorum*), POSA (*Poa sandbergii*); Ecological conditions—L = low; M=medium; H=high; MH=medium-high; ML=medium-low; M-ML=medium to medium-low; M-MH=medium to medium-high.

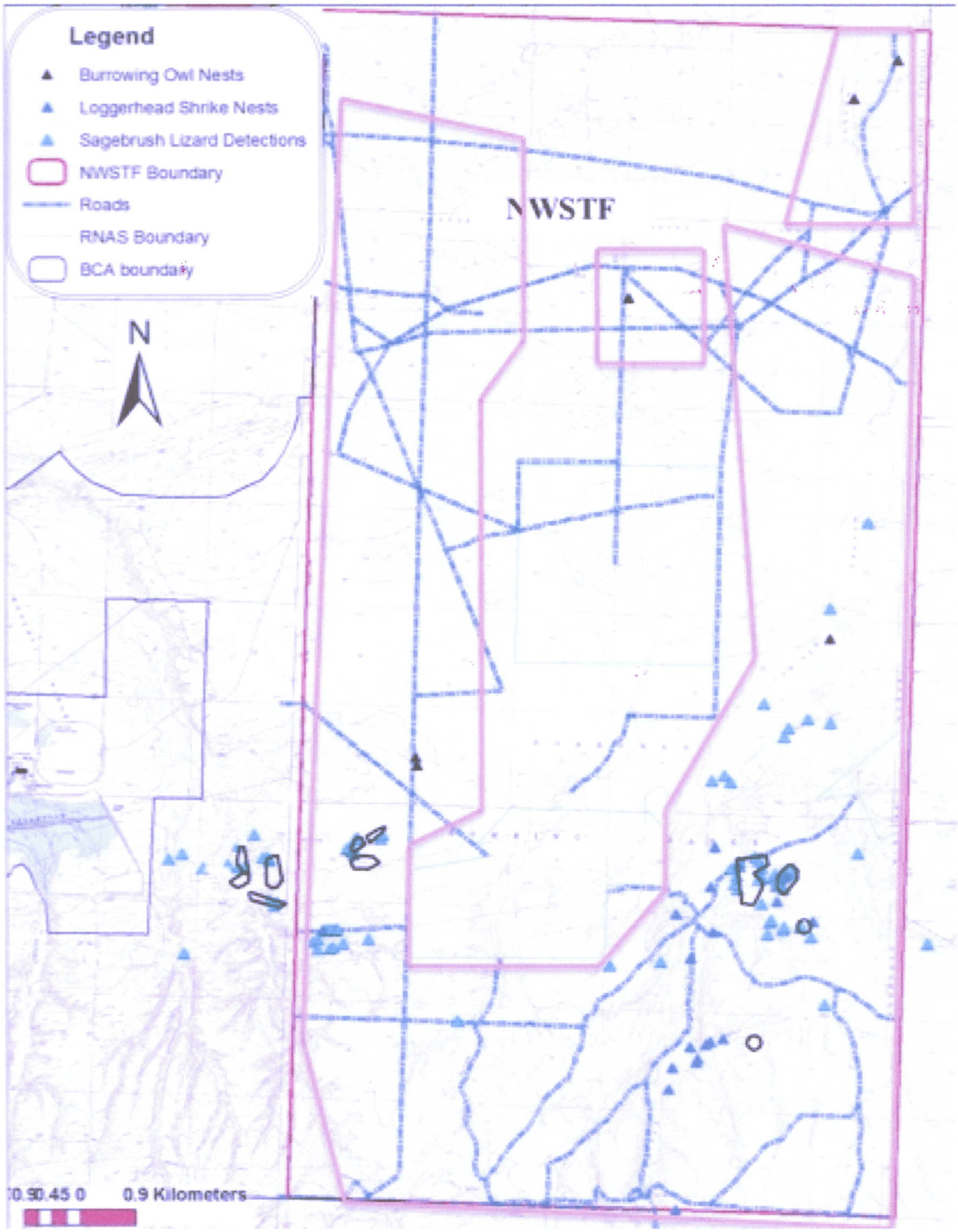


Figure 1. Boardman NWSTF areas surveyed for Sage Sparrows, Loggerhead Shrikes, and Burrowing Owls. The areas outlined in orange were all searched for appropriate habitat and for evidence of the three bird species during 2009. Once birds were located, more intensive searches for nests (shrikes, owls) and mapping territories (sparrows) was conducted.

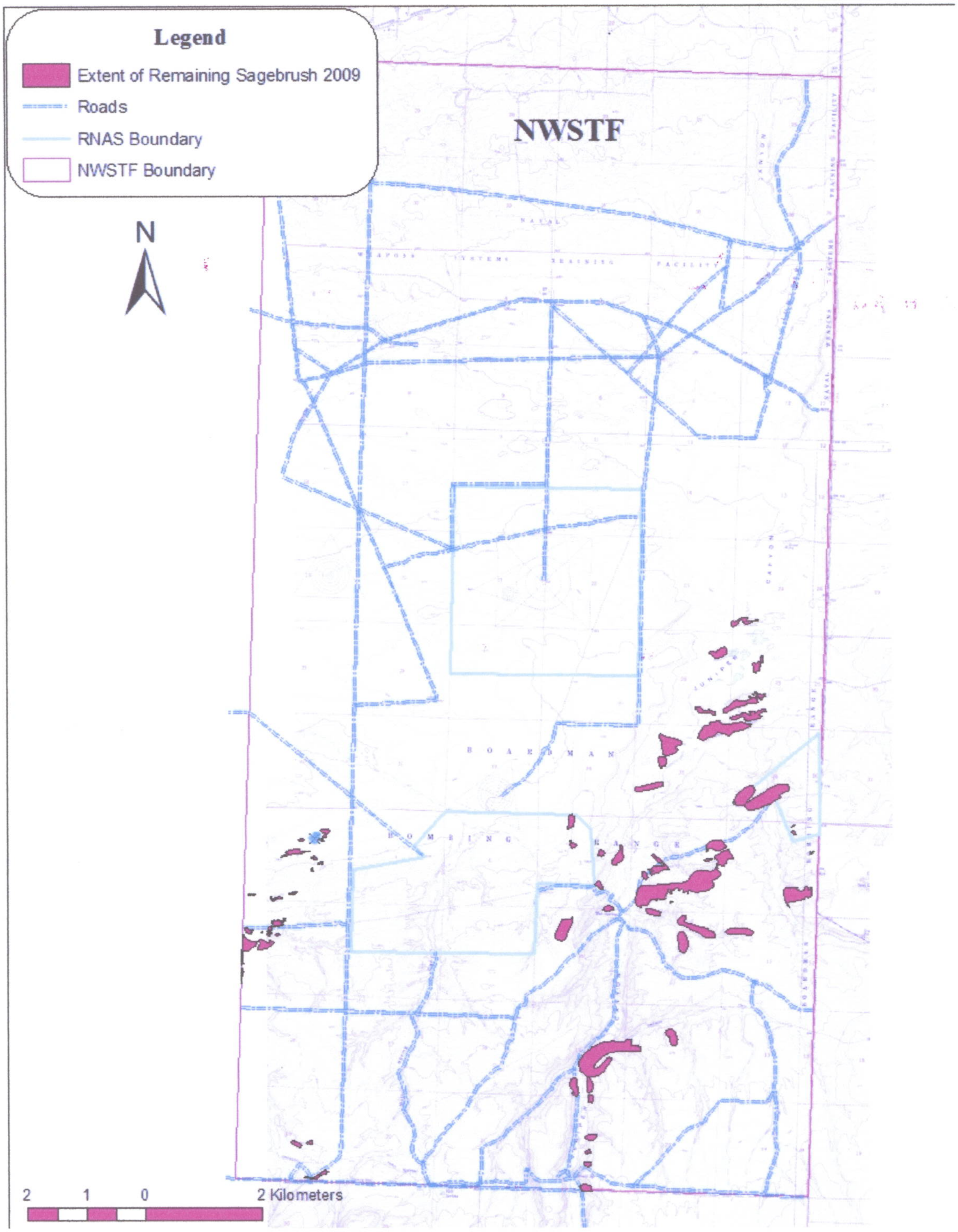


Figure 1a. Remaining sagebrush patches (red) on Boardman NWSTF, 2009. All patches were surveyed for the species of concern.

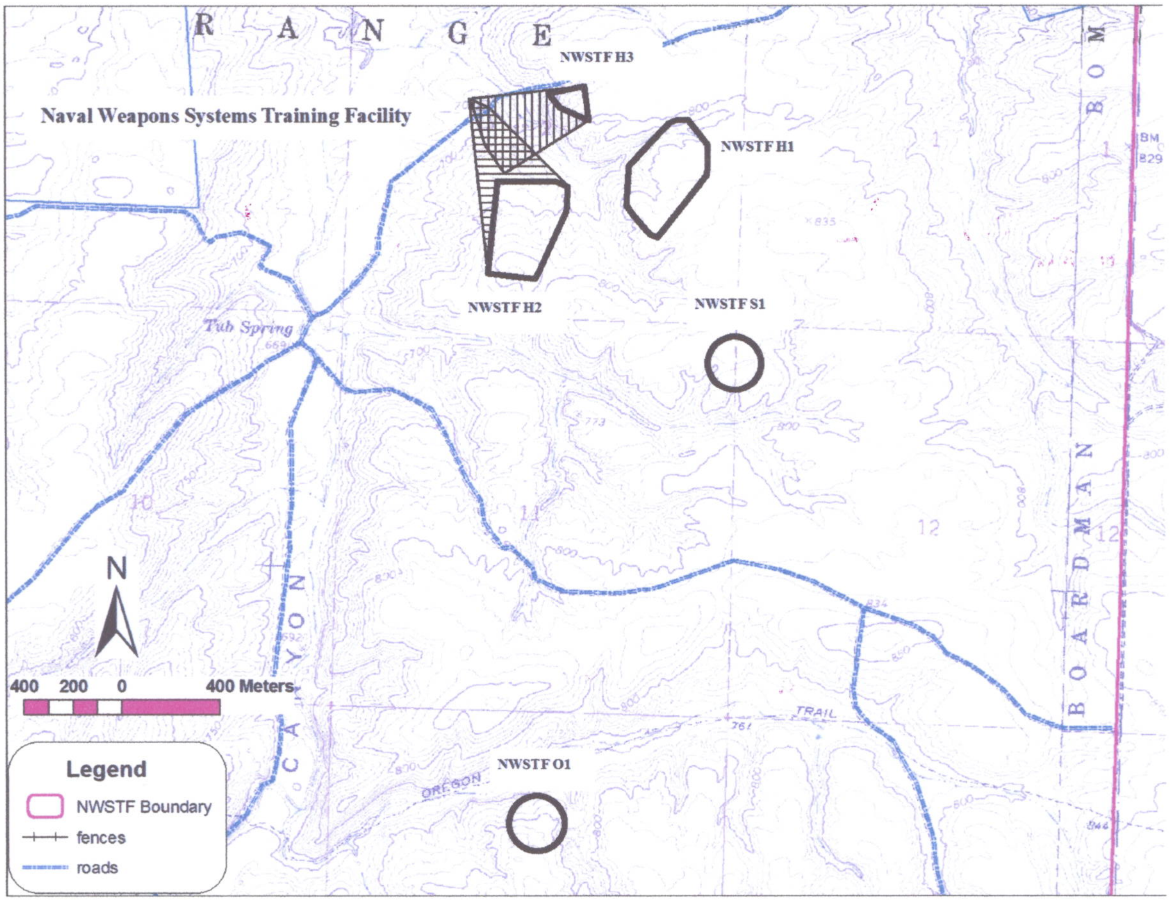


Figure 2a. Locations of Sage Sparrow nesting territories in the southeastern portion of Boardman NWSTF, 2009. The polygons and circles indicate minimum convex polygons around territories. The hatched areas include zones with few detections that probably involve movements to the north and west of the indicated territories. An alternative, but less likely, explanation for those sightings within the hatched areas is that they represent two additional territories inhabited by very inconspicuous pairs.

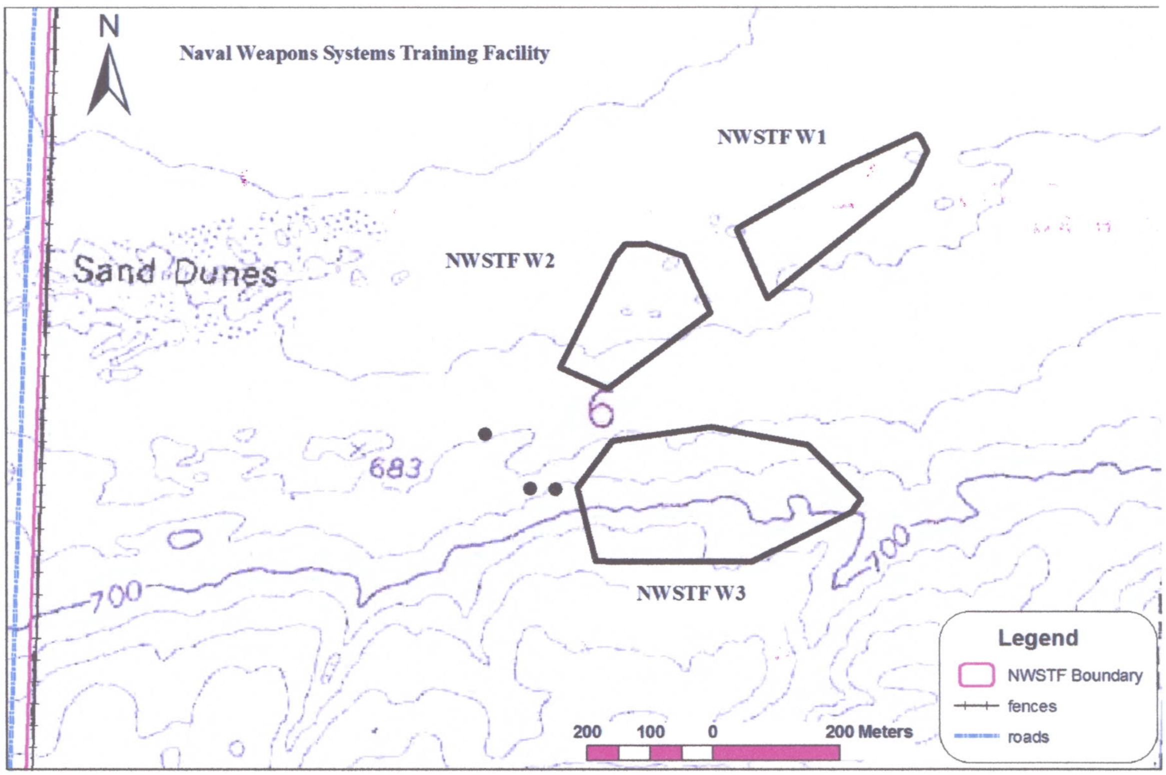


Figure 2b. Locations of Sage Sparrow nesting territories in the southwestern portion of Boardman NWSTF, 2009. The polygons indicate minimum convex polygons around three territories (NWSTF1, NWSTF2, and NWSTF3). The three points west of NWSTF3 probably represent a transient male detected on only one day in early April, well within the normal migratory period of Sage Sparrows.

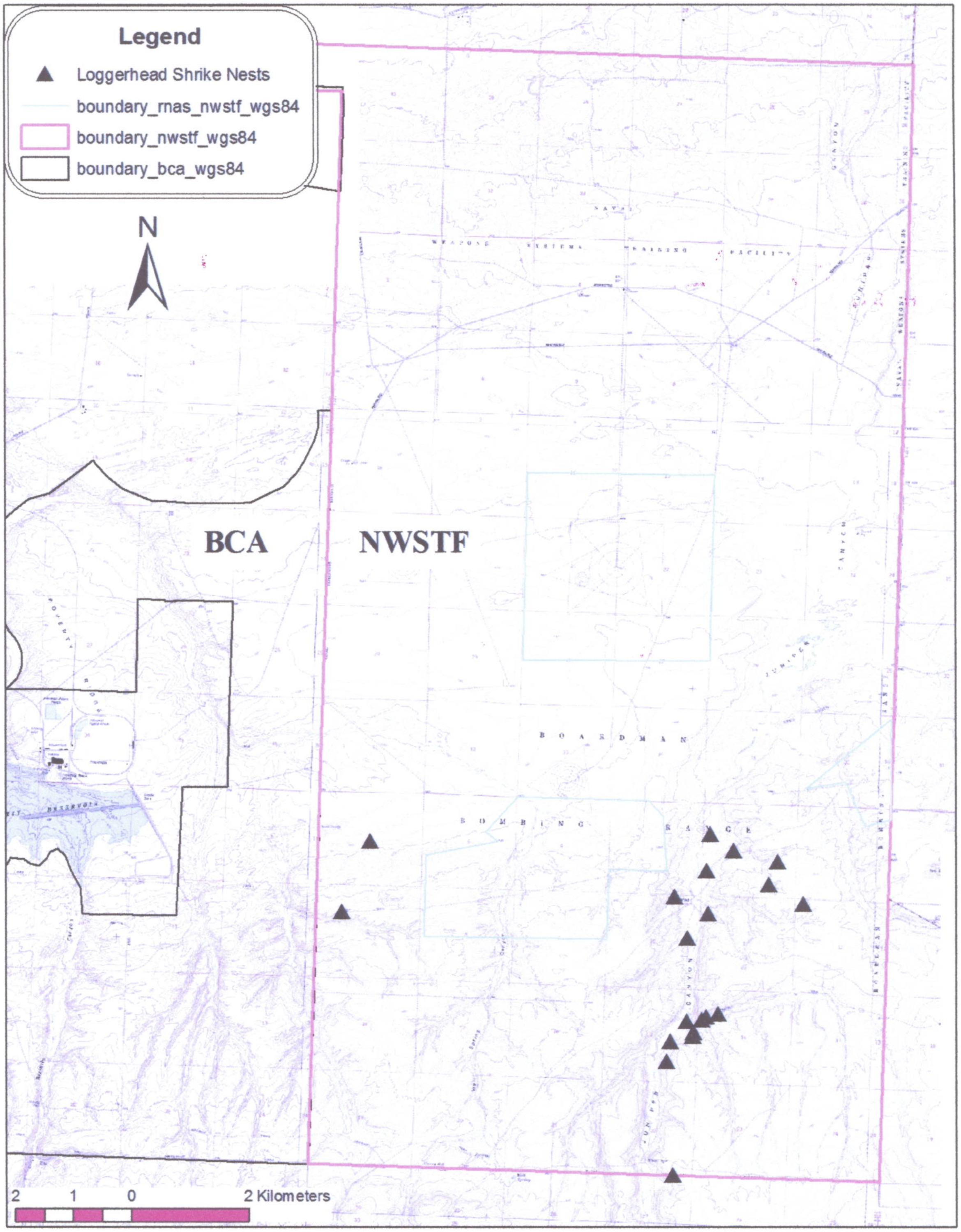


Figure 3a. Locations of Loggerhead Shrike nesting territories on Boardman NWSTF, 2009.

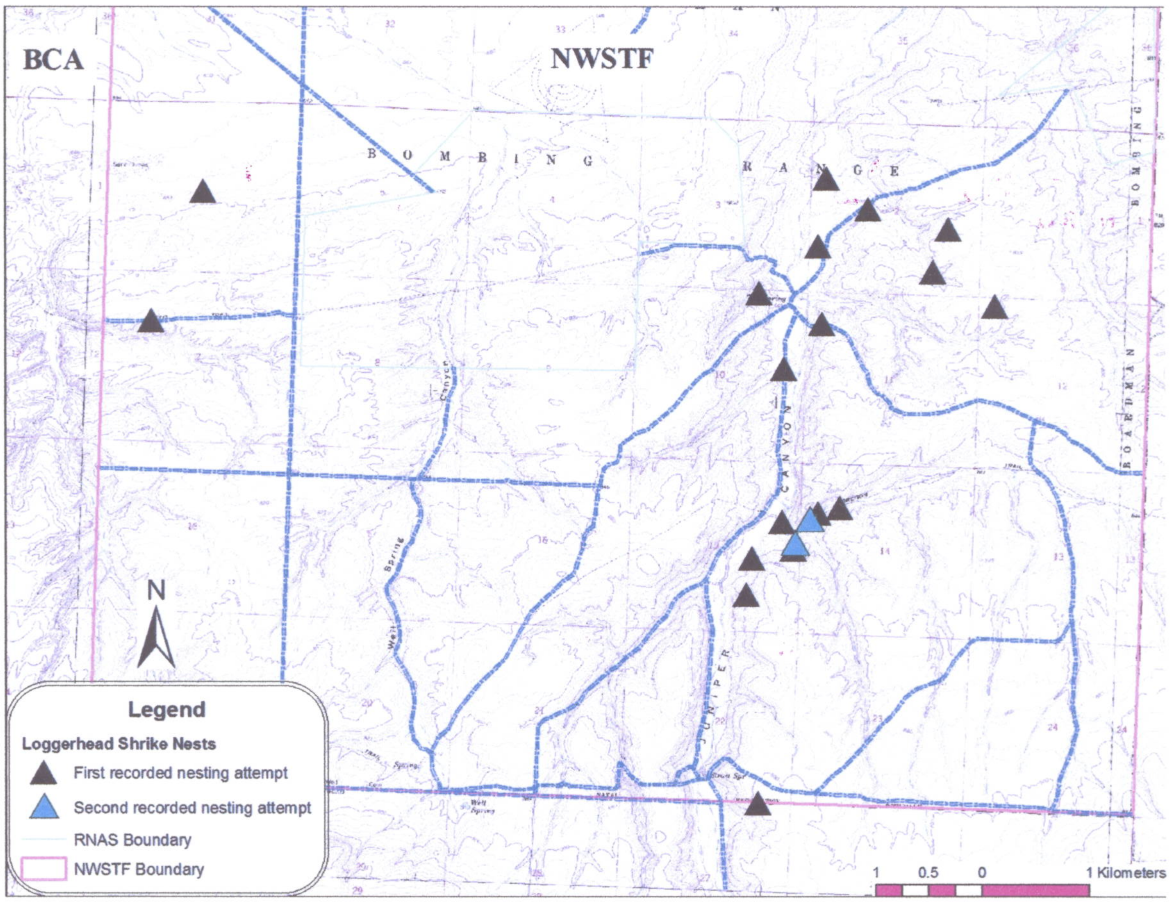


Figure 3b. Locations of Loggerhead Shrike nesting territories on Boardman NWSTF, 2009, shown at a larger spatial scale focused on the eastern cluster of territories around Juniper Canyon and the western cluster of territories near the border with the Boardman Conservation Area. The green triangles are locations of re-nest attempts of pairs that failed with earlier nesting attempts.

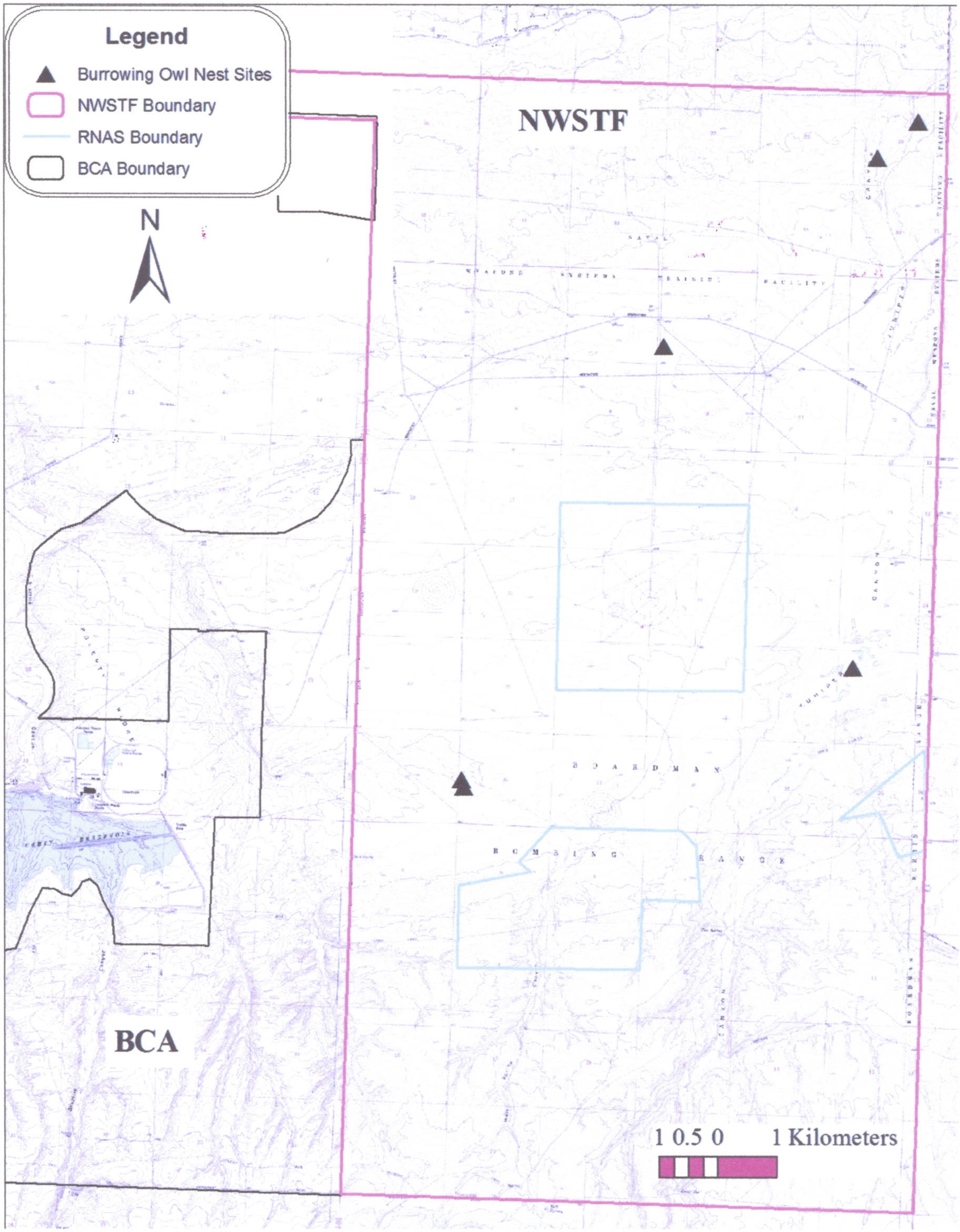


Figure 4a. Locations of Burrowing Owl nests on Boardman NWSTF, 2009.

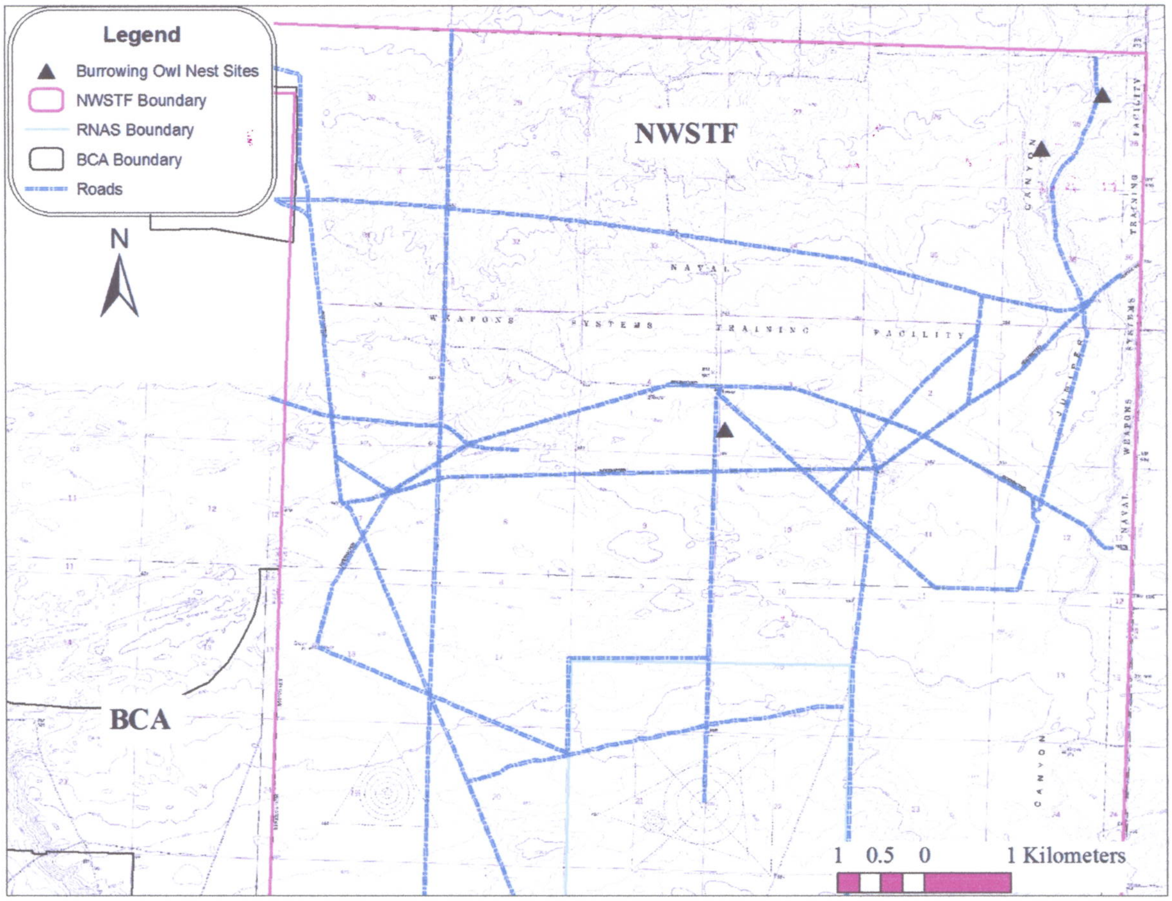


Figure 4b. Larger scale view of locations of Burrowing Owl nests in the northern section of Boardman NWSTF, 2009.

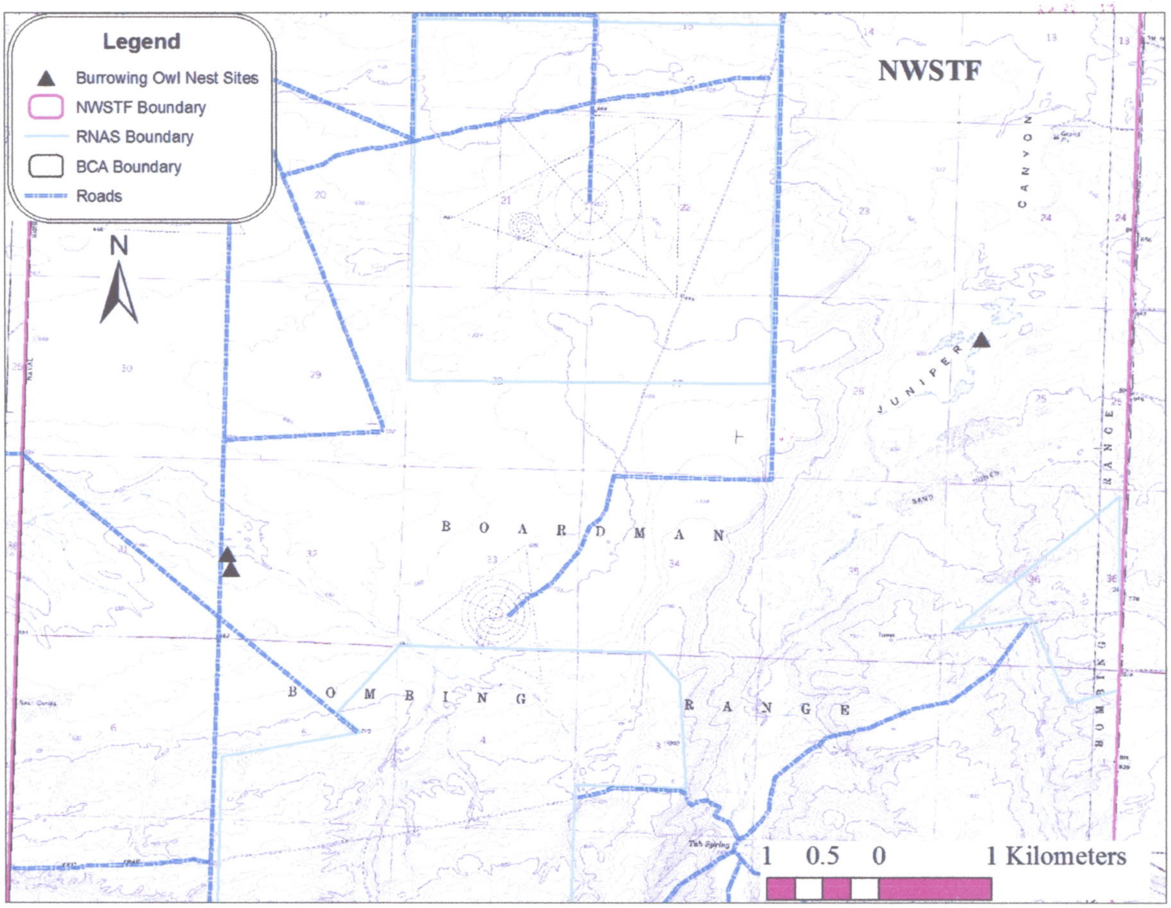


Figure 4c. Larger scale view of locations of Burrowing Owl nests in the southern section of Boardman NWSTF, 2009.

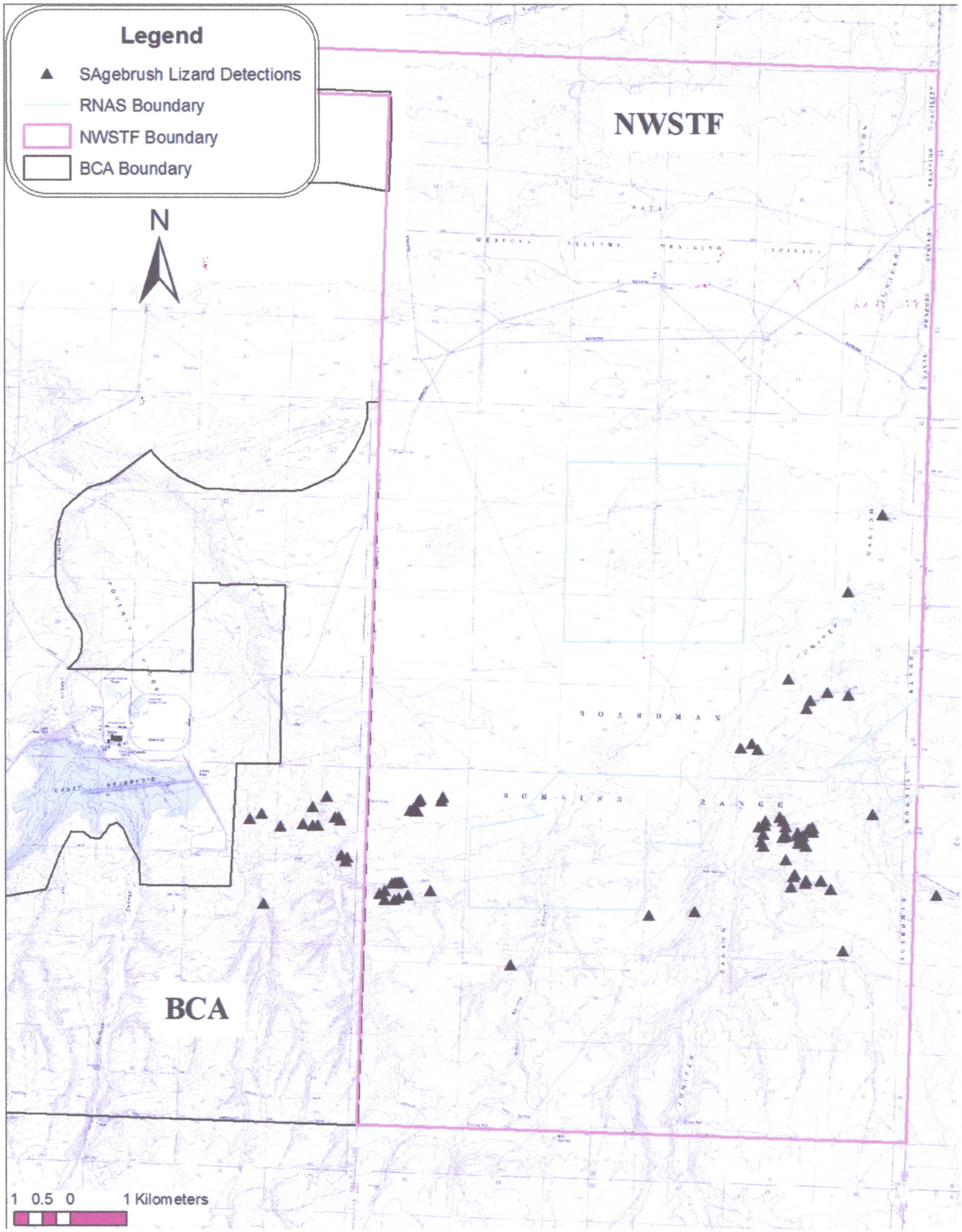


Figure 5a. Locations of sightings of Sagebrush Lizards on Boardman NWSTF and the eastern portion of the Boardman Conservation Area, 2009.

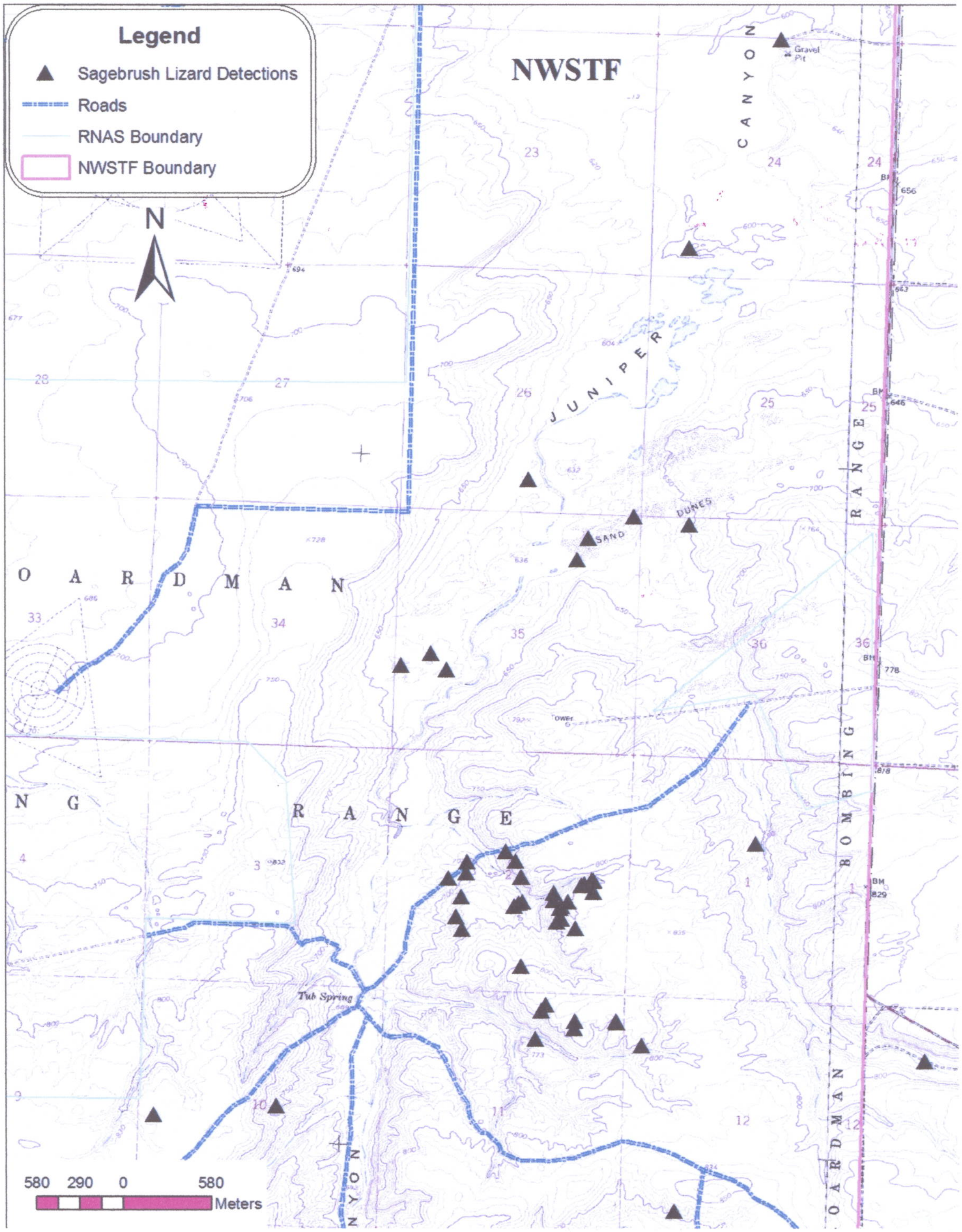


Figure 5b. Larger scale view of Sagebrush Lizard locations in the eastern NWSTF, 2009.

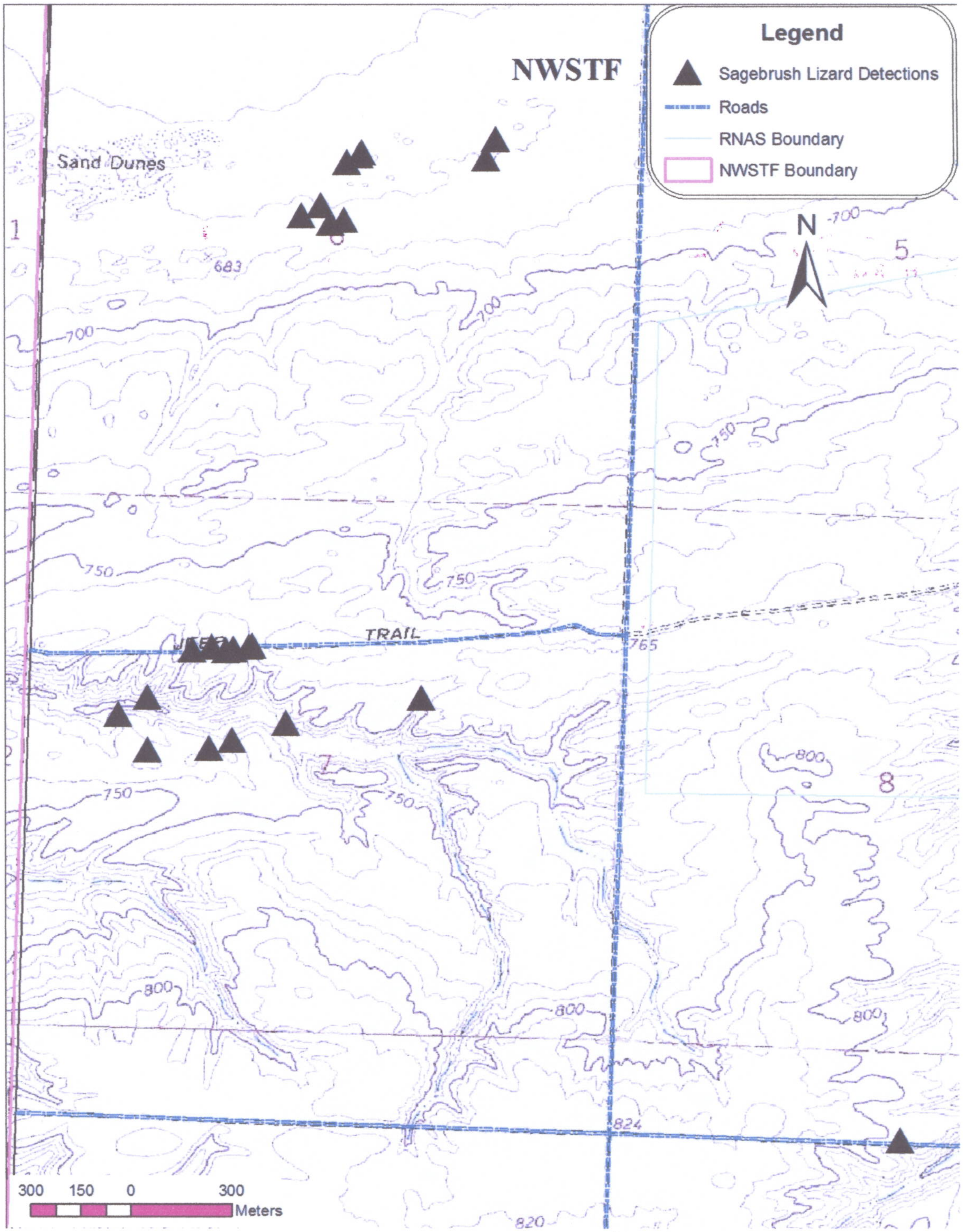


Figure 5c. Larger scale view of Sagebrush Lizard locations in the western NWSTF, 2009.

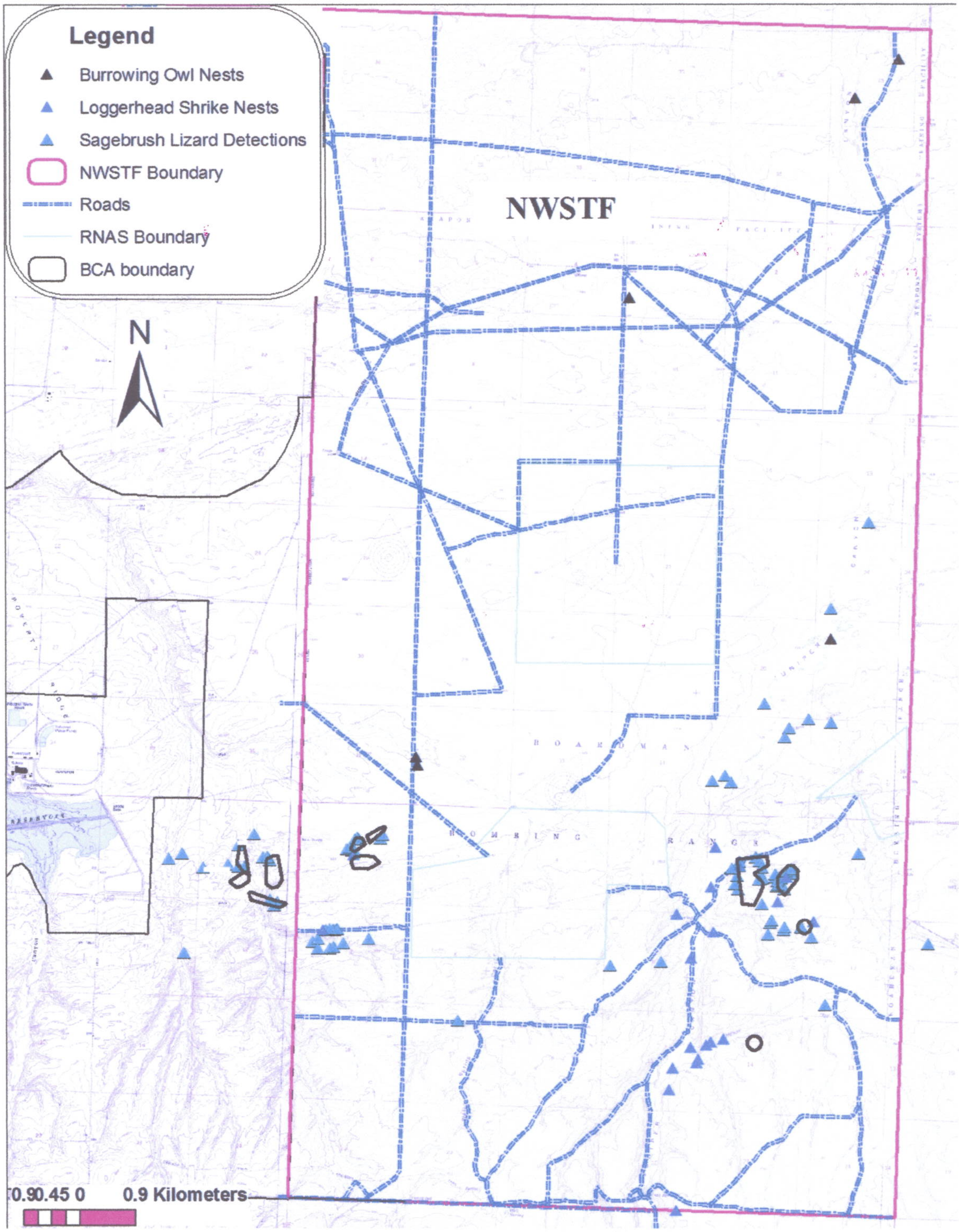


Figure 6. Map of the NWSTF and eastern portions of Boardman Conservation Area showing occurrences of Burrowing Owls (solid triangles), Loggerhead Shrike nests (blue triangles), Sagebrush Lizards (green triangles), and Sage Sparrow territories (black polygons). The areas of highest coincidence, and therefore highest density of sensitive species, are in Juniper Canyon, along Hey Road, and in the sagebrush remnants west of the Interstate near the border with Boardman Conservation Area.

HABITAT SELECTION BY NORTHERN SAGEBRUSH LIZARDS IN THE COLUMBIA BASIN, OREGON

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ABSTRACT- Habitat use by northern sagebrush lizards *(Sceloporus graciosus)* was investigated on the U.S. Navy's 19,400-ha Naval Weapons Systems Training Facility Boardman, Oregon, as part of an integrated multiresource research program. The objectives of the study were to determine what vegetation types these lizards occupied, and what specific habitat components they selected within these types. In general, northern sagebrush lizards were found in vegetation communities dominated by big sagebrush *(Artemisia tridentata)* and antelope bitterbrush *(Purshia tridentata),* and largely avoided communities dominated by gray rabbitbrush *(Chrysothamnus nauseosus),* cheatgrass *(Bromus tectorum),* and western needle-and-thread grass *(Stipa comata).* Usage within the bitterbrush and sagebrush habitats was determined by comparing sites occupied by lizards ($n$ □ 30) with general habitat sites randomly located within each habitat ($n$ □ 30). Results showed that these lizards selected for areas with significantly higher than average bare soil coverage and significantly lower than average coverage of grass, litter, and lichen. Furthermore, all sites occupied by lizards were located in sandy soils even though this soil type represented only half of the general habitat available. Overall, northern sagebrush lizards selected for sand blows with approximately 20% shrub coverage, and avoided areas with loamier soils covered (stabilized) with grass, litter, or lichen.

KEYWORDS: Northern sagebrush lizard, *Sceloporus graciosus,* habitat selection, shrub- steppe, Columbia Basin.

The northern sagebrush lizard *(Sce/oporus graciosus)* is a small iguanid lizard endemic to the sagebrush plains of Oregon and Washington (Storm and others 1995). It is especially common in the big sagebrush *(Artemisia tridentata)* and antelope bitterbrush *(Purshia tridentata)* habitats of central Columbia Basin. However, few studies have quantified habitat use by this species. Marcellini and Mackey (1970) found this species in California to prefer shrubby and open areas. Rose's (1976a) habitat descriptions for California sagebrush lizards were limited to study area specific terms such as the "loggy area" or "wide creek bottom". Reynolds (1979) found sagebrush lizards in Idaho to prefer sagebrush areas over areas dominated by introduced crested wheatgrass *(Agropyron cristatum).* Collectively, these studies and Rodgers (1953) suggest that sagebrush lizards prefer shrubby areas interspersed with open ground. In some cases, sagebrush lizards occur in rocky areas in the absence of competing western fence lizards (S. *occidenta/is)* (Rose 1976a, Storm and others 1995). These general habitat descriptors, however, make it difficult to identify or predict important sagebrush lizard habitat because not all shrubby or open areas in the West harbor these lizards.

The sagebrush lizard was listed as an Oregon Sensitive Species (Vulnerable) in 1997, largely due to continued conversion of Columbia Basin shrub-steppe to agriculture (Dobler and others 1996) and to invasion of shrub-steppe by non-native weedy annuals including cheatgrass *(Bromus tectorum*). This paper is to provide detailed information on habitat use requisites of this species so that land managers can accurately determine how much suitable habitat remains, and how to manage this habitat to reverse apparent population declines in this lizard.

## STUDY AREA AND METHODS

The study was conducted in May and June, 1995, on the U.S. Navy's 19,400-ha Naval Weapons Systems Training Facility Boardman (NWSTF Boardman), locally known as the Boardman Bombing Range, which is located 3 km south of Boardman, Oregon. The topography ranges from flat to undulating with elevations ranging from 120 m on the northern border to 250 m on the southern hillocks. Annual precipitation is approximately 22 cm; summers are characteristically hot and dry with temperatures occassionally exceeding 40°C. NWSTF Boardman is entirely shrub-steppe dominated by cheatgrass, western needle-and-thread grass *(Stipa comata),* gray rabbitbrush *(Chrysothamnus nauseosus),* and antelope bitterbrush on the sandy-soiled northern half of the range, and cheatgrass, and big sagebrush on the more loamy-soiled southern half. Small sand dune systems are found on both halves, the northern associated with bitterbrush, and the south with sagebrush. There are some small remnant stands of bluebunch wheatgrass *(A. spicatum),* and scattered small groves of western juniper *(Juniperus occidentalis*).

Information collected from reconnaissance surveys, during numerous studies of other vertebrates on NWSTF Boardman, and from the authors' detailed knowledge of the range revealed that the majority of sagebrush lizards occur either in bitterbrush- or sagebrush-dominated communities. Sagebrush lizards were occassionally observed along fencelines or at sand blows utilizing Russian thistle *(Salsola kali)* as cover. However, few or no lizards were observed in communities wholly dominated by rabbitbrush, bunchgrass, or cheatgrass. Given this information, two study subsites were established; a 1,500 ha bitterbrush area on the north end, and a 1,500 ha sagebrush study area on the southern end of the base.

To determine which habitat features sagebrush lizards selected for, habitat variables were measured at 15 plots in each the bitterbrush and sagebrush habitats where lizards were found (occupied sites). These were compared with measurements at 15 randomly located plots in each habitat regardless of whether lizards were present (general habitat). All occupied site plots were located during high lizard activity periods. Plot centers for occupied sites were determined by locating a random point in the study site, then traversing in a random location from the point until a sagebrush lizard was found. The plot center was then placed at the lizard burrow found nearest to the lizard sighting. It was assumed that significant differences in habitat values between occupied sites and the general habitat indicate selection for or against such variables.

Vegetation was sampled along 4 transects, each 5 m in length, radiating from the plot center. The transects were 90° apart with the first direction selected randomly. Percent cover of bare ground, shrub, forb, grass, litter, lichen, and dead shrub were determined using the line-intercept method (Piper 1973). An additional variable, shrub volume, was calculated by multiplying shrub intercept distance by 90% height of the intercepted shrub. In addition, soil type (loamy, loamy-sand, sandy-loam, or sand) was determined at each plot.

Differences in vegetative characteristics between occupied sites and the general habitat was tested using univariate analyses. In some cases, data were log normal transferred to achieve normality. Normally distributed data were tested using the two-sample t-test; for data where normality could not be achieved the nonparametric Mann-Whitney U-test was used.

## RESULTS

There were significant ($p < 0.05$) differences in vegetative characteristics between occupied sites and general habitat for both the bitterbrush and sagebrush habitats (Table I). In the bitterbrush habitat, sagebrush lizards selected for higher bare ground coverage and lower coverages of grass and litter. Similarly, in sagebrush habitat, lizards selected for higher bare ground coverage and lower grass, litter and soil lichen coverages. (Soil lichen is much more prevalent in sagebrush vs. bitterbrush habitats due to the loamier soils in sagebrush habitats.) The discrepancy between the apparent preference for higher coverage of dead shrubs in bitterbrush and for lower coverage of dead shrubs in sagebrush may be due to high standard deviations of this variable (which was larger than the mean in 5 of 6 cases), rather than actual habitat preference.

Soil texture was significantly different (.$x^2 = 23.72$, $p < 0.05$) between occupied sites and the general habitat. The soil texture at all lizard sites in both habitats was sandy, while IO (67%) of the bitterbrush general habitat sites and 7 (47%) of the sagebrush sites were loamy-sanded soils. The amount ofloam in the soil at a plot had a direct bearing on the percentage of grass, forbs, and litter and, consequently, the amount of bare ground. The sandy-soiled general habitat sites had on average 28.1% bare ground compared to only 19.1% on loamy-sand sites. However, sandy-soiled sites occupied by lizards had a much higher average percent bare ground (56.4%).

## DISCUSSION

Results from this study indicate that northern sagebrush lizards occupying NWSTF Boardman select habitats with a component of tall shrubs, such as bitterbrush or sagebrush, and a higher percentage of sandy, bare ground. These results are similar to Marcellini and Mackey's (1970) conclusion that sagebrush lizards at their northern California study site "tended to occupy areas with fine, sandy soil and little ground cover" and that "Widely scattered shrubs were used for shade and shelter." Both Rodgers (1953) and Rose (1976a) agree with our conclusion that sagebrush lizards favor areas with a high degree of bare ground; however, a portion of the populations studied by both of those observers were rock-dwelling and, therefore, not directly analogous to the population in this study.

The availability of sandy, bare ground and large shrubs is ecologically important to sagebrush lizards because of their foraging tactics. Sagebrush lizards are characterized as "sit-and-wait" predators (Rose 1976a). They wait under a shrub which provides cover from both the sun and aerial predators such as loggerhead shrikes *(Lanius ludovicianus*), and dash into open ground to capture passing ants or beetles (the major prey for this species [Rose 1976b, Guyer and Linder 1985)]). Bare ground facilitates the lizard's ability to move quickly and to scan greater distances for prey. Also, in an earlier study of burrowing owls on the NWSTF Boardman, Green and Anthony (1989) found owls selecting for habitats with a high percentage of bare ground, which they attributed to a high availability of ground-dwelling arthropods. Dense grass and litter not only provide protective cover for ground-dwelling arthropods, but they also impede movements and, possibly, the ability to mate (Tester and Marshall 1961). Rickard and Haverfield (1965) found beetle populations to be highest in their Columbia Basin study site where bare ground was predominant.

Much of northern Morrow County is underlain by unconsolidated sand derived from Columbia River sandbars of apparent Pleistocene age (Daubenmire 1970, Franklin and Dyrness 1973). Historically, our study area was known locally as "The Sands", a designation found on older maps, and a testament of the series of dunes that dominated the area. Today, many of these dunes have been stabilized through active sand blow control, or overgrown by invading cheatgrass, Russian thistle, and other weedy species of plants. Overgrown dunes and existing sagebrush lizard habitat are identifiable from aerial photography, and suggest that a large portion of the original sagebrush lizard habitat on NWSTF Boardman has been lost in the past century. The results from this study should be useful to land managers in accurately identifying remaining suitable habitat where habitat protection measures are needed.

## ACKNOWLEDGMENTS

This research was supported by Navy contract N44255-94-D-7309 and the Navy agricultural outleasing program. Steve Pennix and Matt Klope, wildlife biologists at Naval Air Station Whidbey Island, and LCDR Robert Purdom, NWSTF Boardman Officer in Charge, are acknowledged for their support. We also thank Aaron Holmes and Shay Howlin for their assistance with field measurements. Shanon Harris graciously assisted in the preparation of the manuscript. Robert Anthony and Clayton Antieau reviewed the manuscript and provided many helpful suggestions.

TABLE 1. Univariate analysis on vegetative characteristics of northern sagebrush lizard occupied and general habitats in bitterbrush and sagebrush communities of northcentral Oregon.

| Habitat | Variable | OccuEied | | General | | Sign. |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | |
| | | n= 15 | | n = 15 | | |
| Bitterbrush | % Bare Ground | 50.5 | 13.5 | 28.5 | 14.4 | *** |
| | % Shrub | 21.2 | 13.0 | 16.3 | 11.5 | |
| | %Forb | 9.7 | 6.7 | 8.8 | 4.5 | |
| | % Litter (np) | 7.1 | 4.4 | 11.8 | 7.2 | * |
| | % Grass (ln) | 2.5 | 3.8 | 24.9 | 22.9 | **** |
| | % Dead Shrub (ln) | 4.7 | 3.7 | 2.5 | 4.0 | * |
| | % Lichen (ln) | 4.4 | 7.7 | 7.2 | 7.5 | |
| | Shrub Volume ($m^2$) | 274.6 | 203.7 | 240.1 | 165.5 | |
| | | n = 15 | | n= 15 | | |
| Sagebrush | % Bare Ground | 62.3 | 16.6 | 15.8 | 15.1 | **** |
| | % Shrub (np) | 19.7 | 14.7 | 12.7 | 5.5 | |
| | % Forb (ln) | 8.3 | 11.6 | 11.3 | 9.3 | |
| | % Litter | 5.4 | 5.5 | 22.7 | 8.5 | **** |
| | % Grass (ln) | 2.5 | 2.5 | 16.2 | 13.5 | **** |
| | % Dead Shrub (np) | 1.2 | 2.5 | 5.3 | 6.0 | * |
| | % Lichen (np) | 0.5 | 2.1 | 16.0 | 13.4 | **** |
| | Shrub Volume (m2; np) | 507.1 | 393.9 | 289.6 | 130.8 | |
| | | n=30 | | n=30 | | |
| Bitterbrush/ Sagebrush (combined) | % Bare Ground | 56.4 | 16.0 | 22.2 | 15.8 | **** |
| | % Shrub (np) | 20.4 | 13.6 | 14.5 | 9.0 | |
| | % Forb (np) | 9.0 | 9.3 | 10.1 | 7.3 | |
| | % Litter (In) | 6.2 | 5.0 | 17.2 | 9.5 | **** |
| | % Grass (ln) | 2.5 | 3.2 | 20.5 | 19.0 | **** |
| | % Dead Shrub (np) | 3.0 | 3.6 | 3.9 | 5.2 | |
| | % Lichen (In) | 2.5 | 5.9 | 11.6 | 11.6 | **** |
| | Shrub Volume ($m^2$; np) | 386.8 | 326.8 | 264.8 | 148.7 | |

Letters in parentheses refer to transformation of data to achieve normality. 1n □ log normal transformation, np □ normality not achieved and nonparametric test applied.
* □p □0.05, ** □p □0.01, *** □p □0.001, **** □p □0.0001: Two-sample t-test for normally distributed variables, Mann-Whitney U-test for non-normally distributed variables.

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## Greg Green Unpublished NWSTF Boardman Research Data

Table 1. Diets of long-eared owls in Juniper Canyon, 1980 and 1994-1997.

| Species | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Perognathus parvus* | 88 | 87 | 19 | 19 | 49 | 52 | 40 | 69 | 64 | 75 | |
| *Dipodomys ordii* | 3 | 3 | 5 | 5 | 25 | 27 | 5 | 9 | 1 | 1 | |
| *Peromyscus maniculatus* | 7 | 7 | 52 | 53 | 10 | 11 | 9 | 16 | 7 | 8 | |
| *Reithrodontomys megalotis* | 0 | 0 | 16 | 16 | 6 | 6 | 1 | 2 | 7 | 8 | |
| *Onychomys leucogaster* | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | |
| *Thomomys talpoides* | 2 | 2 | 1 | | 2 | 2 | 0 | 0 | 2 | 2 | |
| *Microtus montanus* | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 4 | 5 | |
| *Microtine* | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 0 | 0 | |
| *Lemmiscus curtatus* | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Aves | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | |
| Total | 101 | 100 | 99 | 100 | 94 | 100 | 58 | 100 | 85 | 100 | |
| n (pellets) | 60 | | 50 | | 50 | | 50 | | 50 | | |
| | | | 1994 | | 1995 | | 1996 | | 1997 | | |

Table 2. Diets of barn owls in Juniper Canyon, 1994-1997.

| Species | 1994 Number | 1994 Percent | 1995 Number | 1995 Percent | 1996 Number | 1996 Percent | 1997 Number | 1997 Percent |
|---|---|---|---|---|---|---|---|---|
| *Perognathus parvus* | 53 | 28 | 35 | 53 | 74 | 46 | 82 | 52 |
| *Dipodomys ordii* | 3 | 2 | 8 | 12 | 4 | 3 | 17 | 11 |
| *Peromyscus maniculatus* | 59 | 31 | 2 | 3 | 23 | 14 | 25 | 16 |
| *Reithrodontomys megalotis* | 57 | 30 | 1 | 2 | 24 | 15 | 18 | 11 |
| *Thomomys talpoides* | 4 | 2 | 16 | 24 | 9 | 6 | 9 | 6 |
| *Microtus montanus* | 16 | 8 | 4 | 6 | 10 | 6 | 5 | 3 |
| *Microtine* | 0 | 0 | 0 | 0 | 16 | 10 | 0 | 0 |
| Sorex | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| *Sylvi/agus nuttalli* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | 192 | 100 | 66 | 100 | 160 | 100 | 159 | 100 |
| n (pellets) | 50 | | 50 | | 50 | | 50 | |

AN ABSTRACT OF THE THESIS OF

Geoffrey J. Pampush for the degree of Master of Science

in Wildlife Science presented on 15 December 1980

Title: Breeding Chronology, Habitat Utilization and Nest-site Selection of the Long-billed Curlew in Northcentral Oregon.

Abstract approved: Robert G. Anthony

Robert G. Anthony


Breeding ecology of long-billed curlews in Umatilla and Morrow Counties, Oregon, was studied during the spring and summer of 1978 and 1979. The first curlews were observed in the study areas on 16 and 19 March of 1978 and 1979, respectively. Earliest clutch completion and onset of incubation was on 1 April of both years.

Ninety percent of the observed nests (N = 112) had a clutch size of four eggs. A mean incubation period of 29 days $\pm$12 h was observed for ten nests of known history. Mean hatching date was 14 and 15 May of 1978 (N = 45, range: 1 May - 2 June) and 1979 (N = 66, range: 3 May - 4 June), respectively. A fledged juvenile (able to fly over 100 m) was first observed on 9 and 10 June of 1978 and 1979, respectively.

Flocking of curlews became evident by mid-June of both years and most curlews had departed from the study areas by mid-August of both years.

Five habitats in which territorial curlews were observed were defined, and habitat utilization by adults and adults with broods were sampled along four transects. Both adults and adults with broods occurred in habitats at frequencies significantly different from availability. In general, a preference for habitats of low vertical profile and low vertical density (plant parts/volume/height) was observed. Habitats of tall, dense shrubs or weedy annual vegetation were generally avoided.

Nest density varied from 0 - 9 nests/40 ha. Highest mean and single study plot nest density occurred in annual grass habitat (cheatgrass (*Bromus tectorum*)/Sandberg's bluegrass (*Poa sandbergii*) association). Nest success was 0.69 in 1978 (N = 40) and 0.65 in 1979 (N = 61). Predators destroyed 10.0 (4) and 16.4% (10) of the nests located in 1978 and 1979, respectively. Eight of 14 (57%) nests depredated over both years were destroyed by mammalian predators; at least three (21%) were taken by corvids, crows (*Corvus brachyrhynchos*) and magpies (*Pica pica*). Nest predation rate was significantly lower in annual grass habitats.

Five significant discriminant functions were generated which defined structural differences between nest-sites and general habitat characteristics. Variables related to vertical stratification of vegetation were important for three of the habitats. Vegetative coverage variables were important discriminants in only one habitat, bunchgrass. Overall, nest-sites were less complex above 5 cm than the habitats in general. Significant differences in nest-site structure among habitats were observed for 5 of 6 paired comparisons, indicating some plasticity in nest-site selection by breeding curlews. Nest density on the 40-ha study plots was negatively correlated with 17 of 21 significant variables. Highest negative correlations were with vegetative height and vertical density.

Breeding Chronology, Habitat Utilization
and Nest-site Selection of the Long-billed
Curlew in Northcentral Oregon

by

Geoffrey J. Pampush

A THESIS

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# BREEDING CHRONOLOGY, HABITAT UTILIZATION AND NEST-SITE SELECTION OF THE LONG-BILLED CURLEW IN NORTHCENTRAL OREGON

## INTRODUCTION

The long-billed curlew (*Numenius americanus*) is the largest North American shorebird and a conspicuous component of grassland avifauna. Formerly, the species bred in shortgrass and mixed grass habitats from coast to coast (Hall 1960). However the long-billed curlew and its congener, the Eskimo curlew (*N. borealis*), were intensively hunted with resulting near extinction of the Eskimo curlew and apparent drastic reduction in breeding long-billed curlew numbers. Concurrently, agricultural development of the prairies reduced the availability of breeding habitat. A continent-wide decline in breeding numbers was recognized (Jewett 1936, Dawson 1923, Sugden 1933, Bent 1962, Wickersham 1902) though quantitative data are not available.

Lewis and Clark mentioned the abundance of curlews along the Columbia River in April 1806 (Thwaites 1904). Dawson (1923) indicated that "wagonloads" of curlews were seen going down the Columbia River which implied a substantial hunting harvest since curlews generally are widely scattered and in low densities today.

Intensive livestock grazing in the late 1800's deteriorated range conditions throughout the Columbia Basin. Large tracts of native bunchgrass were stressed beyond recovery and the invasion of exotic cheatgrass (*Bromus tectorum*) resulted in a significant change in the vegetative structure of the shrubsteppe. Many sites formerly dominated by a sagebrush (*Artemesia tridentata*)-bluebunch wheatgrass

(*Agropyron spicatum*) association were burned and/or heavily grazed with fire killing the sagebrush, and cheatgrass, along with other seral species, replacing the bunchgrass. A plant community of low shrub cover and shorter grass resulted.

Throughout the 1970's, considerable discrepancy prevailed over the status of breeding curlews in the Columbia and Great Basins. Extensive agricultural development occurred in the Columbia Basin during the 1970's with over 100,000 ha of shrubsteppe vegetation converted to circle pivot irrigation systems in a five-county area alone (Muckleston and Highsmith 1978). Historical breeding curlew population numbers in this area were unknown, though many long-time residents believed that a drastic reduction in the breeding population has occurred as a result of the agricultural development (H. Curtis, pers. comm.). These changes in community physiognomy as well as protection of migratory birds from unrestricted hunting probably changed the abundance and distribution of breeding curlews in the Columbia and Great Basins.

Avian habitat preferences and utilization patterns are often intimately tied to structural features of the habitat (Cody 1968, Eiserer 1980, Hilden 1965, Wiens 1973). In order to predict how changes in habitat structure and overall availability might influence curlew breeding it was necessary to examine the relationship between structural features of habitat utilized by curlews and general features of the habitat available. In order to pursue this topic, I addressed two questions:

(1) Do curlews select particular habitats during the breeding cycle?

(2) Do curlews select a specific microhabitat for nest-site placement?

# STUDY AREAS

The study areas lie within the Columbia River Basin in northern Umatilla and Morrow Counties, Oregon (Fig. 1). All study plots are within 25 km of the Columbia River. Gently undulating topography characterizes the study areas near the river with increasingly steeper slopes occurring further south. Elevation ranges along a continuous gradient from 95 m at the study areas to roughly 1500 m in the Blue Mountains, 80 km south of the study areas. Sandy soil occurs along the Columbia River, grading into more tuffaceous soil to the south.

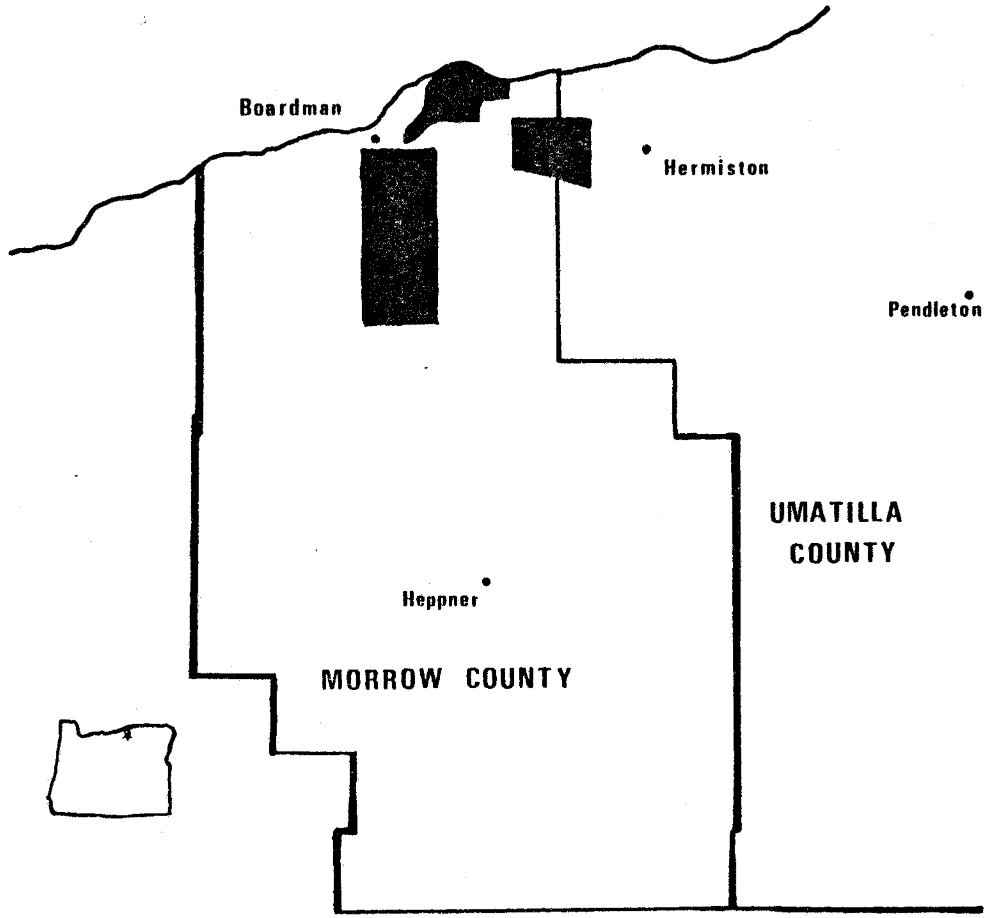
The climate of the area is characterized by hot, dry summers and moderately cold, moist winters. The 30-yr mean annual precipitation for the study areas was 21.67 cm (Ruffner 1978). Only one other isolated region in Oregon receives so little annual precipitation.

Dominant plant associations[1] are primarily grey rabbitbrush (*Chrysothamnus nauseosus*)-cheatgrass or bitterbush (*Purshia tridentata*)-cheatgrass associations along the Columbia River with sagebrush-bluebunch wheatgrass associations within 10 km south of the Columbia River.

Most of the former native vegetation has been drastically changed by intensive grazing, burning, and attempted cultivation on the sandy soils in the areas. In general, the study areas are of

[1]Associations are species groups recurrently observed by the author.

Figure 1. Location of study areas in northcentral Oregon.



two habitat types[2]; sagebrush-needle and thread (*Stipa comata*) on the sandy soils grading into a sagebrush-bluebunch wheatgrass habitat type on the southern end of one study area.

Currently the study areas are dominated by a grey rabbitbrush-cheatgrass association with lesser amounts of needle and thread, snowy buckwheat (*Eriogonum niveum*) and patchy Jim Hill mustard (*Sysimbrium altissimum*). On the more tuffaceous sites, some patches of sagebrush-bluebunch wheatgrass are extant with snakeweed (*Gutierrezia sarothrae*)-grey rabbitbrush-Sandberg's bluegrass-cheatgrass dominating the more disturbed sites.

Due to the extensive circle pivot agricultural development in the two-county area, potential study areas of adequate size were limited to federal landholdings. Three study areas were chosen for intensive investigation.

Umatilla National Wildlife Refuge-(McCormack Slough) - The refuge was established in 1968 primariy as mitigation for loss of Great Basin Canada Goose (*Branta canadensis moffitti*) habitat through a lease agreement with the U.S. Army Corps of Engineers. Formerly the land was heavily grazed with some parts cultivated. Currently the Fish and Wildlife Service maintains a cooperative farming program to provide forage for migratory waterfowl and to maintain wildlife diversity. Roughly 285 ha of a total land area of 1800 ha are farmed. The majority of the non-irrigated land on McCormack Slough is dominated by a grey rabbitbrush-cheatgrass

[2]Habitat types from Daubenmire, 1970.

association. Throughout much of this association, snowy buckwheat is subdominant with small patches of sagebrush and bitterbrush occurring. Cheatgrass is the ubiquitous, dominant grass species throughout the refuge. In some of the more stabilized areas, Sandberg's bluegrass codominates with crustose lichens and acrocarpous mosses covering the soil in the interstices between bluegrass clumps.

Umatilla Ordnance Depot - The Depot encompasses roughly 5,300 ha of a bitterbrush-cheatgrass-Sandberg's bluegrass association. The area is administered by the U.S. Army and serves as a military storage and supply depot. The depot is interlaced with a series of asphalt roads along which concrete-walled "igloos" are located, serving as storage structures. Approximately 1,000 "igloos" are systematically distributed over most of the depot excepting approximately 25% of the area which is free of man-made structures. The open areas generally surround the core of roads and igloos and form a 0.6 km wide band around the depot. From this band a number of study plots were chosen for investigation.

The U.S. Navy Boardman Bombing Range - The Bombing Range encompasses 20,300 ha and is used as a training site for U.S. Navy and Air Force bombers. Although the area is subjected to almost daily bombing during the curlew breeding season, a small central target area absorbs most of the training bombs. The study plots chosen for investigation were at least 3.0 km from the central target area.

The range's plant associations are variegated with a grey rabbitbrush-cheatgrass association dominating the sandy soils on the north end and a sagebrush-cheatgrass and rabbitbrush-snakeweed association dominating the deeper soils on the south end of the range. Roughly 80% of the range has been and currently is grazed by sheep and cattle. Those areas are dominated by plant associations indicative of disturbed sites (i.e. cheatgrass, Jim Hill mustard, evening primrose (Oenothera pallida), tumbleweed (Salsola kali), grey rabbitbrush and snakeweed). Some smaller tracts of land on the Bombing Range, roughly 10% of the total area, have not recently been grazed and have escaped heavy disturbance. Robust stands of sagebrush-bluebunch wheatgrass are found within those tracts. Two major canyon systems contribute to the greater topographical relief on the south end of the range. The canyon slopes are dominated by sagebrush with occasional junipers and a fairly uniform distribution of cheatgrass. The flat ridges are dominated by a snakeweed-grey rabbitbrush-cheatgrass association over most of the southern end of the range.

From the above three study areas, five habitats were chosen for intensive investigation. These habitats were chosen because curlews utilized them in varying degrees and they were each structurally unique and contiguous with each other. Some less dominant plant species were common to two or more habitats but dominant plant species varied between habitats with resultant unique physiognomy in each habitat.

THE HABITATS: Annual grass habitat - This habitat is of uniformly low vertical profile. Cheatgrass is the dominant graminoid with scattered patches of Sandberg's bluegrass intermixed and few perennial shrubs (Table 1). Prickly pear (Opuntia polyacantha) was common in some of the study plots along with tumbleweed and filaree (*Erodium cicutarium*). This habitat was grazed intensively by sheep on the Bombing Range.

Bitterbrush habitat - This habitat was dominated by a bitterbrush-cheatgrass association. The vegetative cover in the interstices between individual shrubs was generally sparse with cheatgrass, prickly pear, and other short forbs dominating these areas (Table 1).

Bunchgrass habitat - This habitat was dominated by fairly uniform stands of ungrazed, perennial bunchgrasses. Either bluebunch wheatgrass or needle and thread were prominent with few species of annual forbs occurring (Table 1).

Denseforb habitat - Dense annual vegetation dominated this habitat. Principal dominants were Jim Hill mustard, tumbleweed and tarweed with an understory of cheatgrass (Table 1). Grey rabbitbrush and snowy buckwheat also occurred in the habitat in low to moderate frequency. This habitat was not grazed by domestic livestock so residual vegetation remained between years.

Open-low-shrub habitat - High shrub coverage with little herbaceous vegetation in the interstices between shrubs characterized this habitat. The structure of this habitat was probably a result of cattle and sheep grazing on the heavier soils. The mean height of this habitat was considerably less than the bitterbrush habitat since it was dominated by the diminutive snakeweed and short grey rabbitbrush bushes. Cheatgrass and some Sandberg's bluegrass occurred in the interstices (Table 1).

Table 1. Quantitative description of the five habitats on the study areas. Means with standard deviations (in parentheses) are provided.

| VARIABLE | HABITAT | | | | |
|---|---|---|---|---|---|
| | Annual grass | Bitterbrush | Bunchgrass | Denseforb | Open-low-shrub |
| annual grass coverage[1] (%) | .28 (.09) | .38 (.14) | .35 (.09) | .37 (.09) | .36 (.10) |
| perennial grass coverage[2] (%) | .02 (.03) | tr[3] (.01) | .18 (.09) | .02 (.09) | tr (.02) |
| bare ground coverage (%) | .40 (.14) | .36 (.16) | .30 (.18) | .26 (.08) | .36 (.10) |
| herb coverage (%) | .20 (.12) | .07 (.09) | .04 (.05) | .20 (.11) | .05 (.07) |
| shrub coverage (%) | .02 (.03) | .08 (.06) | .02 (.02) | .07 (.05) | .12 (.05) |
| effective height (cm) | 24.80 (3.33) | 32.90 (6.94) | 29.60 (7.60) | 32.00 (4.00) | 28.00 (2.90) |
| overall vertical density | 1.18 (.26) | 1.42 (.36) | 1.63 (.20) | 1.66 (.23) | 1.29 (.27) |

[1] includes Sandberg's bluegrass (*Poa sandbergii*)

[2] *Stipa comata* and *Agropyron spicatum*

[3] trace - less than 1% coverage

# METHODS

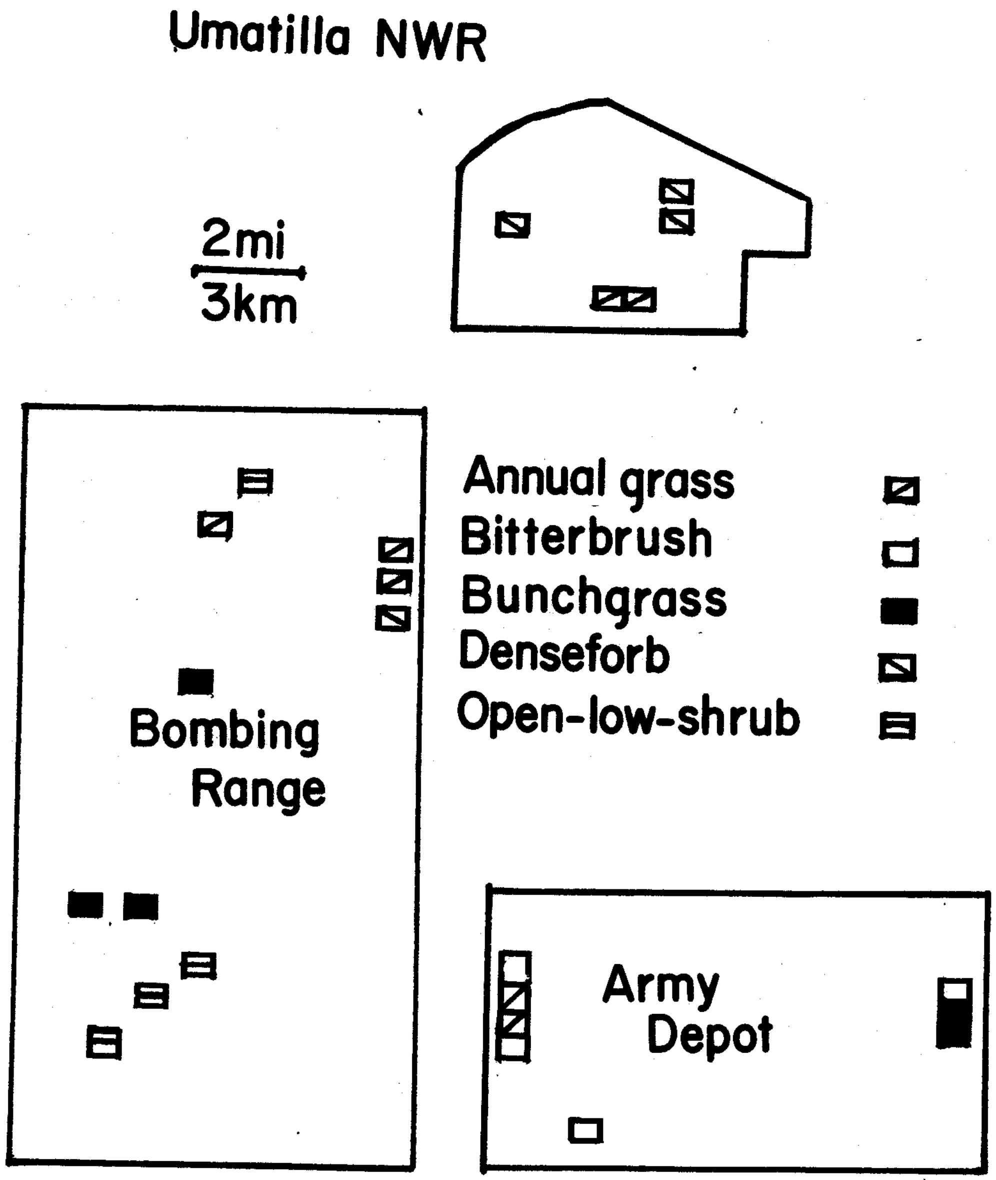
Upon arrival of the earliest returning curlews in 1978, (approx. 15 March) observations were initiated to determine the distribution and abundance of curlews on the three study areas. Behavior was observed throughout the prenesting phase of the breeding cycle to determine movement patterns and habitat utilization of breeding curlews. Most observations were conducted from a vehicle with 7 x 35 binoculars and a 20x spotting scope.

Systematic nest searching was begun in early April of both years. Nest searching was conducted by spacing people roughly 5 m apart and walking slowly, in a line, across the study plots. It was assumed that a majority of fixed proportion of nests was found in each plot by flushing the incubating adult.

During the early phase of the 1978 field season prior to nesting, it was not possible to estimate breeding territory size or nesting density. Also manpower was not readily available for nest searching. Therefore, it was not until late in the 1978 season that reasonable study plot size was established for comparison of nesting densities.

In 1979, 40-ha plots were established in each of the five habitats with at least four replicates (24 plots total) of each habitat (Fig. 2). These study plots were nest-searched from 7 April to 2 May using the technique described above with the aid of 1,300 students. Each of the five habitats was nest-searched sequentially with the replicate plots being searched under the same scheme (i.e., annual grass 1, bitterbrush 1, bunchgrass 1, denseforb 1, open-low-shrub 1, annual grass 2...open-low-shrub 4). This scheme was adopted

Figure 2: Distribution of 24--40-ha study plots on the three study areas.



to avoid sampling bias toward a particular habitat since the onset of nesting could vary over a six-week period.

Nest density per plot, clutch size, fate of nest, type of predator depredating nest, number of addled eggs, and number of eggs hatched per clutch were recorded during both seasons.

Censusing and Habitat Utilization - A modified strip census technique (Hayne 1949) was employed to determine habitat utilization and preference patterns of adult curlews and adults with broods. Four predetermined census routes through the three study areas were sampled throughout the breeding cycle. The assumption was made that all adult curlews within 50 m of the transect road (except incubating adults) were included in the sample. Curlews flying over the transect strip were not included unless they were males performing "display-flights". Since "display-flights" were performed over relatively fixed areas, the males performing them within the 100-m census strip were included in the sample.

Since adult curlews attending young exhibit a strong defensive response by flying toward and swooping down toward intruders (predator, vehicle, or human on foot), the census strip was widened to 150 m on either side of the transect road when censusing broods.

All of the habitat included within the transect strip was classified according to the previously described scheme (annual grass, bitterbrush, bunchgrass, denseforb, open-low-shrub) and also included cropland on McCormack Slough. Percentage of each habitat occurring along the transect routes was calculated.

Vegetative Measurements - A series of measurements was taken to describe characteristics of vegetative structure of study plots and nest-sites. In each of the 40-ha study plots, ten--100-m random transects were established perpendicular to each other with compass direction of the first randomly chosen. Variables measured were as follows:

Vertical density---number of touches of plant parts within 5-cm height increments on a 6-mm diameter vertical rod (Wiens 1973).

Effective height---height at which 90% of a white board, 30 cm wide, was obscured by vegetation when viewed from 10 m at 1-m eye-level.

Coverage---estimate of canopy coverage of grasses, herbs and bare ground using Daubenmire's (1959) technique. This consisted of using a 10 x 50 cm (0.1 $m^2$) frame along the transect and estimating coverage by class.

Shrub coverage---estimated using line-intercept method (Piper 1973) by summing the number of meters of each 100-m transect intercepted by a shrub and dividing by 100.

Evenness and Diversity---these indices were computed from the vertical density measurements described above.

See Table 2 for complete list of variables measured or computed.

Statistical Analyses - Habitat utilization data were analyzed on two levels. First, a chi-square test for independence was employed to determine whether or not habitats were utilized in proportion to availability. Secondly, after chi-square testing, confidence intervals were constructed about the theoretical proportion in order to determine

Table 2. Description of structural variables measured at nest-sites and in study plots.

| | |
|---|---|
| DENS | mean number nests per plot |
| ANGR | percent coverage of annual grass (Daubenmire 1959). |
| PERGR | percent coverage of perennial grass |
| TOTGR | percent coverage of all grass |
| BRGD | percent coverage of bare ground |
| HERB | percent coverage of herbaceous plants |
| CHNA | percent coverage by grey rabbitbrush (*Chrysothamnus nauseousus*) |
| ARTR | percent coverage by sagebrush (*Artemsia tridentata*) |
| GUSA | percent coverage by snakeweed (*Guttierezia sarothrae*) |
| PUTR | percent coverage by bitterbrush (*Purshia tridentata*) |
| SHRUB | mean coverage of all shrub spp. (by line intercept) |
| EFHT | height at which 90% of a white board is occluded by vegetation when viewed from 10 m at height of 1 m |
| FHDG | foliage height diversity of grass (based on 5-cm intervals) |
| FHDH | foliage height diversity of herbs |
| FHDS | foliage height diversity of shrubs |
| FHDTOT | foliage height diversity of all vegetation |
| FHEG | foliage height evenness of grass (based on 5-cm intervals) |
| FHEH | foliage height evenness of herbs |
| FHES | foliage height evenness of shrubs |
| FHETOT | foliage height evenness of all vegetation |
| HG25 | mean vertical density (0 - 25 cm) of grass (Wiens 1968) |
| HH25 | mean vertical density (0 - 25 cm) of herbs |
| HS25 | mean vertical density (0 - 25 cm) of shrubs |
| HTOT25 | mean vertical density (0 - 25 cm) of all vegetation |
| HG50 | mean vertical density (25 - 50 cm) of grass |
| HH50 | mean vertical density (25 - 50 cm) of herbs |
| HS50 | mean vertical density (25 - 50 cm) of shrubs |
| HTOT50 | mean vertical density (25 - 50 cm) of all vegetation |
| HGTALL | mean vertical density (50 cm) of grass |
| HHTALL | mean vertical density (50 cm) of herbs |
| HSTALL | mean vertical density (50 cm) of shrubs |
| HTOTALL | mean vertical density (50 cm) of all vegetation |
| HTOVRL | mean vertical density over all intervals of all vegetation |

whether the expected values for each habitat fell within the range of significant effects. Because several parameters were being estimated simultaneously, a $(1-\alpha)$ 100 percent "family" of confidence intervals with an $\alpha$ of 0.10 was used (Neu et al. 1974).

Nest-site characteristics were analyzed in three ways. First, discriminant function analysis was employed to determine which structural variables were important in discriminating between nest-sites and habitat in general. Discriminant functions were generated for four of the habitats plus one with all nests and habitats pooled. One discriminant function was generated in each comparison and variables were added stepwise with a minimum $\alpha$ of 0.15 ($F = 4.0$). A varimax vector rotation was used since it is believed to highlight the variable in the function which loads most heavily without change in variable composition of the model (Nie et al. 1975).

Nest-site characteristics were compared between habitats with Hotelling's $T^2$ test, to determine whether or not nest-sites were structurally different between habitats. Because the number of variables used exceeded the capacity of the C.D.C. 3300 computer, factor analysis was employed to generate linear combinations of variables used for $T^2$ analysis. After factor analysis, univariate t-tests were conducted to determine which variables contributed most to the significant differences between groups.

Nest density was tested for correlations with 28 variables describing vegetative characteristics of the plots using the Pearson correlation coefficient (Nie et al. 1975).

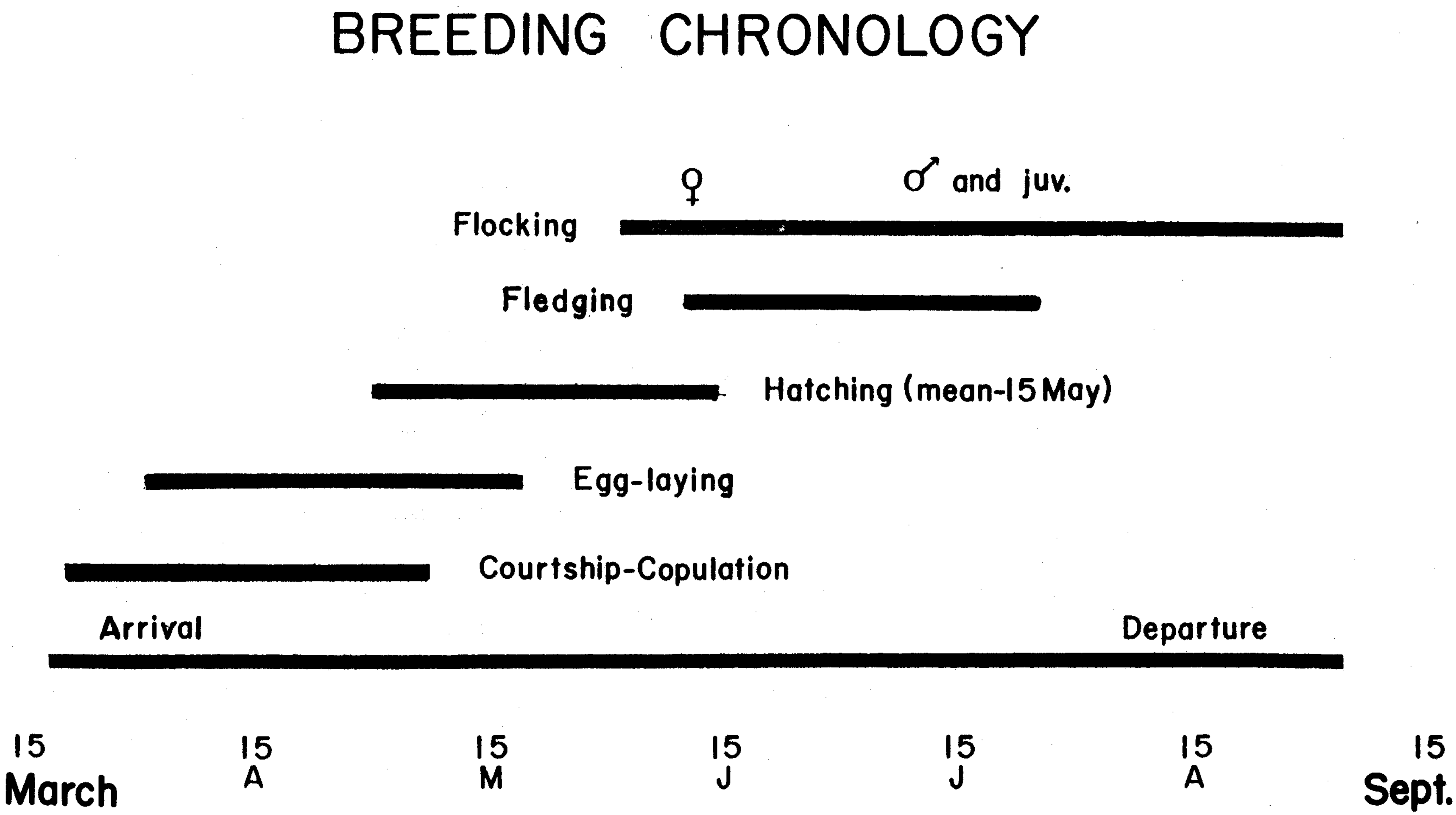
Normality of the structural data was checked and non-normal data were transformed. All coverage data were recorded as percent and thus were arcsine transformed; vertical density data were log transformed.

# RESULTS

Breeding Chronology - The first curlew was observed on the study areas on 16 and 19 March of 1978 and 1979, respectively (Fig. 3). Within two days after arrival, males began performing display-flights (See Allen 1980, pg. 35--Bounding SKK Flight). These display-flights were performed by paired and especially unpaired males. Frequency of display-flying was highest during the prenesting phase of the breeding cycle, and males performed these flights more or less synchronously in a given area. Males foraging in association with a female occasionally performed these display-flights during the prenesting phase. These may possibly have been incipient pairs which were not together during the previous breeding season. Most other males with females performed display-flights infrequently, if at all, which suggested that these were more firmly established pair bonds.

A distinct population component of "non-breeding" males was evident on the study areas and comprised up to 20% of the total population. These males defended relatively plastic territories which were often contiguous with the territory of a mated pair. Flight of a female or mated pair through its territory generally elicited a display-flight from a non-breeding male and these non-breeders performed display-flights into June, often soliciting for copulation with a female while she was away from her territory. On numerous occasions I observed non-breeding males performing display-flights over the territory of a mated pair, and occasionally directly over an incubating male.

Figure 3: Diagram of breeding chronology of long-billed curlews in northcentral Oregon during spring/summer 1978-79.



"Scraping" by adult males was first observed on 20 and 21 March of 1978 and 1979, respectively. "Scraping" appeared to function as the first step in a behavioral sequence culminating in copulation. Over the course of 3 - 10 days, females became progressively less evasive of the males' copulation attempts and finally submitted. The earliest "successful" copulation was observed on 26 March 1978. Earliest clutch completion and onset of incubation on the three study areas was 1 or 2 April (backdated 29 days from earliest hatching date) with a few clutches completed as late as 15 May. Renesting was not documented though the protracted clutch completion period suggested this possibility.

Ninety percent of the observed nests (N = 112) had a clutch size of four eggs, nine percent contained three eggs and one nest (1%) contained only two eggs. Net clutch size might be influenced by predators since an incomplete clutch may be unattended up to five days during egg-laying. Crows and magpies regularly foraged throughout the study areas and may have removed one or the only egg from the nest cup. Corvid depredated eggs were often found near tall shrubs.

A mean incubation period of 29 days $\pm$ 12 h was observed (range: 28 - 31 days) for 10 nests of known history. Mean hatching date was 14 and 15 May of 1978 (N = 45, range: 1 May - 2 June) and 1979 (N = 66, range: 3 May - 4 June), respectively.

A fledged juvenile (able to fly over 100 m) was first observed on 9 and 10 of 1978 and 1979, respectively. During this same time period, many adult females disappeared from the study areas leaving the adult males in attendance with the broods.

Flocking became evident in mid-June of both years with peak numbers occurring in July on Carty Reservoir near the Bombing Range. A flock of 500 curlews was observed from mid through late July 1979 on the reservoir mudflats (R. Klein, pers. comm.). During this time period large flocks were observed foraging on grasshoppers on the Bombing Range in the snakeweed-cheatgrass flats. Based on bill lengths and wing and tail-feather development, it appeared that no adult females remained in the flocks and that at least 80% of the birds were juveniles. By mid-August most curlews had departed from the vicinity of the study areas.

Nest Density and Success - Nest density varied considerably between habitats and between plots within habitats (Table 3). Highest mean nest density and highest single study plot density occurred in annual grass habitat. Nine nests were located in one 40-ha plot in a gently sloping, cheatgrass dominated swale. No other study plots within annual grass habitat supported such a high density. Nest density was not uniformly high throughout the annual grass habitat, and curlews nested in low densities in all other habitats. The greatest density observed in any other plot (other than in annual grass) was in bunchgrass habitat (3 nests/40-ha). This particular plot adjoined several hundred hectares of annual grass habitat, and the dispersion of nest-sites within the bunchgrass plot was linear along the short-grass-bunchgrass interface. The presence of annual grass habitat apparently influenced nest-site placement.

Table 3. Observed nest densities for long-billed curlews in the five habitats in 1979 (N=45).

| HABITAT | MEAN DENSITY PER 40-ha PLOT | RANGE |
|---|---|---|
| Annual grass | 3.6 | 2 - 9 |
| Bunchgrass | 1.4 | 0 - 3 |
| Denseforb | 1.3 | 0 - 2 |
| Open-low-shrub | 1.0 | 0 - 2 |
| Bitterbrush | 0.5 | 0 - 1 |

Nest success was high during both breeding seasons. Including both predation and abandonment, nest success (Mayfield 1975) was 0.69 in 1978 and (N = 40) and 0.65 in 1979 (N = 61). Predators destroyed 10 (4) and 16.4% (10) of the nests located in 1978 and 1979, respectively. Four nests were abandoned in 1978 and two in 1979. Cause of nest abandonment was unknown.

Nest predation rate was significantly higher than expected in habitats other than annual grass ($X^2 = 6.36$, $p < 0.05$), suggesting that either predators were more dense or nests were more vulnerable in non-annual grass habitats.

Eight of 14 nests (57%) depredated over the two-season study were destroyed by mammalian predators. Corvids (crows and magpies), were responsible for at least three of 14 (21%) of the nest predations.

Depredation rate of partial clutches was immeasurable and may have occurred at rates higher than calculated daily depredation rate during incubation. Egg shells were frequently found alongside tall shrubs during nest-searching, suggesting that corvids were responsible for the depredation.

Habitat Utilization--Adults - Adult curlews utilized habitats in proportions different from availability on all three study areas ($p < 0.05$)(Table 4). The annual grass habitat was highly preferred along the two transects which had the highest density of curlews (Bombing Range North, 1.88 km/curlew and Army Depot, 2.48 km/curlew). Annual grass habitat was used roughly in proportion to availability along the other two transects.

Table 4. Habitat utilization of adult long-billed curlews along four transects in northcentral Oregon during spring 1979.

| TRANSECT | HABITAT | NUMBER OF ADULTS OBS. | PRECENT USE | % AVAIL. | CONFIDENCE LIMITS |
|---|---|---|---|---|---|
| Bombing Range South ($X^2 = 20.4$, $P < 0.05$) | Annual grass | 10 | .09 | .08 | .03-.15 |
| | Bunchgrass | 9 | .08* | .17 | .02-.14 |
| | Denseforb | 2 | .02* | .15 | .00-.05 |
| | Open-low-shrub | 74 | .70* | .59 | .60-.80 |
| Bombing Range North ($X^2 = 53.4$, $P < 0.05$) | Annual grass | 122 | .55* | .33 | .47-.63 |
| | Bunchgrass | 14 | .06* | .12 | .02-.10 |
| | Denseforb | 77 | .35* | .44 | .27-.43 |
| | Open-low-shrub | 7 | .03* | .11 | .00-.06 |
| Army Depot ($X^2 = 500.3$, $P < 0.05$) | Annual grass | 177 | .76* | .20 | .70-.82 |
| | Bitterbrush | 26 | .11* | .39 | .06-.16 |
| | Bunchgrass | 27 | .12* | .05 | .07-.17 |
| | Denseforb | 4 | .02* | .36 | .00-.04 |
| Umatilla Rufuge ($X^2 = 176.5$, $P < 0.05$) | Annual grass | 26 | .11 | .09 | .07-.15 |
| | Denseforb | 27 | .12* | .54 | .08-.16 |
| | Cropland | 177 | .77* | .37 | .73-.81 |

* Denotes a statistically significant difference in use of habitat from expected based on availability.

Cropland was highly preferred along the Umatilla Refuge transect though the particular field utilized varied with changes in vegetative structure. Curlews used cropland as long as the vegetation was low profiled (or the ground fallow) and ceased use when the vegetation grew beyond 30 cm tall. Wheat, potatoes and alfalfa comprised the cropland and the alfalfa was recurrently available for utilization by curlews, depending upon haying schedule.

Bunchgrass on the Army Depot and open-low-shrub on the Bombing Range South were both slightly preferred. However the bunchgrass tract was contiguous with an irrigated pasture and annual grass habitat in which two nests were located. The proximity of these two habitats may have influenced use of the bunchgrass habitat in this area. The open-low-shrub habitat comprised 59% of the available habitat on the Bombing Range South which, coupled with low curlew density, may have influenced the slight preference for this habitat. Even though the open-low-shrub habitat was dominated by snakeweed along the transect, it is a much shorter shrub than rabbitbrush or bitterbrush with mean effective height (EFHT) of 16 cm.

Denseforb and bitterbrush habitats were avoided wherever they occurred along the transects. Bunchgrass was avoided on the Bombing Range North and South transects. Open-low-shrub was avoided on the Bombing Range North. In general, curlews preferred habitats of low vertical profile or low mean vertical density and avoided habitats of greater vertical profile or high mean vertical density.

Adults with Broods - Although adult females generally abandon their mates and broods prior to fledging of the young, adult males generally remain with the brood until the young are able to fly. Habitat utilization patterns of pairs or males alone with broods were similar to adult habitat utilization patterns. (Tables 5 and 6).

Along three of four transects, broods occurred in habitats at significantly different frequencies than expected ($p < 0.05$)(Table 5). Annual grass habitat was preferred along all three transects. Chicks foraged extensively on grasshoppers (*Orthoptera*) which grazed on *Psoralea* in the annual grass habitat.

Habitats of greater height and vertical density were avoided by the broods. Bitterbrush habitat was avoided on the Army Depot even though the interstices between shrubs were very similar structurally, to the adjacent annual grass habitat. The vertical component of this habitat appeared to influence habitat utilization. Denseforb habitat was avoided on all three transects, even though grasshopper densities appeared as high in this habitat as in annual grass. Denseforb habitat had the highest mean vertical density of all five habitats (4.42) and second greatest effective height (behind Bitterbrush habitat). Curlew chicks often struggled to get through the dense annuals (*Sysimbrium*, *Amsinckia*) and adults probably had limited visibility when in the habitat.

Cropland was used by broods on a periodic basis along Umatilla Refuge transect. Median hatching date roughly coincided with first alfalfa cutting on Umatilla Refuge. Immediately prior to swathing, alfalfa fields were unused by curlews. However, swathing provided a habitat of low vertical profile and unveiled an abundance of invertebrates. Curlews opportunistically exploited the alfalfa

Table 5. Habitat utilization of adult long-billed curlews with broods along four transects in northcentral Oregon during spring/summer 1979.

| TRANSECT | HABITAT | NO. OF BROODS OBS. | % USE | % AVAIL. | CONFIDENCE LIMITS |
|---|---|---|---|---|---|
| Bombing Range South ($X^2 = 1.25$, $P < 0.05$) | Annual grass | 2 | .06 | .08 | |
| | Bunchgrass | 4 | .12 | .17 | |
| | Denseforb | 6 | .18 | .15 | |
| | Open-low-shrub | 22 | .65 | .59 | |
| Bombing Range North ($X^2 = 81.9$, $P < 0.05$) | Annual grass | 99 | .64* | .33 | .55-.73 |
| | Bunchgrass | 4 | .02* | .12 | .00-.05 |
| | Denseforb | 27 | .17* | .44 | .10-.24 |
| | Open-low-shrub | 24 | .16 | .11 | .09-.23 |
| Army Depot Transect ($X^2 = 400.1$, $P < 0.05$) | Annual grass | 159 | .74* | .20 | .67-.81 |
| | Bitterbrush | 37 | .17* | .39 | .11-.23 |
| | Bunchgrass | 10 | .05 | .05 | .02-.08 |
| | Denseforb | 8 | .04* | .36 | .01-.07 |
| Umatilla Refuge ($X^2 = 17.0$, $P < 0.05$) | Annual grass | 8 | .28* | .09 | .11-.45 |
| | Denseforb | 7 | .24* | .54 | .08-.40 |
| | Cropland | 14 | .48 | .37 | .29-.67 |

* Denotes a statistically significant difference in use of habitat from expected based on availability.

Table 6. Summary of habitat utilization patterns by adults and adults with broods along four transects in northcentral Oregon.*

| TRANSECT | ADULTS | | | ADULTS WITH BROODS | | |
|---|---|---|---|---|---|---|
| | Preferred | Neutral | Avoided | Preferred | Neutral | Avoided |
| Army Depot | Annual grass<br>Bunchgrass | | Denseforb<br>Bitterbrush | Annual grass | Bunchgrass | Bitterbrush<br>Denseforb |
| Bombing Range North | Annual grass | | Bunchgrass<br>Denseforb<br>Open-low-shrub | Annual grass | Open-low-shrub | Bunchgrass<br>Denseforb |
| Bombing Range South | Open-low-shrub | Annual grass | Bunchgrass<br>Denseforb | (Chi-square insignificant, P > 0.05) | | |
| Umatilla Refuge | Cropland (alfalfa) | Annual grass | Denseforb | Annual grass | Cropland (alfalfa) | Denseforb |

* Preference determined with "family" confidence intervals, $\alpha = 0.10$.

fields for some period of time following cutting. When the alfalfa grew beyond approximately 30 cm tall, curlew use ceased, at least until the next swathing. On Umatilla Refuge, adults with broods remained in a given alfalfa field for up to three weeks although the annual grass habitat in which the pairs nested was contiguous with the alfalfa fields.

The bunchgrass habitat was avoided by broods on the Bombing Range North and used in proportion to availability on the Army Depot. The patchiness of needle and thread grass along the Army Depot transect provided microhabitat of annual grass interspersed with bunchgrass. Use of bunchgrass habitat was restricted to stands which were contiguous with annual grass habitat. Expansive stands of bunchgrass habitat were avoided by adults with broods.

The open-low-shrub habitat was used in proportion to availability on the Bombing Range North. This habitat comprised 11.0% of the available habitat and annual grass (33%) and denseforb (44%) habitats occurred in close proximity to open-low-shrub. This habitat may be particularly important in conjunction with annual grass habitat as a source of thermal cover during hot days before the young have fledged.

Nest-site Selection - Statistically significant structural differences between nest-sites and general habitats were found in four of five habitats (Table 7). When pooled nest-site data were compared with pooled habitat data, a significant discriminant function was generated which discriminated nest-sites from habitats in general. A significant discriminant function was not generated between nest-sites and habitat for the bitterbrush habitat. Although ocular comparison indicated distinct differences, the small sample size of nests (N = 2) made statistical comparison futile. The bitterbrush habitat was generally avoided by curlews even when it was contiguous with annual grass habitat on the Army Depot.

For the annual grass habitat, the discriminant function correctly classified nest-sites and random transects for 74% of the cases (nests and random transects). Three significant variables loaded similarly in the model and all three were measures of vertical components of the habitat; effective height (EFHT), overall foliage evenness (FHETOT) and vertical density of herbs from ground to 25 cm high (HH25). Effective height (EFHT) and foliage height evenness (FHETOT) were greater in the habitat in general than at nest-sites, which indicated that the nest-sites were of shorter and vertically patchier vegetation than the habitat. Mean vertical density of herbaceous plants in the 0 - 25 cm height interval (HH25) was greater at the nest-sites than along random transects, reflecting the frequency of occurrence of standing dead tumbleweed plants and live Opuntia cactus that occurred in association with the nest-site microhabitats in the sandy soil.

For the bunchgrass habitat, the discriminant function correctly classified 54% of the cases. Three significant variables; total grass coverage (TOTGR), bare ground coverage (BRGD) and herb coverage (HERB), all coverage related, were included in the model. Total grass coverage (TOTGR) loaded most heavily with a higher mean value at nest-sites than along random transects. Though annual grass coverage constituted a significant component of the habitat (35%), the differences between mean coverage values at nests and along random transects were small (37 and 35%, respectively). Herb coverage (HERB) was slightly higher at nest-sites than along random transects (6.0 versus 4.0%), due primarily to the occurrence of Phlox and Lupinus. Bare ground coverage (BRGD) was included in the model, but its inclusion is an apparent artifact of the computer analysis because the differences in means and standard deviations at nest versus random transects are negligible (means: 0.296 vs 0.297, S.D.: 0.067 vs 0.081, respectively).

The discriminant function for denseforb habitat correctly classified 87% of the cases with three variables (TOTGR, EFHT, FHDH). Effective height (EFHT) was the most important variable in the model with nest-sites having lower mean values than random transects (23.7 and 32.0 cm, respectively). Total grass coverage (TOTGR) and foliage height diversity of herb (FHDH) loaded similarly in the model and were lower for nest-sites than along random transects.

The denseforb habitat was compositionally similar but structurally quite different from annual grass habitat. Mean effective height at nest-sites was very similar for both habitats but mean effective height values for random transects between the habitats differed considerably (Table 7). Curlews chose nest-sites away from the taller, denser cover as evidenced by the inclusion of the herb height diversity variable in the discriminant model. Sysimbrim and Amsinckia, both annual herbs, occurred in highest frequencies where recent soil disturbance had occurred. Nest-sites were generally located in patches where the soil was more stabilized and cheatgrass-Sandberg's

Table 7. Discriminant function coefficients for comparisons between nest-sites and general habitat characteristics of long-billed curlews in northcentral Oregon. Means and standard deviations for variables at nest-sites and habitats are given in parentheses.

| HABITAT | TOTGR | BRGD | HERB | EFHT | FHDG | FHDH | FHETOT | HH25 | HG50 | HSTALL | Correctly Classified |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Variables in the discriminant models | | | | | | | |
| Annual grass | | | | -.52 | | | -.64 | 55 | | | 74% |
| nest-sites | | | | (22.2±2.8) | | | (.68±.16) | (.50±.31) | | | |
| habitat | | | | (24.8±3.3) | | | (.76±.07) | (.38±.22) | | | |
| Bunchgrass | 1.48 | .86 | .97 | | | | | | | | 84% |
| nest-sites | (67±.16) | (.30±.07) | (.06±.08) | | | | | | | | |
| habitat | (55±.12) | (.30±.08) | (.04±.05) | | | | | | | | |
| Denseforb | -.51 | | | -1.25 | | .58 | | | | | 87% |
| nest-sites | (.32±.08) | | | (23.7±3.5) | | (.62±.08) | | | | | |
| habitat | (.40±.09) | | | (32.7±4.0) | | (.72±.26) | | | | | |
| Open-low-shrub | | | | 1.00 | | | | | | | 82% |
| nest-sites | | | | (22.0±3.7) | | | | | | | |
| habitat | | | | (28.0±2.9) | | | | | | | |
| Pooled Data | | | | -.89 | .80 | | -.54 | | -.50 | -.31 | 76% |
| nest-sites | | | | (23.8±3.8) | (.60±.12) | | (.70±.12) | | (.80±.12) | (.02±.09) | |
| habitat | | | | (28.9±5.1) | (.62±.16) | | (.76±.08) | | (.15±.18) | (.05±.15) | |

bluegrass dominated. Cheatgrass grew in dense patches in some areas within the denseforb habitat. Generally, the open, cheatgrass dominated areas where curlews nested were of lower plant biomass than the denseforb habitat in general. Edaphic and external (zootic or man-caused) factors probably manifested the patchy nature of this habitat which supported a lower density of breeding curlews than annual grass habitat.

For open-low-shrub habitat, a discriminant model with only one variable, effective height (EFHT), correctly classified 82% of the cases. Mean effective height for nests and random transects was 22.0 and 28.0 cm, respectively. The dominant vegetative element contributing to the difference in effective height was snakeweed. This shrub-dominated habitat supported a low nesting density even though its mean effective height differed from the shortgrass habitat by only 3.5 cm. Nest-sites in open-low-shrub habitat were characterized by lower shrub coverage than random transects (8.0 vs 11.0%) but the difference was not statistically significant.

For the pooled habitats and nest-sites, a discriminant function was generated which included five variables, all related to vertical stratification, and correctly classified 76% of the cases (Table 7). Effective height (EFHT) loaded most heavily in the model followed closely by foliage height diversity of grass (FHDG). This model indicated that over the pooled habitats, curlews selected nest-sites of shorter and less complex vegetation than available in the habitats in general. Also, the vertical distribution of vegetation at nest-sites was "patchier" than in the pooled habitats, as indicated by the inclusion of the foliage height evenness (FHETOT) variable. This indicated that curlews may be selecting vertically "patchy" nest-sites possibly as an anti-predator strategy to aid in crypticity.

Comparisons Between Nests among Habitats - Comparisons of nest-sites among habitats revealed statistically significant differences for 5 of 6 paired comparisons by Hotelling's $T^2$ analysis. The small nest sample size in the bitterbrush habitat (N = 2) precluded use of these data for comparison.

Seven variables in the annual grass/bunchgrass comparison pair contributed significantly to differences ($p < 0.0001$). All seven variables were related to vertical stratification of the vegetation with effective height, diversity, and vertical density all higher at nest-sites in the bunchgrass habitat (Table 8). For nest-sites in the annual grass/denseforb comparison, mean values for bare ground coverage (BRGD) and grass foliage height diversity (FHDG) were statistically different ($p < 0.001$). Bare ground coverage was higher at nests in annual grass habitat whereas grass height diversity was higher at the denseforb nest-sites.

In the comparison of the annual grass/open-low-shrub pair, only two variables (BRGD and HH25) were significantly different ($p < 0.05$). Mean bare ground coverage (BRGD) and annual herb vertical density in the 0 - 25 cm height interval (HH25) were greater at annual grass nest-sites.

For the bunchgrass/denseforb nest comparison, three variables were significantly ($p < 0.0001$) different (FHDG, HG25, HH25). The differences were related to vertical stratification and diversity.

Table 8. Comparison of nest-site characteristics between habitats for long-billed curlews in northcentral Oregon.

| NEST-SITES IN HABITATS COMPARED | RESULTS OF HOTELLING'S $T^2$ TEST BETWEEN GROUPS ($P < 0.05$): Significant | -- not significant | VARIABLES CONTRIBUTING TO SIGNIFICANT UNIVARIATE T-TESTS: |
|---|---|---|---|
| Annual grass/Bunchgrass | X ($P < 0.0001$) | | EFHT, FHDG, FHDTOT, HG25, HH25, HTOT-25, HG50, HTOVRL |
| Annual grass/Denseforb | X ($P < 0.0001$) | | BRGD, FHDG |
| Annual grass/Open-low-shrub | X ($P < 0.05$) | | BRGD, HH25 |
| Bunchgrass/Denseforb | X ($P < 0.0001$) | | FHDG, HG25 HH25 |
| Bunchgrass/Open-low-shrub | X ($P < 0.001$) | | HG25, HG50, HTOVRL |
| Denseforb/Open-low-shrub | | X | |

Grass was denser and more diverse at the bunchgrass nest-sites whereas annual forb density at the 0 - 25 cm height interval was greater at the denseforb nest-sites.

For the bunchgrass/open-low-shrub nest comparison, three variables were significantly ($p < 0.001$) different between habitats (HG25, HG50, and HTOVRL). All three variables were measures of mean vertical density of vegetation and nests in the bunchgrass habitat had a higher mean grass vertical density from 0 - 50 cm and a higher overall vertical density. The results of these pairwise comparisons indicated that curlews selected nest-sites with considerable structural variability from one habitat to the next. These differences may be a reflection of inherent differences between habitats and interpretation of these results must be made in light of reproductive success rate among the various habitats over time.

Nest Density Correlation - Nest density on the 40-ha plots was negatively correlated ($p < 0.05$) with 17 of 21 variables (Table 9). The three highest negative correlations ($r \geq -.30$) were with effective height (EFHT), mean vertical density from 0 - 25 cm (HTOT25), and overall mean vertical density (HTOVRL). Eleven of the remaining 14 negative correlations were with variables relating to vertical stratification of the vegetation. A high negative correlation was found between nest density and shrub coverage (-.27) and a lower negative correlation for both annual grass (ANGR, -.16) and total grass coverage (TOTGR, -.16). Foliage height evenness of annual herbs

Table 9. Correlation of nest density (nests/40 ha) of long-billed curlews with habitat characteristics of plots within five different habitats in northcentral Oregon.

| VARIABLE | R |
|---|---|
| ANGR | -.16 |
| Pergr | -.07* |
| TOTGR | -.16 |
| BRGD | .16 |
| Herb | .14 |
| Shrub | -.27 |
| EFHT | -.31 |
| FHDG | -.13 |
| FHDH | .11 |
| FHDS | -.26 |
| FHDTOT | -.23 |
| FHEG | .03* |
| FHEH | .20 |
| FHES | -.24 |
| FHETOT | .02* |
| HG25 | -.22 |
| HH25 | .03* |
| HS25 | -.21 |
| HTOT25 | -.30 |
| HG50 | -.17 |
| HH50 | -.03* |
| HS50 | -.17 |
| HTOT50 | -.21 |
| HGTALL | .02* |
| HHTALL | -.09* |
| HSTALL | -.15 |
| HTOTALL | -.16 |
| HTOVRL | -.32 |

* nonsignificant ($P > 0.05$)

(FHEH, .20) bare ground coverage (BRGD, .16), herb coverage (HERB, .14), and foliage height diversity of herbs (FHDH, .11), were positively correlated with nest density.

Generally, correlation of the structural variables with nest density indicated that curlews nested in highest densities in plots with shorter, less complex vegetation.

# DISCUSSION

North American curlew (N. tahitiensis, N. hudsonicus, N. borealis and N. americanus) breeding ecology is relatively unknown compared to the confamilial calidridinae. As with most other Scolopacids, the curlews breed in open, essentially two-dimensional habitats. Bristle-thighed curlews (N. tahitiensis) bred in western Alaskan tundra dominated by grey reindeer moss and black lichens with weathered rock fragments protruding through the vegetation. (Allen and Killingstad 1949). The Eskimo curlew (N. borealis) bred along the Bering Sea in the "barren grounds"; treeless tundra (Bent 1962). Whimbrels bred in muskeg community near Hudson Bay, Manitoba (Skeel 1976).

The long-billed curlew is the most southerly breeding curlew and breeds in several habitats continentally. Most literature describes the curlew in mixed-grass and shortgrass habitats (Baileey and Neidrach 1965, Bicak 1977, Davis 1949, Graul 1971, King 1978, McCallum et al. 1977, Sadler and Maher 1976). In the Columbia and Great Basins, curlews breed in mixed-grass meadows, annual grassland (cheatgrass and/or medusahead (Taeniatherum asperum) dominated), saltgrass (Distichylis stricta) - greasewood (Sarcobatus vermiculatus) associations and occasionally in agricultural or crested wheatgrass habitats (Pampush 1980).

Hubbard (1973) speculated that the long-billed curlew had its evolutionary origins in one of several North American refugia resulting from the extensive glaciation of the Pleistocene. Two congeners, *N. arquata* and *N. madagascariensis* are considered possible palearctic differentiates of the long-billed curlew (Hubbard 1973).

The long-billed curlew's center of geographic origin is questionable although the Great Plains, as Johnsgard (1978) implies, seems likely. This speculation seems credible since the long-billed curlew breeds in shortgrass habitats throughout its range and shortgrass and mixed-grass prairie are predominant communities of the western Great Plains. In contrast, the Columbia Basin fostered expanses of grassland historically but the vast majority was bunchgrass-dominated (Daubenmire 1970). Curlews avoided the bunchgrass habitat in this study and were infrequently observed or reported in bunchgrass habitat in a breeding status survey in the Columbia and Great Basins (Pampush 1980). Curlews were reported breeding along the Columbia River by the Lewis and Clark expedition (Thwaites 1904) which predates significant human influence on vegetation structure. Habitat composition and structure at the site of the earliest recorded observations are unknown, though lithosolic sites dominated by Sandberg's bluegrass were probably extant at the time and may have been preferred curlew breeding habitat.

Habitat Utilization Patterns - In this study, an overall preference for habitats of low vertical profile and low vertical density was evident. Nesting adult curlews often foraged away from the territory while not incubating. Both non-incubating adults and adults with broods foraged in cropland both on the study areas and adjacent to them. Short or freshly swathed alfalfa was used extensively as a foraging area even though no nesting behavior was ever observed in this habitat. Skeel (1976) observed whimbrels regularly foraging away from the defended territory and monogamous calidridine sandpipers often exhibit similar foraging patterns during the incubation period (Jehl 1973, Miller 1979, Holmes 1971). Although foraging often occurred at a distance from the defended territory, curlews regularly foraged in the annual grass habitat throughout the breeding season. Both 1978 and 1979 were years of high grasshopper (Orthoptera) population levels and curlews were often observed foraging on them. During these two breeding seasons, a preference for a particular habitat was not obvious, but rather a preference for habitats of certain structural characteristics. Some pairs which nested within 300 m of alfalfa fields were observed brooding young in the annual grass habitat throughout the brood-rearing period. However, during breeding seasons of low grasshopper population levels, I suspect foraging patterns would be different.

Nest Density and Success - Curlews nested in highest densities and had highest nest success in annual grass habitat. The mean nest density of 3.57 nests/40 ha in annual grass habitat compares closely with the density Skeel (1976) observed for whimbrels near Churchill, Manitaba. She observed 17 nests over a 166 ha study area (4.10 nests/40 ha) in hummock-bog habitat--the habitat in which the whimbrels had highest nest success over two seasons of observation. The hummock-bog habitat was of dense vegetation and was the most heterogeneous of the three habitats Skeel observed whimbrels nesting in. She attributed the high density and success in the structurally more complex habitat to the advantages of greater crypticity in denser vegetation. Primary whimbrel nest predators were jaegers (*Stercorarius* sp.), species which forage from the air. In contrast, long-billed curlews in this study nested in highest densities and were most successful in the simplest, most open habitat available. Since eight of 14 nests depredated were destroyed by mammalian predators and nest predation was significantly higher in habitats other than annual grass, it appears that curlews in north-central Oregon are adapted to breeding in habitats of low shrub cover and of low vertical profile. Mammalian predators, particularly coyotes, may be utilizing shrubbier habitats more than open habitats. Small rodents (*Perognathus*) occurred in much higher densities in shrub-dominated habitats than cheatgrass-dominated habitats on the Bombing Range (G. Green, pers. comm.). Therefore, the density of potential prey may be influencing mammalian predator foraging patterns and a ground nesting bird nest may have a greater probability of predation in these habitats.

Crows and magpies also forage extensively in shrub dominated habitats. Though my observations are not quantified, I suspect that these corvids forage significantly more in shrub-dominated habitats than in annual grass habitats and may, therefore, pose a greater threat to curlew nests in shrub-dominated habitats.

Curlews produced a "bob-white" vocalization when broadwinged hawks (*Buteo* sp.), prairie falcons (*Falco mexicanus*) or golden eagles (*Aquila chrysaetos*) appeared over the breeding "colony". Also, group mobbing occurred in response to alarm calls given by a curlew reacting toward a predator. On two occasions during the incubation period, I observed up to 15 curlews standing around a badger (Taxidea taxus) and occasionally making aerial swoops toward it. These anti-predator behavioral patterns suggest some advantages of loose "colonial" nesting and apparently confer some advantage to a breeding pair, as evidenced by the higher nest success in annual grass habitats.

In this study, broods occasionally foraged within the previously defended territorial boundary. However, emigration was more common and communal use of foraging areas with occasional brood mixing occurred. These behavioral patterns suggest that the function of territoriality in curlews may be to space out to avoid predation while maintaining the advantages of loose coloniality as Soikelli (1967) hypothesized for calidridine sandpipers.

Nest-Site Selection - Comparison of nest-site characteristics among habitats in this study indicated that curlews were relatively plastic in nest-site selection though a preference for structurally simple habitats was evident. Grassland ecosystems are characterized by climatic variability and unpredictability (Wiens 1974). With yearly variation in precipitation/temperature regime, the structure of an annual grassland may vary considerably between years. Although significant differences were evident between nest-sites and habitats in general, the structural tolerances of the species probably have not been fully identified in analysis of one breeding season's data.

Nest-site selection is presumably adaptive if some survival or ultimate reproductive advantage is conferred to the breeding pair. In attempting to understand nest-site selection of a species, other environmental factors must be considered (sociality, philopatry, individual past reproductive patterns) besides the learned or innate psychological factor involved.

In comparison of nest-site and habitat characteristics, variables related to vertical stratification of vegetation were important factors in the discriminant analysis. Vegetative height and foliage diversity were lower at nest-sites than in the habitat in all cases except one. Herbaceous plant vertical density from 0 - 25 cm was higher at nest-sites in the annual grass habitat which probably resulted from the occurrence of the dense Russion thistle and _Opuntia_ cactus that grew in association with cheatgrass patches. The cactus and Russian thistle plants were generally considerably shorter than 25 cm, although the variable does not discriminate finely enough to illustrate dispersion of vegetation within the 25-cm interval.

The inclusion of overall foliage height evenness (FHETOT) in two discriminant models (annual grass and pooled habitats) indicated that curlews selected nest-sites with vertically patchier vegetation than occurred in the habitats in general. Crypticity of eggs and plumage suggest that predation has been a strong selective force and the vertically uneven distribution of vegetation around nest-sites may enhance adult survival or nest-success. Nesting adult mortality was low over the two years. Only 6 of 101 nests were abandoned and adult mortality was possible in only 3 cases. Cause of abandonment was unknown although 4 of these nests were incubated into June and daytime high temperatures (30°C) may have influenced abandonment. Although these results were based on one breeding season and annual vegetation may vary markedly from year to year, vertical patchiness may be a key stimulus in nest-site selection. Bicak (1977) found that curlew nest-sites in Nebraska had greater vertical biomass at the 5 - 10 cm height interval than did the shortgrass habitat in general, but he did not examine relative vertical dispersion (evenness) of vegetation.

Results of discriminant analyses in the bunchgrass habitat indicated that coverage variables were most important in discriminating between nest-sites and the habitat in general. These results must be considered in light of nest density and nest success. Curlews avoided expanses of bunchgrass habitat on the Bombing Range even though it was contiguous with annual grass habitat in which a high breeding density occurred. Therefore, bunchgrass may be a sub-optional breeding habitat and individuals breeding in this habitat may be expressing a psychological reaction to a complex of environmental factors (dominance, age, site-familiarity, etc.) which results in behavior contrary to individuals of greater "fitness".

The avoidance of native bunchgrass habitat is perplexing because it was the climax dominant community prior to the arrival of European man on the study areas (Poulton 1955). Intensive grazing and burning eradicated the bunchgrass and sagebrush and left prime conditions for the subsequent invasion of annual cheatgrass, an exotic.

Curlews currently breed in high densities in cheatgrass-dominated habitat where bunchgrass formerly dominated. The question of former breeding numbers and dispersion in the Columbia Basin is perplexing although various habitats probably supported curlews prior to the advent of European man. Sandberg's bluegrass-dominated sites and saltgrass habitat around playas support breeding curlews in limited numbers throughout the Basins. These habitats may have fostered breeding curlews prior to the invasion of cheatgrass and the dispersion of breeding curlews may have changed after cheatgrass became well established.

In order to more fully understand the breeding ecology of long-billed curlews, long term study of marked individuals is necessary. Available data suggest that curlews are long-lived (up to 32 years in *N. Arquata*, Boyd 1962), realize low annual recruitment, and tend to be philopatric (R. Redmond, pers. comm.). This conservative reproductive strategy may be geared toward reproductive success in the "average year" as Parmalee and Payne (1973) have hypothesized for calidridine sandpipers in the Arctic.

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# NEST SUCCESS, HABITAT UTILIZATION AND NEST-SITE SELECTION OF LONG-BILLED CURLEWS IN THE COLUMBIA BASIN, OREGON [1]

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*Abstract.* Breeding ecology of Long-billed Curlews *(Numenius americanus)* in north-central Oregon was studied during spring and summer, 1978-1979. Five habitats were used by territorial curlews, and habitat selection by adults with and without broods was studied. Both adults and adults with broods used habitats significantly different from availability. A preference for habitats of low vertical profile and low vertical density (plant parts/volume/height) was observed; habitats with tall, dense shrubs or weedy annual vegetation were generally avoided. Nest density varied from 0-9 nests/40 ha. Highest nest density occurred in cheatgrass habitats. Nest success as computed by the Mayfield method was 0.69 in 1978 ($n = 40$) and 0.65 in 1979 ($n = 61$). Predators destroyed 10 (4) and 16% (10) of the nests in 1978 and 1979, respectively. Eight of 14 (57%) nests over both years were destroyed by mammalian predators; at least three (21%) were taken by crows *(Corvus brachyrhynchos)* or magpies *(Pica pica).* Nest predation rate was significantly lower in annual grass habitats. Differences between nest sites and randomly selected habitats were related to vertical strat- ification of vegetation. Vegetative cover was important in only the bunchgrass habitat. Overall, nest sites were less complex above 5 cm than surrounding areas. Significant dif- ferences in nest-site structure between habitats were observed for five of six paired com- parisons, indicating some plasticity in nest-site selection by breeding curlews.

*Key words: Long-billed Curlew;* Numenius americanus; *habitat use; nest-site selection; nest success; Columbia Basin; Oregon.*

## INTRODUCTION

The Long-billed Curlew is the most southerly breeding curlew in North America, and it nests in several habitats. Nesting habitat for the species is usually described as mixed-grass and short- grass communities (Davis 1949, Bailey and Nei- drach 1965, Graul 1971, Sadler and Maher 1976, Bicak 1977, McCallum et al. 1977, King 1978, Redmond and Jenni 1986). In the Columbia and Great Basins, curlews breed in mixed-grass meadows, annual grassland (cheatgrass or me- dusahead *[Taeniatherum asperum])* associations and occasionally in agricultural or crested- wheatgrass habitats (Allen 1980).

Agricultural development of prairies has re- duced breeding habitat for Long-billed Curlews, which resulted in declines in breeding numbers over the last century (Wickersham 1902, Daw- son 1923, Sugden 1933, Jewett 1936, Bent 1962). Extensive agricultural development occurred in the Columbia Basin during the 1970s with over 100,000 ha of shrubsteppe vegetation converted to circle-pivot irrigation systems in a five-county area alone (Muckleston and Highsmith 1978). During this time, the status of breeding curlews in the Columbia Basin was unknown, although many long-time residents believed that a drastic reduction in the breeding population occurred as a result of the agricultural development (H. Cur- tis, pers. comm.). These historical changes in community physiognomy probably changed the abundance and distribution of Long-billed Cur- lews, because avian habitat preferences and uti- lization patterns are often intimately tied to structural features of the habitat (Hilden 1965, Cody 1968, Wiens 1973, Eiserer 1980).

Intensive livestock grazing in the late 1800s deteriorated range conditions throughout the Co- lumbia Basin. Large tracts of native bunchgrass were stressed beyond recovery, and the invasion of exotic cheatgrass *(Bromus tectorum)* signifi- cantly changed the vegetative structure of shrub- steppe communities. Many sites formerly dominated by the sagebrush *(Artemesia triden- ta)*-bluebunch wheatgrass *(Agropyron spicatum)* association were burned or heavily grazed, with

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fire killing the sagebrush. Cheatgrass, along with other seral species, replaced bunchgrass.

We examined the habitat relationships ofLong- billed Curlews and general features of the habitat available to predict how changes in habitat struc- ture and overall availability might influence their populations. Herein, we report on nest success, habitat utilization, and nest-site selection oflong- billed curlews in the Columbia Basin of north- central Oregon.

## STUDY AREA

The study was conducted in the Columbia Basin of northern Umatilla and Morrow Counties, Or- egon. The area is characterized by hot, dry sum- mers and moderately cold, moist winters. The 30-year mean annual precipitation for the study areas was 2l .67 cm (Ruffner 1978), most of which falls during winter and early spring. Sandy soil occurs along the Columbia River, grading into more loamy soils to the south. Most native veg- etation has been drastically changed by intensive grazing, burning, and cultivation on the sandy soils in the areas. In general, the study area was comprised of two habitats; sagebrush/western- needle-and-thread *(Stipa comata)* on the sandy soils grading into a sagebrush/bluebunch wheat- grass habitat on the southern end of the study area (Daubenmire 1970). The study area was dominated by a gray rabbitbrush (*Chrysotham- nus* baysisus)/cheatgrass association with lesser amounts of needle and thread, snowy buckwheat *(Eriogonum niveum)* and patchy Jim Hill mus- tard *(Sysimbrium altissimum).* On more loamy sites, some patches of sagebrush/bluebunch wheatgrass were extant with snakeweed *(Gutier- rezia sarothrae)lgray* rabbitbrush-Sandberg's bluegrass *(Poa sandbergi)!cheatgrass* dominat- ing the more disturbed sites.

Five habitats were chosen for intensive inves- tigation, because Long-billed Curlews used them in,varying degrees, and they were each structur- ally. unique and contiguous with each other. The five habitats included cheatgrass grassland, bunchgrass grassland, bitterbrush shrubland, open-low shrub, and dense forb (see Pampush 1981, Green and Anthony 1989 for detailed de- scriptions).

## METHODS

Upon arrival of the earliest returning curlews in mid-March, observations were initiated to de- termine the distribution and abundance of cur- lews on the study area. Behavior was observed throughout the prenesting phase of the breeding cycle to determine habitat use of breeding cur- lews. Most observations were conducted from a vehicle with 7 x 35 binoculars and a 20 x spot- ting scope so as not to disturb them.

Systematic nest searches were initiated in early April of both years. Nest searching was con- ducted by people roughly *5* m apart and walking slowly, in a line, across the study plots. This approach assured complete coverage of the plots and detection of most all of the active nests. In 1979, 40-ha plots were established in each of five habitats with at least four replicates of each hab- itat (24 plots total). These study plots were searched from 7 April to 2 May using the tech- nique described above with the aid of 1,300 vol- unteer, high-school students. Each of the five habitats was searched sequentially with the rep- licate plots being searched under the same scheme. This scheme was adopted to avoid sam- pling bias toward a particular habitat since the onset of nesting could vary over a six-week pe- riod. Nest density per plot, clutch size, fate of nest, type of predator depredating nest, number of addled eggs, and number of eggs hatched per clutch were recorded for all nests.

### CENSUSING AND HABITAT UTILIZATION

A modified strip transect technique (Hayne 1949) was employed to determine habitat utilization and preference patterns of adults with and with- out broods. Four large transects were sampled by foot from l April to 1 August on the Umatilla National Wildlife Refuge, US Army Ammuni- tion Depot, and the US Navy Bombing Range (two transects on the North and South sectors). Transects were sampled during the early morn- ing hours when curlews were most active. The assumption was made that all adult curlews with- in *50* m of the transect (except incubating adults) were included in the sample. Curlews flying over the transect were not included unless they were males performing "display flights." Because "display flights" were performed over relatively [1] fixed areas, the males performing them within the 100-m transect were included in the sample and assigned to the habitat that they were ob- served flying over. Since adult curlews attending young exhibit a strong defensive response by fly- ing toward and swooping down on intruders (predator, vehicle, or human on foot), the census strip was widened to 150 m on either side of the transect when adults with broods were surveyed. This is approximately the maximum distance at which curlews with broods responded to hu- mans. All of the area included within the transect strip was classified into one of the five habitats, and the percentage of each habitat occurring along

the transects was calculated.

VEGETATIVE MEASUREMENTS

The importance of vegetative structure in nest- site selection was determined by comparing veg- etative characteristics of nest sites to those of the general habitat. In each of the 40-ha study plots (*n* □ 24), ten I 00-m transects were established randomly, and subsample points were selected randomly within each 10 m interval for vege- tative measurements. To measure vegetative characteristics at nest sites, we established four I 00 m transects at 90□ angles and originating from the nest cup. Subsample points along each of the transects were established randomly with- in each 10 m interval, providing a total of 40 sample points for each nest. At each of the sam- ple points for nests and the general habitat, a number of vegetative characteristics were mea- sured. Vertical density was described as the num- ber of touches of plant parts within 5-cm height intervals on a 6-mm diameter vertical rod (Wiens 1973). Effective height was the height at which 90% of a white, 30-cm wide, board, was obscured by vegetation when viewed from 10 m at eye level (Wiens 1973). Percent cover of grasses, herbs, and bare ground was estimated using a 10

x 50 cm (0.1 $m^2$ plot as described by Dabenmire (1959). Shrub cover was estimated by the line- intercept method along each transect (Piper 1973). Foliage height evenness and diversity were com- puted from the vertical density measurements according to Pielou (1975). Nineteen vegetative characteristics plus eight computed variables (Table 1) were used to compare nest sites with general habitat characteristics.

STATISTICAL ANALYSES

Data on habitat utilization were analyzed at two levels. First, a $x^2$ test was used to determine whether habitats were utilized in proportion to their availability. Secondly, confidence intervals were constructed around the theoretical propor- tion to determine whether observed use of each habitat was significantly different from expected. Because several parameters were being estimated

TABLE I. List and description of variables measured in characterizing the habitat of occupied and potential nest sites of Long-billed Curlews in the Columbia Ba- sin.

| Variable | Description |
|---|---|
| Percent bare ground<br>Percent forb<br>Percent grass | Percentage estimate of cover of bare ground, forbs, annual and peren- nial grasses. |
| Shrub intercept | Meters of shrubs inter- cepted along I 00 m transects divided by 100 (Piper 1973). |
| Shrub volume | Shrub intercept multiplied by the mean height of the intercepted shrubs. |
| Effective height | Height at which 90% of a white board is obscured by vegetation when viewed I m from the ground at a distance of 10 m (Wiens 1973). |
| Vertical density, grasses<br>Vertical density, forbs<br>Vertical density, shrubs<br>Vertical density, all veg- etation<br>Vertical density total | Number of touches by plants within 25 cm height intervals (0-25, 26-50, 50□) along a thin vertical rod (Wiens 1973). |
| Foliage height diversity of grasses, forbs, shrubs and all vegeta- tion | Indices computed from vertical density mea- surements according to Pielou (1975:8-15) |
| Foliage height evenness for grasses, forbs, shrubs and all vegeta- tion | Indices computed from vertical density mea- surements according to Pielou (1975:8-15) |

simultaneously, a "family" of confidence inter- vals with an *a* ofO.IO was used (Neu et al. 1974). Nest-site characteristics were analyzed in two ways. First, discriminant function analysis was used to describe differences in vegetative char- acteristics between nest sites and habitats in gen- eral. Discriminant functions were generated for four of the habitats, nest sites within habitats, and one with all nests and habitats combined. One discriminant function was generated in each comparison, and variables were added stepwise with a minimum *a* of 0.15 to enter the model (*F* □ 4.0). A varimax vector rotation was used be- cause it highlights the variable that explains the most variability in the data without change in variable composition of the model (Nie et al. 1975). Secondly, nest-site characteristics were compared with Hotelling's *T2* test to determine whether or not nest sites were structurally different between pairs of habitats. Factor analysis was employed to generate linear combinations of variables used for *T2* analysis. After factor analysis, univariate !-tests were conducted to de- termine which variables contributed most to the significant differences between habitats.

Normality of the data was checked, and non- normal data were transformed. All coverage data were recorded as percent and thus were arcsine transformed; vertical density data were log trans- formed. All differences were considered signifi- cant at the 0.05 level unless stated otherwise.

## RESULTS

Ninety percent of the observed nests *(n* □ 112) had a clutch size of four eggs, 9% contained three eggs, and one nest (I%) contained two eggs. A mean incubation period of 29 days □ 12 hr was observed (range: 28-31 days) for 10 nests of known history. Mean hatching dates were 14 May 1978 *(n* □ 45, range □ 1 May-2 June) and 15 May 1979 *(n* □ 66, range □ 3 May-4 June).

### NEST DENSITY AND SUCCESS

Nest density varied considerably among habitats and plots within habitats. Highest nest density (3.6 nests□40 ha, range □ 2-9 nests) occurred in the cheatgrass habitat. Density of nests in the other habitats was low; density in bunchgrass habitats was 1.4 nest□40 ha (range □ 0-3 nests), dense forb was 1.3 nests□40 ha (range□ 0-2 nests); open low shrub was 1.0 nests□40 ha (range□ 0- 2 nests), and bitterbrush was 0.5 nests□40 ha (range □ 0-1 nest). The greatest density observed in any plot, other than cheatgrass, was (3.0 nests□ 40 ha) in the bunchgrass habitat. This particular plot adjoined several hundred hectares of an- nual-grass habitat, and the distribution of nest sites within the plot was along the edge of the shortgrass-bunchgrass interface.

Nest success as computed by Mayfield (1975) was 0.69 in 1978 *(n* □ 40) and 0.65 in 1979 *(n* □ 61). Predators destroyed 10 (4) and 16% (10) of the nests in 1978 and 1979, respectively. Four nests were abandoned in 1978 and two in 1979. Nest predation rate was significantly higher than expected in habitats other than annual grass ($x^2$ □ 6.36, *P* □ 0.05), suggesting that predators were more dense or nests were more vulnerable in these habitats. Eight of 14 nests (57%) depre- dated over the two years were destroyed by mammalian predators, primarily badgers *(Tax- idea taxus)* and coyotes *(Canis latrans).* Corvids (crows and magpies) were responsible for at least three of 14 (21%) nest predations.

### HABITAT UTILIZATION: ADULTS WITHOUT BROODS

Adult curlews without broods utilized habitats in proportions different from availability on all four transects *(P* □ 0.05) (Table 2). The cheat-grass habitat was highly preferred along the two transects which had the highest density of cur- lews (1.88 and 2.48□40 ha) and was used roughly in proportion to availability along the other two transects.

Cropland was highly preferred along the Uma- tilla Refuge transect, although the particular field utilized varied with changes in vegetative struc- ture. Curlews used cropland as long as the crop was low in profile (or the ground fallow) and moved elsewhere when it was □30 cm tall. Wheat, potatoes, and alfalfa comprised the major crops, and alfalfa was available recurrently depending on haying schedule.

Bunchgrass on one portion of the study area and open-low shrub on another were both pre- ferred *(P* □ 0.05). However, the bunchgrass tract was contiguous with an irrigated pasture and an- nual grass habitat in which two nests were lo- cated. The proximity of these two habitats may have influenced use of the bunchgrass habitat. The open low shrub habitat comprised 59% of the available habitat on the Bombing Range South and was used significantly more than other hab- itats. Snakeweed dominated the open-low shrub habitat and was much shorter than rabbitbrush or bitterbrush with mean effective height (EFHT) of 16 cm.

Dense forb and bitterbrush habitats were used less than expected along the transects. Bunch- grass was used less than expected on the Bombing Range North and South transects, as was the open-low shrub on the Bombing Range North. In general, curlews selected habitats of low ver- tical profile or low mean vertical density and avoided habitats of greater vertical profile or high mean vertical density.

### HABITAT UTILIZATION: ADULTS WITH BROODS

Females generally abandon their mates and brood prior to fledging of the young, and males gen- erally remain with the brood until the young are able to fly (Pampush 1981). Habitat utilization of adults with and without broods were similar

TABLE 2. Habitat utilization of adult Long-billed Curlews without broods along four transects in north-central Oregon during spring and summer 1979.

| Transect | Habitat | No. of adults obs. | % use | %avail. | Confidence limits |
|---|---|---|---|---|---|
| Bombing Range South | Cheat grass | 10 | 0.09 | 0.08 | 0.03-0.15 |
| ($\chi^2$ = 20.4, $P < 0.05$) | Bunchgrass | 9 | 0.08[a] | 0.17 | 0.02-0.14 |
| | Dense forb | 2 | 0.02[a] | 0.15 | 0.00-0.05 |
| | Open-low-shrub | 74 | 0.70[a] | 0.59 | 0.60-0.80 |
| Bombing Range North | Cheat grass | 122 | 0.55[a] | 0.33 | 0.47-0.63 |
| ($\chi^2$ = 53.4, $P < 0.05$) | Bunchgrass | 14 | 0.06[a] | 0.12 | 0.02-0.10 |
| | Dense forb | 77 | 0.35[a] | 0.44 | 0.27-0.43 |
| | Open-low-shrub | 7 | 0.03[a] | 0.11 | 0.00-0.06 |
| Army Depot | Cheat grass | 177 | 0.76[a] | 0.20 | 0.70-0.82 |
| ($\chi^2$ = 500.3, $P < 0.05$) | Bitterbrush | 26 | 0.1[illegible][a] | 0.39 | 0.06-0.16 |
| | Bunchgrass | 27 | 0.12[a] | 0.05 | 0.07-0.17 |
| | Dense forb | 4 | 0.02[a] | 0.36 | 0.00-0.04 |
| Umatilla Refuge | Cheat grass | 26 | 0.11 | 0.09 | 0.07-0.15 |
| ($\chi^2$ = 176.5, $P < 0.05$) | Dense forb | 27 | 0.12[a] | 0.54 | 0.08-0.16 |
| | Cropland | 177 | 0.77[a] | 0.37 | 0.73-0.81 |

[a] Denotes statistically significant difference in use of habitat from availability.

(Tables 2-4, respectively). Along three of four transects, adults with broods used habitats significantly different from availability ($P < 0.05$) (Table 3). Cheatgrass habitat was selected along all three transects. Habitats of greater height and vertical density were used less than available by broods. Bitterbrush was avoided even though the interstices between shrubs were very similar structurally to the adjacent annual-grass habitat. The vertical component of this habitat appeared to influence habitat utilization. Dense forb was avoided on all three transects, even though grasshopper (a common food) densities appeared as high in this habitat as in cheatgrass. Dense forb had the highest mean vertical density of all five habitats and second greatest effective height (behind bitterbrush habitat). Curlew chicks often struggled to get through the dense annuals (*Sysimbrium, Amsinckia),* and adults probably had limited visibility when in this habitat.

Cropland was used by broods on a periodic basis on the Umatilla Refuge, and medium

TABLE 3. Habitat utilization of adult Long-billed Curlews with broods along four transects in north-central Oregon during spring and summer 1979.

| Transect | Habitat | No. of adults obs. | % use | %avail. | Confidence limits |
|---|---|---|---|---|---|
| Bombing Range South | Cheat grass | 2 | 0.06 | 0.08 | |
| ($\chi^2$ = 10.3, $P < 0.05$) | Bunchgrass | 4 | 0.12 | 0.17 | |
| | Dense forb | 6 | 0.18 | 0.15 | |
| | Open-low-shrub | 22 | 0.65 | 0.59 | |
| Bombing Range North | Cheat grass | 99 | 0.64[a] | 0.33 | 0.55-0.73 |
| ($\chi^2$ = 81.9, $P < 0.05$) | Bunchgrass | 4 | 0.02[a] | 0.12 | 0.00-0.05 |
| | Dense forb | 27 | 0.17[a] | 0.44 | 0.10-0.24 |
| | Open-low-shrub | 24 | 0.16 | 0.11 | 0.09-0.23 |
| Army Depot | Cheat grass | 159 | 0.74[a] | 0.20 | 0.67-0.81 |
| ($\chi^2$ = 400.1, $P < 0.05$) | Bitterbrush | 37 | 0.17 | 0.39 | 0.11-0.23 |
| | Bunchgrass | 10 | 0.05 | 0.05 | 0.02-0.08 |
| | Dense forb | 8 | 0.04[a] | 0.36 | 0.01-0.07 |
| Umatilla Refuge | Cheat grass | 8 | 0.28[a] | 0.09 | 0.11-0.45 |
| ($\chi^2$ = 17.0, $P < 0.05$) | Dense forb | 7 | 0.24[a] | 0.54 | 0.08-0.40 |
| | Cropland | 14 | 0.48 | 0.37 | 0.29-0.67 |

[a] Denotes statistically significant difference in use of habitat from availability.

in the 0-25 cm height interval was greater at the nest sites than along random transects, reflecting the occurrence of standing dead tumbleweed plants and live *Opuntia* cactus that were asso- ciated with nest sites on sandy soil.

For bunchgrass habitats, total grass cover (TOTGR), bare ground cover (BRGD), and herb cover (HERB) were significantly different be- tween nest sites and the general habitat. Total grass cover was significantly ($P <$ 0.05) higher at nest sites (67%) as compared to random plots (55%). Herbaceous cover was slightly higher at nest sites than random plots (6.0 versus 4.0%) due primarily to the occurrence of *Phlox* and *Lupinus.* Bare-ground cover was included in the model, but the difference in means at nest sites versus random plots was not significant (mean: 0.296 vs. 0.297; SD: 0.067 vs. 0.081, respectively), so these results appear spurious.

For the dense forb habitat total grass cover, effective height, and foliage height diversity dis- criminated between nest and random plots. Ef- fective height was the most important variable in the model, and nest sites had lower mean val- ues than random plots ($\bar{x}$ = 23.7 and 32.0 cm, respectively). Total grass cover and foliage height diversity of herbs were lower for nest sites than random plots.

The dense forb habitat was compositionally similar but structurally quite different from the annual-grass habitat. Mean effective height at nest sites was very similar for both habitats, but mean effective height for random plots among the hab- itats (Table 5) differed significantly ($P <$ 0.05). Curlews chose nest sites away from the taller, denser cover as evidenced by the inclusion of effective height and foliage height diversity of herbs in the discriminant model. Nest sites were generally located in patches where the soil was more stabilized and cheatgrass-Sandberg's blue-grass dominated. Cheatgrass grew in dense patches in some areas within the dense forb hab- itat. Generally, the open cheatgrass-dominated areas, where curlews nested, were oflower plant biomass than the dense forb habitat.

For open-low shrub habitat, the discriminant function selected only effective height. Mean ef- fective height for nests and random plots was 22.0 and 28.0 cm, respectively. The dominant vegetative element contributing to the difference in effective height was snakeweed. The open-low shrub habitat supported a low nesting density, even though its mean effective height was higher than that of the cheatgrass habitat by only 3.2 cm. Nest sites in open-low shrub habitat were characterized by lower shrub cover than random plots ($\bar{x}$ = 8.0 vs. 11.0%), but the difference was not statistically significant ($P >$ 0.05).

For the habitats combined, five variables were important in discriminating between nest versus random plots (Table 5). Effective height ex- plained most of the variability in the data fol- lowed closely by foliage height diversity of grass. This model indicated that curlews selected nest sites with shorter and structurally less complex vegetation than available in the habitats in gen- eral. Also, the vertical distribution of vegetation at nest sites was "patchier" than in the pooled habitats, as indicated by the inclusion of foliage height evenness in the model.

COMPARISONS OF NESTS AMONG HABITATS

Comparisons of nest sites among habitats re-vealed statistically significant ($P <$ 0.05) differ-ences for five of six paired habitat comparisons. Seven variables in the cheatgrass–bunchgrass comparison contributed significantly to the dif- ferences ($P <$ 0.0001). All seven variables were related to vertical stratification of the vegetation with effective height, diversity, and vertical den-sity all higher at nest sites in the bunchgrass hab- itat (Table 6). For nest sites in the cheatgrass–dense forb comparison, mean values for bare- ground cover and grass foliage height diversity were statistically different ($P <$ 0.001). Bare ground cover was higher at nests in cheatgrass habitat, whereas foliage height diversity of grass- es was higher at the dense forb nest sites. Percent bare ground and vertical density of annual herbs were significantly different ($P <$ 0.05) in the cheat- grass–open-low-shrub comparison. Mean bare ground cover and annual herb vertical density in the 0- to 25-cm height interval were greater at cheatgrass nest sites. For the bunchgrass–dense forb comparison, three variables were signifi- cantly ($P <$ 0.0001) different and all were related to vertical stratification and diversity. Grass was denser and more diverse at the bunchgrass nest sites, whereas annual forb density at the 0-25 cm high was greater at the dense forb nest sites. For the bunchgrass–open-low-shrub nest compari- son, three variables were significantly ($P <$ 0.001) different between habitats. All three variables were measures of mean vertical density of veg- etation, and nests in the bunchgrass habitat had a higher vertical density of grasses from 0-50 cm

TABLE 5. Discriminant function coefficients for comparison of nest sites and randomly selected plots ofLong- billed Curlews in north-central Oregon. Means and standard deviations for variables at nest sites and habitats are given in parentheses.

| Habitat | Variables in the discriminant models: TOTGR | BRGD | HERB | EFHT | FHDG |
|---|---|---|---|---|---|
| Cheatgrass | | | | -0.52 | |
| Nest sites (*n* = 25) | | | | (22.2 ± 2.8) | |
| Habitat (*n* = 70) | | | | (24.8 ± 3.3) | |
| Bunchgrass | 1.48 | 0.86 | 0.97 | | |
| Nest sites (*n* = 9) | (67 ± 0.16) | (0.30 ± 0.07) | (0.06 ± 0.08) | | |
| Habitat (*n* = 50) | (55 ± 0.12) | (0.30 ± 0.08) | (0.04 ± 0.05) | | |
| Dense forb | -0.51 | | | -1.25 | |
| Nest sites (*n* = 7) | (0.32 ± 0.08) | | | (23.7 ± 3.5) | |
| Habitat (*n* = 40) | (0.40 ± 0.09) | | | (32.7 ± 4.0) | |
| Open-low-shrub | | | | 1.00 | |
| Nest sites (*n* = 4) | | | | (22.0 ± 3.5) | |
| Habitat (*n* = 40) | | | | (28.0 ± 2.9) | |
| Habitats Combined | | | | -0.89 | 0.80 |
| Nest sites (*n* = 45) | | | | (23.8 ± 3.8) | (0.60 ± 0.12) |
| Habitat (*n* = 240) | | | | (28.9 ± 5.1) | (0.62 ± 0.16) |

"TOTGR - Total grass cover, BRGD - Bare ground cover, HERB - Herbaceous cover, EFHT - Effective height, FHDG - Foliage height diversity of grasses. FHDH - Foliage height diversity of herbs, FHETDT - Total from 0-25 cm, HG50 - Vertical density of grasses from 26-50 cm, HSTALL - Vertical density of all vegetation.

and a higher overall vertical density. The results of these pairwise comparisons indicated that cur- lews selected nest sites with considerable struc- tural variability among habitats, which was a reflection of inherent differences between habi- tats.

## DISCUSSION

Hubbard (1973) speculated that the evolutionary origin of Long-billed Curlews was in one of sev- eral North American refugia resulting from the extensive Pleistocene glaciation. The center of geographic origin of Long-billed Curlews is not known, although the Great Plains (Johnsgard 1978) seems likely, because they breed in short- grass habitats throughout their range. The Co- lumbia Basin historically was dominated by tall bunchgrass (Daubenmire 1970), but curlews pre- ferred cheatgrass habitats and avoided the bunchgrass habitats in this study. In addition, they were observed infrequently in bunchgrass habitats in a breeding survey by the senior author in the Columbia and Great Basins.

### NEST DENSITY AND SUCCESS

Long-billed Curlews had highest nest success and density in cheatgrass habitats in this study. The mean nest density of 3.57 nests/40 ha in this habitat is similar to the highest density (4.10 nest/40 ha) observed by Skeel (1983) for Whim- brels near Churchill, Manitoba. She attributed the high density and nesting success in her hab- itat to the advantages of greater cryptic colora- tion in denser vegetation. In contrast, Long-billed Curlews in this study nested in highest densities and were most successful in the simplest, most open habitats. Because 57% of depredated nests were destroyed by mammalian predators and nest predation was significantly higher in habitats other than cheatgrass, it appears that Long-billed Curlews in northcentral Oregon are adapted to breeding in habitats of low shrub cover and of low vegetative profile. This phenomenon may be an adaptation for predator detection and avoid- ance, because coyotes, badgers, crows, and mag- pies are common nest predators throughout their breeding range. Similarly, Redmond and Jenni (1986) found that most nest losses in western Idaho were a result of canids, badgers, or corvids.

### HABITAT UTILIZATION PATTERNS

In this study, an overall preference for habitats of low vertical profile and low vertical density was evident. Nesting adult curlews often foraged away from their territory when they were not incubating. Adults with and without broods for- aged in cropland on the study areas and adjacent to them. Short or freshly swathed alfalfa was used

TABLE 5. Continued.

| | Variables in the discriminant models | | | | | |
|---|---|---|---|---|---|---|
| | Correctly HSTALL | FHDH classified | FHETOT | | HH25 | HG50 |
| | -0.64 (0.68 ± 0.16) (0.76 ± 0.07) | 0.55 (0.50 ± 0.31) (0.38 ± 0.22) | | | | 74 |
| | | | | | | 84 |
| (0.62 ± 0.08) (0.72 ± 0.26) | | | | | 0.58 | 87 |
| | | | | | | 82 |
| | (0.70 ± 0.12) (0.76 ± 0.08) | -0.54 | -0.50 | (0.80 ± 0.12) (0.15 ± 0.18) | -0.31 (0.02 ± 0.09) (0.05 ± 0.15) | 76 |

extensively as a foraging area even though no nesting behavior was observed in this habitat. Redmond (1986) observed curlews flying to un- defended foraging sites on agricultural land with- in 10 km of their territories in western Idaho. Redmond (1986) also observed Long-billed Cur- lews to forage away from their defended terri- tories in years when dense residual vegetation covered most of their territories, and this re- sulted in lower clutch size. Skeel (1983) observed Whimbrels regularly foraging away from defend- ed territories, and monogamous calidridine sandpipers often exhibit similar foraging patterns during the incubation period (Holmes 1971, Jehl 1973, Miller 1979). Although foraging often oc- curred at a distance from the defended territory in this study, curlews regularly foraged in the cheatgrass habitat throughout the breeding sea- son. Both 1978 and 1979 were years of high grasshopper (Orthoptera) numbers, and curlews were often observed foraging on them.

NEST-SITE SELECTION

Comparison of nest-site characteristics in differ- ent habitats in this study indicated that Long- billed Curlews were relatively plastic in nest-site selection, although a preference for structurally short (low vertical profile) habitats was evident.

TABLE 6. Comparison of nest-site characteristics between habitats for Long-billed Curlews in north-central Oregon.

| Habitats compared | Results of Hotelling's T² test between groups (P < 0.05) | Variables contributing to significant univariate t-tests[a] |
|---|---|---|
| Cheatgrass–Bunchgrass | (P < 0.0001) | EFHT, FHDG, FHDTOT, HGWE, HTOT-25, HGTO, HTOVRL |
| Cheatgrass–Dense forb | (P < 0.0001) | BRGD, FHDG |
| Cheatgrass–Open-low-shrub | (P < 0.05) | BRGD, HH25 |
| Bunchgrass–Dense forb | (P < 0.0001) | FHDG, HG25, HH25 |
| Bunchgrass–Open-low-shrub | (P < 0.001) | HG25, HG50, HTOVRL |
| Dense forb–Open-low-shrub | Nonsignificant | |

[a] EFHT - Effective height, FHDG - Foliage height diversity of grasses. FHDTOT - Foliage height diversity of all vegetation, HG25 - Vertical density of grasses from 0-25 cm., HTOT - Vertical density of all vegetation from 0-25 cm, HG50 - Vertical density of grasses from 0-50 cm, HTOVRL - Vertical density of all vegetation overall, BRGD - Bare ground cover, HH25 - Vertical density of herbaceous plants from 0-25 cm.

Grassland ecosystems are characterized by cli- matic variability and unpredictability (Wiens 1974), and yearly variation in precipitation and temperature may result in varying structure of an annual grassland. Comparison of nest-site and general habitat characteristics indicated that ver- tical structure of vegetation was an important factor in nest-site selection. Vegetative height and foliage height diversity were lower at nest sites than surrounding habitats in all cases except one. The importance of overall foliage height even- ness in the cheatgrass habitat and all habitats combined indicated that curlews selected nest sites with vertically patchier vegetation than oc- curred in the general landscape. Cryptic colora- tion of eggs and plumage suggest that predation has been a strong selective force, and the verti- cally uneven distribution of vegetation around nest sites may enhance adult survival or nest success. Mortality of nesting adults was low over the two years; only six of 101 nests were aban- doned and mortality was possible only in three of these cases. Bicak (1977) found that Long- billed Curlew nest sites in Nebraska had greater vertical biomass at the 5-10 cm height interval than did the shortgrass in general, but he did not examine relative vertical dispersion (evenness) of vegetation.

Long-billed Curlews avoided bitterbrush and bunchgrass habitats in this study even though these habitats were contiguous with cheatgrass habitats in which a high breeding density oc- curred. Avoidance of native bunchgrass habitat is interesting because it was the dominant climax community prior to the arrival of Europeans in the area (Poulton 1955). Historically, curlews ei- ther did not use native bunchgrass habitats for nesting, or these habitats are different now than they were 200 years ago. In addition, intensive grazing likely reduced the abundance of bunch- grass and left prime conditions for the subse- quent invasion of exotic cheatgrass. Curlews currently breed in high densities in cheatgrass- dominated areas, which were formerly domi- nated by bunchgrass. Various habitats probably supported curlews prior to the advent of Euro- pean people, including areas dominated by Sand- berg's bluegrass and saltgrass around playas. These habitats may have supported breeding curlews prior to the invasion of cheatgrass, and the distribution of breeding curlews may have changed after cheatgrass became well estab- lished. Similarly, wild fires may have played an important role in the evolution of habitat and nest-site selection of this species, because fires kill most shrubs and create open habitats. Such changes would create more favorable habitat conditions for Long-billed Curlews; Burrowing Owls, *Athene cunicularia* (Green and Anthony 1989); and Loggerhead Shrikes, *Lanus ludovi- cianus* (Poole 1993). All three species are prom- inent breeders in shrubsteppe communities of the Columbia Basin of Oregon and Washington.

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# NESTING SUCCESS AND HABITAT RELATIONSHIPS OF BURROWING OWLS IN THE COLUMBIA BASIN, OREGON[1]

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*Abstract.* Burrowing Owls *(Athene cunicularia)* were studied to determine their nesting success and patterns of nest-site selection in northcentral Oregon during the breeding seasons of 1980 and 1981. Nest success was 57% for 63 nests in 1980 and 50% for 76 nests in 1981. Desertion was the major cause (32%) of nest failures and was related to the proximity of other nesting pairs. Depredation of nests by badgers *(Taxidea taxus)* was the next most frequent cause (14%) of nest failure. Nests lined with livestock dung were significantly less prone to predation than unlined nests. Burrowing Owls occupied three of the five habitats surveyed for pairs. Burrows with good horizontal visibility and little grass coverage were preferred. Elevated perches were used in habitats with average vegetation height □5 cm and not in habitats with vegetation □5 cm. Elevated perches presumably improved the Burrowing Owl's ability to detect both predators and prey by increasing their horizontal visibility. Low grass cover may be indicative of a high availability of prey preferred by Burrowing Owls. The nesting ecology of Columbia Basin Burrowing Owls appears to be strongly influenced by the availability of badger burrows for nesting and, in tum, on predation pressures by badgers.

*Key words: Burrowing Owl;* Athene cunicularia; *nesting success; nesting habitat; shrub-steppe; Columbia Basin; nest predation.*

## INTRODUCTION

Burrowing Owls *(Athene cunicularia)* inhabiting the prairie grasslands of the midwestern and southwestern United States frequently use aban- doned prairie dog *(Cynomys* spp.) and ground squirrel *(Spermophilus* spp.) burrows for nesting and shelter (Butts 1971, Coulombe 1971, Martin 1973, MacCracken et al. 1985). Prairie dogs and ground squirrels also modify the habitat by in- tense grazing and clipping of unpalatable vege- tation around their burrows (Bonham and Ler- wick 1976, Hansen and Gold 1977). This removal of vegetation is important to nesting Burrowing Owls as it increases their horizontal visibility (Best 1969, Coulombe 1971, MacCracken et al. 1985) which aids in early detection of potential nest predators, especially mammalian predators (Byrkjedal 1987).

Burrowing Owls in the Pacific Northwest fre- quently use abandoned badger *(Taxidea taxus)* burrows for nesting (Maser et al. 1971, Gleason and Craig 1979, Rich 1986) and, in the Columbia Basin, may be dependent on badgers for burrows, because the burrows of resident ground squirrels are too small. However, Burrowing Owls pre- sumably risk lower nesting success by nesting in badger burrows (Messick and Hornocker 1981), because badgers commonly prey on Burrowing Owl eggs and nestlings (Coulombe 1971, Gleason and Craig 1979). Consequently, Columbia Basin Burrowing Owls may have adopted strategies of nest-site selection that exhibit well-developed antipredator behaviors in response to badgers.

The purpose of this paper is to describe the causes of nesting failures and characterize nest sites of Burrowing Owls in the Columbia Basin. We also discuss diet and its influence on nesting success and how nest-site selection may be in- fluenced by prey availability and predation by badgers.

## STUDY AREA

The study area was in the shrub-steppe zone of northern Gilliam, Morrow, and Umatilla coun- ties in northcentral Oregon. The topography there ranges from flat to undulating with elevations ranging from 75 m on the loamy-sand soils near the Columbia River to 200 m on the silty-loam soils in the southern uplands. The average annual precipitation in the area is approximately 22 cm (Ruffner 1978), most of which falls during the

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winter and early spring. Summers are hot and dry with several days of maximum temperatures exceeding 40°C.

The natural vegetation of the study area is in- cluded in the *Artemisial Stipa* or *Artemisial Agro- pyron* plant associations (Poulton 1955), but vegetation climaxes are rare because of edaphic conditions, fire, or livestock grazing. Cheatgrass *(Bromus tectorum),* needle-and-thread *(Stipa comata),* blue-bunch wheatgrass *(Agropyron spi- catum),* and Sandburg's bluegrass *(Poa sandbur- gii)* are the most abundant grasses. Important shrubs are antelope bitterbrush *(Purshia triden- tata*), snakeweed *(Gutierrezia sarothrae),* gray rabbitbrush (*Chrysothamnus nauseosus),* and big sagebrush *(Artemisia tridentata).* Locally abun- dant forbs include hairy plantain *(Plantago pa- togonica),* filaree *(Erodium cicutarium),* and snowy buckwheat *(Eriogonum niveum).* Five distinct plant communities or habitats were se- lected for study: cheatgrass grassland, bunchgrass grassland, rabbitbrush shrubland, bitterbrush shrubland, and an intensively grazed habitat dominated by forbs and snakeweed (see Green 1983 for detailed descriptions).

## METHODS

Nesting pairs of Burrowing Owls were located by systematically searching the study areas. All areas were searched at least twice a season to locate late-nesting pairs. When a nest was found, the immediate area was repeatedly searched for neighboring pairs.

Because young Burrowing Owls may continue to use the nest burrow for shelter into the late summer and fall, a nesting attempt was consid- ered successful when young had reached flight stage (6 weeks ofage). Occurrence of eggshells in pellets (castings) aided in determining whether nesting had occurred, as Burrowing Owls fre- quently ingest their own eggshell fragments (Green 1983). Behavioral activities which coincide with egg laying, incubation, and brooding (see Cou- lombe 1971, Martin 1973) plus the length of known occupancy were also used to determine if nesting occurred. Unsuccessful nests were those destroyed or deserted after eggs had been laid. Desertion was defined as adult abandonment of a nest occupied by eggs or young, for whatever reason, including death of the adults. Determi- nation of desertion was made by noting a lack of tracks or fresh prey. Entrances of deserted bur- rows were often covered with webs ofblack wid- ow spiders *(Latrodectus mactans),* common in- habitants ofnest burrows in the Columbia Basin. The area within 300 m of a deserted nest burrow was intensively searched for a "new" nest burrow to determine if shifting of burrows had occurred as described by Henny and Blus (1981).

Diets of Burrowing Owls were determined by analyzing regurgitated pellets (castings). Pellets were collected in groups from around perches and burrows at each nest site approximately once monthlyin 1980andevery2weeksin 1981.Each group was soaked overnight in a 2-M (8%) so- lution ofNaOH, a method which dissolves hair and feathers but leaves chitin and osseus material intact (Degn 1978). After material was strained and dried, vertebrate and arthropod parts were separated from the pellet mass, identified to the lowest taxon possible, and the number of indi- viduals per taxon counted. Head capsules, elytra, and jaws of arthropods, and lower mandibles of rodents were the main body parts used in the identification.

Abundance of badger burrows was estimated along transects by stratified random sampling; stratification was relative to the five different habitats. Burrow abundance was surveyed on 110 randomly located transects, each 500 m in length. Transect width varied between 30 and 60 m de- pending on vegetation density. These data were used to establish and compare burrow avail- ability and density among the five habitats.

The importance of vegetative structure in nest- site selection was determined by comparing veg- etative characteristics of occupied nest sites with the general habitat. Assuming Burrowing Owl habitat requires available burrows, vegetation measurements around unoccupied burrows ("potential" nest sites) were used in describing the general habitat. Vegetation was systemati- cally sampled along four transects, each 50 min length, radiating from the burrow. The transects were 90° apart with the first direction selected randomly. Percent cover of shrubs, forbs, grass- es, and bare ground was estimated systematically at 40 quadrats (10 x 50 cm), distributed every 5 m along the transects (Daubenmire 1959). Ef- fective height and vertical density (Wiens 1973) were also recorded at each of the 40 quadrats. Shrub cover was estimated using the line-inter- cept method (Piper 1973), and shrub volume was estimated by multiplying intercept distance by

TABLE 1. List and description of variables measured in characterizing the habitat of occupied and potential nest sites of Burrowing Owls in the Columbia Basin.

| Variable | Description |
| --- | --- |
| Percent bare ground Percent forb Percent grass Percent shrub | Percentage estimate of coverage of bare ground, and canopy coverage of forbs, grasses, and shrubs (Daubenmire 1959). |
| Shrub intercept | Meters of shrubs intercepted along a 50-m transect divided by 50 (Piper 1973). |
| Shrub volume | Shrub intercept multiplied by the mean height of the intercepted shrubs. |
| Effective height | Height at which 90% of a white board is obscured by vegetation when viewed I m from the ground at a distance of I O m. |
| Vertical density 0-10 cm Vertical density 10-20 cm Vertical density 20-30 cm Vertical density 30-40 cm Vertical density 40□ cm Vertical density total | Number of touches by plants within 10-cm height intervals along a thin vertical rod (Wiens 1973). |
| Number of perches | Number of elevated perches located within 300 m of each nest site. |
| Mean perch distance | Mean distance from burrow to perches at each nest site. |
| Mean perch height | Mean height of perches at each nest site. |
| Foliage height diversity Foliage height evenness | Indices computed from vertical density measurements according to Pielou (1975:8-15). |

90% height of intercepted shrub. Fifteen vege- tative characteristics plus three computed vari- ables (Table 1) were used to compare occupied vs. potential nest sites and to compare nest sites among habitats.

## STATISTICAL **ANALYSIS**

To determine whether nest desertion was related to proximity to another nest, a median test (Steel and Torrie 1980) was performed on distances between nearest-neighbor nests. Specific nearest- neighbor distances were used only once in the analysis to prevent bias by pairs having recip- rocal nearest neighbors. Nests known to be lost by depredation were not used in the analysis. A 2 x 2 contingency table was used to test for differences in nest success between nests lined and not lined with livestock dung. Direct Dis- criminant Function Analysis **(SPSS;** Klecka 1975) was used to test for differences in vegetative char- acteristics between occupied and potential nest sites and to determine which variables were sig- nificant *(P* □ 0.05). One of each pair of variables that were highly correlated *(r* □ 0.70) was re- moved from the variable set to eliminate inter- dependencies before discriminant analyses were performed. Variables were compared between habitats by t-tests.

# RESULTS

## NEST SUCCESS

In 1980, 33 of 63 (57%) occupied nests success- fully fledged young, and 38 of 76 (50%) were successful in 1981. Desertion was the major cause of nest failure and accounted for 35% and 30% of the nesting attempts in 1980 and 1981, re- spectively. Predation resulting in nest failure oc- curred at 8% of the nests in 1980 and 20% of the nests in 1981; badgers were responsible for 18 of the 20 (90%) nests lost (as indicated by re- excavation characteristic of badgers). The other two nests were destroyed by canids; one by a coyote *(Canis latrans)* and the other by a do- mestic dog *(Canis familiaris).* Overall nest suc- cess (53%) of Burrowing Owls in the Columbia Basin was much lower than the 79% *(n* □ 54) found in Oklahoma (Butts 1971) but similar to the 54% *(n* □ 24) reported by Thomsen (1971) in California. There was a significant ($x^2$ □ 12.7, *P* □ 0.0001) difference in distances between nearest neighbors for successful and deserted Burrowing Owl nests. For all pairs of nests with an internest distance less than 110 m, at least one of the two nests was deserted in midnesting cycle, whereas only three of 21 (14%) pairs with internest distances greater than 110 m aban-

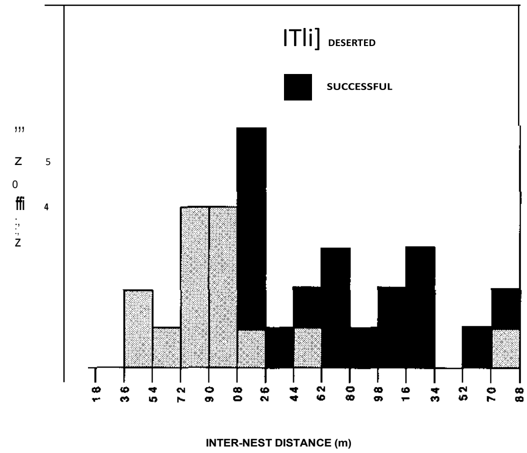


FIGURE 1. Nesting success of Burrowing Owls in relation to distance to nearest nesting pair of conspe- cifics. "Deserted" values are intemest distances where at least one of two associated nests was deserted. If both nests fledged young, the intemest distance was called "successful."

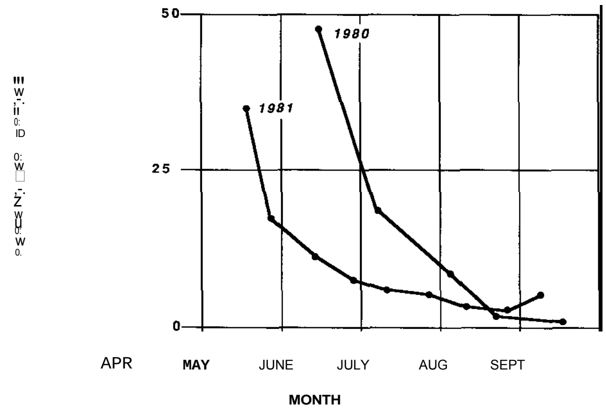


FIGURE 2. Seasonal change in vertebrate compo- sition of the diet by frequency of occurrence (prey $\geq$ 3 mg) for Burrowing Owls in the Columbia Basin.

doned at least one of the nests (Fig. 1). Many of the desertions occurred after hatching, and no evidence of burrow shifting was found at badger den nest sites. In three cases, lethargic (thought to be starving) young were found at burrow en- trances in which no adults were seen then or thereafter.

Martin (1973) hypothesized that Burrowing Owls line their nest and the tunnel entrance with cattle dung in order to avoid predators by mask- ing nest odors. Many nest sites in our study were located in areas where livestock dung was not available. Thus, we had an opportunity to test this hypothesis. In 1981, 15 nests were lost by predation, of which only two (13%) were lined with dung. In contrast, of 32 nests which were successful, 23 (72%) were lined. The difference was significant ($\chi^2 = 14.1$, $P < 0.0001$).

DIET

Analysis of 5,559 pellets revealed that arthro- pods (mainly insects) comprised 92% of the total diet by number while vertebrates (mostly ro- dents) comprised the remaining 8%. However, because of the size difference of the two taxa, vertebrates comprised 78% of the biomass. Nearly 90% of the vertebrate prey were rodents and >99% were mammalian. Composition of the two taxa in owl diets was not constant throughout the breeding season. Burrowing Owls preyed heavily upon rodents in the spring, then shifted to an almost exclusively insect diet by the sum- mer (Fig. 2). We attributed this shift in diet to an increase in concealing cover for rodents and a general seasonal increase in insects. Further analysis of diet can be found in Green (1983).

NESTING HABITAT

Of the five habitats searched for Burrowing Owl nest sites, nesting pairs were found in the snak- eweed, cheatgrass, and bitterbrush habitats, but not in the bunchgrass or rabbitbrush habitats. Only dispersing juveniles were occasionally ob- served in the latter habitats. Densities of badger burrows were estimated in all habitats to deter- mine if burrow availability influenced the dis- parity in habitat selection. There was an average of 1.8 (SE ± 0.42) potential burrows/ha in the three habitats used by the owls for nesting and 3.1 (SE ± 1.26) potential burrows/ha in the two habitats (bunchgrass and rabbitbrush) not used. Burrow availability was obviously not the reason for the absence of nesting owls in the bunchgrass and rabbitbrush habitats.

There was a significant ($P < 0.05$) difference in vegetative characteristics between occupied and potential nests (burrows) in both the cheat- grass and bitterbrush habitats (Table 2). For the cheatgrass habitat, mean perch height and per- cent grass were important variables that discrim- inated between the occupied and potential sites. Burrowing Owls selected nest sites with higher perches (85.9 cm vs. 31.6 cm) and less grass cov- erage (28% vs. 50%) as compared to potential nest sites (Table 2). The discriminant function correctly reclassified 82% of the sites in the cheat-

TABLE 2. Discriminant function analysis on vegetative characteristics of occupied and potential nest sites of Burrowing Owls in cheatgrass and bitterbrush habitats in northcentral Oregon.

| Habitat | Percent correctly classified | Variables entered | Occupied nests' X | (SD) | Potential nests[2] X | (SD) |
|---|---|---|---|---|---|---|
| Cheatgrass | 82 | Mean perch height (cm) | 85.9 | (43.0) | 31.6 | (37.8) |
| | | Percent grass cover | 28.3 | (13.1) | 49.6 | (19.4) |
| Bitterbrush | 88 | Shrub volume | 9.3 | (4.7) | 13.5 | (3.7) |

[1] *n* □ **18 nests for each of the cheatgrass and bitterbrush habitats.**
' *n* - IS nests for each of the cheatgrass and bitterbrush habitats.

grass habitat. Shrub volume was the only vari- able important in discriminating the two groups in the bitterbrush habitat; Burrowing Owls se- lected nest sites with lower mean shrub volumes (9.3 cm vs. 13.5 cm) as compared to potential sites (Table 2). For the bitterbrush habitat, 88% of the nests were reclassified correctly by the dis- criminant function. Although the bitterbrush habitat provided a large number of suitable perches, high shrub cover probably obstructed vision. As a result, Burrowing Owls selected nest sites in the habitat with lower shrub volumes than surrounding areas which may indicate a trade-off between the high number of potential perches and a minimum level of horizontal vis- ibility.

Significant correlations between the variables selected by the DFA and other variables revealed further differences between occupied and poten- tial burrows. Percent grass cover was negatively correlated (r □ -0.897) with percent bare ground and positively correlated with vertical density at the 0-10 cm (r □ 0.700), 0-20 cm (r □ 0.708), and total height classes (r □ 0.800) for the cheatgrass habitats (Table 3). No variables were highly correlated with mean perch height (P □ 0.05). Shrub volume was positively correlated with shrub cover (r □ 0.881) and effective height (r □ 0.827) for the bitterbrush habitats. Of these correlated variables, percent bare ground, ver- tical density (0-10 cm), and shrub intercept were significantly different (P □ 0.05) univariately be- tween occupied and potential burrows. There- fore, Burrowing Owls selected nest sites with more bare ground and less vertical density (0-10 cm) than that available in the cheatgrass habitat, and in the bitterbrush habitat the owls selected sites with less shrub cover (Table 3).

MacCracken et al. (1985) compared canopy coverage around Burrowing Owl nest sites in South Dakota prairie dog towns with the prairie outside of towns. They too found Burrowing Owls were selecting for higher bare ground (42% vs. 39%) and less grass coverage (35% vs. 44%) and at levels closely approximating our results for the cheatgrass habitat.

Intrahabitat comparisons were not made in the snakeweed habitat because all badger burrows found in both years were occupied by nesting pairs. However, interhabitat comparisons showed

TABLE 3. Variables that are highly correlated (r □ 0.700) with variables that significantly separated occupied and potential nest sites of Burrowing Owls using direct Discriminant Function Analysis.

| Discriminant function variables | Correlated variables | Correlation coefficients | Occupied nests[1] X | (SD) | Potential nests[2] X | (SD) | p |
|---|---|---|---|---|---|---|---|
| Cheatgrass habitat: | | | | | | | |
| Mean perch height | None | | | | | | |
| Percent grass | Percent bare ground | -0.897 | 54.8 | (15.2) | 41.3 | (15.5) | □ |
| | Vertical density 0-10 cm | 0.700 | 1.50 | (0.66) | 1.64 | (0.57) | □ |
| | Vertical density 10-20 cm | 0.708 | 0.35 | (0.28) | 0.61 | (0.34) | ns |
| | Vertical density total | 0.800 | 1.95 | (0.91) | 2.49 | (1.07) | ns |
| Bitterbrush habitat: | | | | | | | |
| Shrub volume | Shrub intercept (cover) | 0.881 | 11.4 | (5.30) | 19.6 | (7.60) | □ |
| | Effective height | 0.827 | 31.1 | (8.80) | 38.3 | (11.9) | ns |

[1] *n* □ **18 nests for each of the cheatgrass and bitterbrush habitats.**
' *n* - 15 nests for each of the cheatgrass and bitterbrush habitats.
□***P*** **□ 0.05, ns □ nonsignificant; umvariate F-ratio.**

that nest sites in the snakeweed habitat were not significantly different from nest sites in any of the cover classes in the cheatgrass habitat, but were significantly different *(P* □ 0.000 I) in ef- fective height and all vertical density classes. The mean effective height for snakeweed nest sites was only 4.7 cm compared to 9.8 cm for cheat- grass nest sites. Mean bare ground for snakeweed nest sites was identical (49%) to bitterbrush nest sites. Mean percent grass coverage was 36%, again very close to the findings (35%) of MacCracken et al. (1985) in South Dakota. Furthermore, Bur- rowing Owls nesting in the snakeweed habitat did not use elevated perches.

The dominant plants of the bunchgrass and rabbitbrush habitats appeared to be structurally unsuitable for owl perches. Burrowing Owls that were perched on rabbitbrush (usually because of our presence near their normal perches) were un- stable. Because the mean effective height of vege- tation in these habitats (□ 20 cm) is probably great enough to restrict horizontal visibility, lack of stable perches may partially explain why Bur- rowing Owls avoided bunchgrass and rabbit- brush habitats for nesting.

Soil texture had a significant effect on the lon- gevity of a burrow and hence its suitability for renesting in subsequent seasons. Of the 85 nests in loamy-sand soils, 46% were silted in by the next nesting season. Of 13 nests in silty-loam soils, none were silted in. Reuse of available (open) burrows for nesting was also different for the two soil types. Of burrows used in the pre- vious nesting season, only 52% of those still open were reoccupied in the loamy-sand soils. How- ever, this is higher than the 31% recorded by Rich (1984) for Burrowing Owls using badger dens in Idaho (soil type not given). In many cases, a nest in a new burrow could be found within 50 m of a previously used burrow. All nest burrows were reused in the silty-loam soils. An extensive search in 1981 also disclosed that all available burrows in silty-loam soils were reoccupied, in- dicating little potential for population expansion and the importance of badger burrows for nesting in this area.

## DISCUSSION

Nest desertion was most frequent when two pairs nested within 110 m of each other. In contrast, Burrowing Owls in Oklahoma (Butts 1971) and California (Thomsen 1971) often nested closer than 110 m, without a high frequency of deser- tion. Although some desertions may have been due to death ofadults, the high frequency of nest desertion by nearest-neighbor Burrowing Owls in the Columbia Basin may be related to the climate of the region and its effects on the activity cycles of prey. Food habits data collected in this study showed a dramatic shift in diet from small mammals in the spring to insects in the summer (Fig. 2). Above ground activity of pocket mice *(Perognathus parvus),* the major small mammal prey of Columbia Basin Burrowing Owls, tends to drop dramatically in June (O'Farrell et al. 1975). At this time foraging pairs began feeding closer to the nest, consistent with Central Place Foraging theory (Orians and Pearson 1979), which predicts that foraging distances decrease as size of prey decreases. Burrowing Owls may have also foraged close to their nests because of high arthropod densities. The senior author ob- served captures of rodents as far as 600 m from the nest but no insect captures beyond 100 m and most within 50 m. Furthermore, activity cycles of ground-dwelling arthropods shifts from diurnal to crepuscular periods as the hot summer progresses (Rickard and Haverfield 1965). Sum- mer foraging bouts for insects usually lasted no more than 1 hr, occurred twice daily, and were very intense. Adjacent nesting pairs may have competed for the same food source in the middle of the nest cycle and, if so, were stressed by the demands of large brood sizes (generally six to eight) at the peak of their growth. When two pairs nested closer than 60 m, both nests were aban- doned, further supporting the contention that as distance between nests decreased, competition intensified.

We also found that the distribution of badger burrows was generally clumped. Nesting pairs may have found it difficult to locate a burrow in suitable habitat not near another nesting pair. Consequently, prospective nesters may have had to choose between nesting near another pair, and the consequences that may follow, or not nesting at all.

Nest loss due to predation by badgers was much higher at nests that were not lined with livestock dung than those that were. Badgers frequently return to dens on a regular basis (Messick and Hornocker 1981) and are largely dependent on olfaction for prey detection (Knopf and Balph 1969, Lampe 1976). Presumably, Burrowing Owls line nests with dung to conceal both the odors of nest occupants and any lingering badger odors that may remain. The suggestion that birds use odiferous substances to conceal nests is not new. Kilham (1968) has described the "sweep- ing" of crushed insects by White-breasted Nut- hatches *(Sitta carolinensis)* around the nest cav- ity as a defense against scent-trailing tree squirrels. Byrkjedal (1987) described the open habitat of nesting Greater Golden-Plovers *(Pluvialis apri- caria)* as an antipredator response to mammals. Early detection of predators allowed the adults to distract predators away from the nest before the predator could detect the nest scent. Presum- ably, Burrowing Owls nest in open habitats for the same reasons. Prairie dog towns are espe- cially attractive to Burrowing Owls, and other open-nesters such as Mountain Plovers *(Cha- radrius montanus)* (Knowles et al. 1982), because open habitats required for nesting already exist and are created by prairie dogs.

Columbia Basin Burrowing Owls nested in open habitats, and habitats with tall dense vege- tation were not used for nesting. The intensively grazed snakeweed habitat, although limited in availability, was particularly selected by nesting pairs as all available burrows were occupied. The cheatgrass and bitterbrush habitats were com- monly used for nesting, particularly when ele- vated perches were available. Elevated perches increased the owl's horizontal visibility, which was probably important for both predator and prey detection in habitats with vegetation of moderate height. Coulombe (1971) has also sug- gested that the use of elevated perches aids in thermoregulation by Burrowing Owls, especially of males which spend much of the day watching for predators. The lightly feathered legs may act as heat dissipators, as in other species (Kahl 1963, Steen and Steen 1964, Butler 1982), if the owl is not near the soil surface where temperatures are high. Nesting in the snakeweed habitat probably does not require elevated perches, because the vegetation is so short that the males can extend their bodies partially into the shaded burrow en- trance and still have good horizontal visibility.

A lack of dense grass cover was common to all occupied nest sites in all habitats. Dense grass or litter may impede movements of *Perognathus parvus* (Gano and Rickard 1982), *Peromyscus maniculatus* (Tester and Marshall 1961), and ground-dwelling arthropods (Tester and Mar- shall 1961, Rickard and Haverfield 1965), all important prey of Columbia Basin Burrowing Owls (Green 1983). Grasses also provide pro- tective cover for the prey, making predation more difficult for raptors (Southern and Lowe 1968, Wakeley 1978, Bechard 1982). Also, higher pop- ulations of small mammals (Rogers and Hedlund 1980, Gano and Rickard 1982) and beetles (Rog- ers and Fitzner 1980) exist in shrub communities in the Columbia Basin which have relatively low grass coverage. In addition, we observed nesting Burrowing Owls invading areas which had re- cently burned, suggesting that fire may also play an important role in reducing vegetation around burrows.

In summary, the nesting ecology of Columbia Basin Burrowing Owls appears to be strongly linked with the denning and foraging behavior of badgers. Badgers are important to Burrowing Owls both because they are the chief provider of nest burrows and the major predator of owl nests. Selecting habitats of relatively short vegetation for nesting, utilizing elevated perches in habitats where the average vegetation height is □ 5 cm, and lining the nest with livestock dung appear to be strategies to prevent predation of adults or nest contents by badgers. Furthermore, the ob- served high rate of nest desertion by Columbia Basin Burrowing Owls may be a result of com- petition between closely nesting pairs, which is influenced by the clumped distribution of badger burrows.

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# Comparative Diets of Burrowing Owls in Oregon and Washington

## Abstract

We studied diets of breeding burrowing owls (*Speotyto cunicularia*) in the Columbia Basin of southcentral Washington and northcentral Oregon during 1977-78 and 1980-81, respectively. Vertebrates, primarily rodents, comprised only 9.6 percent of the total prey numbers contained in 6,328 regurgitated pellets but 87.3 percent of the biomass in the two samples combined. Vertebrate prey use was twice as high in Washington (17.1%) as in Oregon (8.4%). We attributed this to differences in habitat, including soil type, and the effects of annual variations in rainfall on prey populations. Great Basin pocket mice (*Perognathus parvus*) dominated the vertebrate prey in both states and contributed the greatest overall biomass (35.0%). Orthopteran insects comprised the greatest invertebrate biomass (10.2%), while three families of beetles contributed 49.0 percent of the total individual prey, but only 1.3 percent of the biomass. Soil type influenced differences in vertebrate composition in Oregon. Mean dry mass of over 76 prey taxa ranged from <4 mg to >40 g, indicating this species has a broad range of prey size.

## Introduction

Knowledge of a raptor's diet is an important component of an effective management plan. Because all raptors are carnivorous, management objectives should consider the prey base. However, raptor diets are often site-specific and contingent upon regional availability of potential prey (Jaksic and Marti 1981). Therefore, locally collected data can be misleading when applied to another site or general region. This is especially true for generalists with a broad foraging niche. Consequently, diet data should be collected locally to insure an accurate assessment of forage use and then compared to other regions to determine the uniqueness of the local diet.

Prey availability can also change within a region on an annual basis as the prey base is influenced by changing factors such as weather, population dynamics, vegetation growth, and human activities (especially agriculture). Therefore, data collected for only one year may provide a misleading view of raptor food habits and a misleading view of the region's potential prey base. Consequently, data should be collected for more than one year to assess annual variation.

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We report on the diet of breeding burrowing owls (*Speotyto cunicularia*) in shrub-steppe habitats at two locations in the Columbia Basin from data collected over separate two-year periods. We compare our results among years, locations, and soil types within our study area to better quantify spatial and temporal variations in the owl's diet. We also compare our results with data collected from other large ecosystems (Colorado, California, and Chile) to gain a better perspective on the regional trophic ecology of the Columbia Basin relative to burrowing owl food habits.

## Study Area and Methods

The studies were conducted in the shrub-steppe zone of northern Gilliam, Morrow, and Umatilla counties in northcentral Oregon and at the U.S. Department of Energy's (DOE) Hanford Site in north Benton County, southcentral Washington. The topography in both study areas ranges from flat to undulating, with elevations ranging from 75 m to 200 m. The average annual precipitation for both study areas is approximately 22 cm (Ruffner 1978), most of which falls during the winter and early spring. Summers are hot and dry with several days of maximum temperatures exceeding 40°C.

The natural vegetation of the study areas is included in the *Artemisia/Stipa* or *Artemisia/Roegneria* [=*Agropyron*] plant associations (Poulton

1955), but climax vegetation is rare because of edaphic conditions, fire, or livestock grazing. Cheatgrass (*Bromus tectorum*) is a major alien invader and dominates much of the study areas. Less disturbed grasslands were dominated by western needle-and-thread (*Stipa comata*) at the lower elevations (< 100 m) and bluebunch wheatgrass (*Roegneria spicata* [= *Agropyron spicatum*]) at the higher elevations (> 100 m). Important shrubs in both study sites included big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), and snakeweed (*Gutierrezia sarothrae*). Burrowing owl nest sites were found in cheatgrass-dominated grasslands, snakeweed shrublands, or sparse shrublands of tall sagebrush or bitterbrush which was associated with cheatgrass or sparse bluebunch wheatgrass.

Diets of burrowing owls were determined by analyzing regurgitated pellets. Pellets were collected from around each nest site and at nearby perches every 1-3 weeks during the nesting season (April-July) and soaked overnight in a 2-molar (8%) solution of NaOH (Degn 1978) to dissolve hair. After material was strained and dried, vertebrate and arthropod parts were separated from the pellet mass, identified to the lowest taxon possible, and the number of individuals counted. Head capsules, elytra, and jaws of arthropods, and skulls and dentaries of vertebrates were the main body parts used in identification. Fragments were identified by comparing to specimens in museum collections at Oregon State University and Battelle PNW Laboratories. All data were converted to biomass (dry weight) from Rogers *et al.* (1976), Gleason and Craig (1979), and specimens collected at the study sites.

## Results and Discussion

We collected and analyzed a total of 6,328 pellets of which 769 were collected from 5 nest sites at the Washington site in 1977-78 and 5,559 from 65 nests at the Oregon study area in 1980-81. These samples comprised a total of 37,431 individual prey representing 35,269 g (dry) of biomass and included 14 species of small mammals, 3 species of birds, 2 reptiles, 1 amphibian, and at least 56 species of arthropods. Estimated biomass of each taxon ranged from 4 mg to 41.6 g. For both study sites and all years combined, arthropods made up 90.4 percent of the prey individuals but only 12.7 percent of the biomass, while small vertebrates, mostly rodents, comprised the balance (Table 1).

A higher percentage of vertebrate prey numbers was found in diets in Washington (17.1%) than from Oregon (8.4%), which may have been a result of a higher availability of Orthoptera (Acrididae, Tettigonidae, and Gryllacrididae) prey at the Oregon study site. Grasshoppers, especially *Melanoplus* sp., were at or near epidemic proportions both years of the Oregon study and were preyed upon heavily by the owls probably to the near exclusion of other prey by late summer. Four species of small mammals were common among the vertebrate prey in Washington and six species in Oregon. Great Basin pocket mice (*Perognathus parvus*) dominated the vertebrate prey in both areas and contributed 35 percent of the total biomass. Other studies (O'Farrell *et al.* 1975, Green 1983) have found pocket mice at greater densities than all other small rodents on both areas. Differences in small mammal prey composition between the two areas reflected differences in prey species ranges and habitat types. Ord's kangaroo rat (*Dipodomys ordii*) does not occur on the Washington study area and consequently was found only in the Oregon owl diets. The sagebrush vole (*Lagurus curtatus*) was found in burrowing owl diets only on the loamy-soils in Washington, while montane voles (*Microtus montanus*) were found only in the diets of Oregon owls. These differences probably reflect habitat rather than range differences. The largest vetebrate prey were neonate Nuttall's cottontails (*Sylvilagus nuttallii*) and black-tailed jackrabbits (*Lepus californicus*) which together contributed > 10 percent of the biomass in Oregon. Northern pocket gophers (*Thomomys talpoides*) in the diets were generally juveniles.

The most common insect prey were the tenebrionid beetles *Conisattus nelsoni* (Washington) and *Blapstinus* sp. (Oregon) and the scarab beetle *Diplotaxis subangulata* (Oregon). These three species alone contributed over 28 percent of the total individuals. All three species are small (< 7 mg) and contributed < 0.3 percent of the total biomass. Active pursuit of these insects by burrowing owls may result in a negative energy gain to the owls, especially since adult burrowing owls carry single prey to their young. Owls were foraging primarily for their young during our study. We speculate that the adults and perhaps nestlings were passively feeding on these insects within the nest and roost

TABLE 1. Diet composition of burrowing owls in the Columbia Basin of southcentral Washington (1977-78) and northcentral Oregon (1980-81).

| Prey | Washington (n=769 pellets) % No. | Washington % Biomass | Oregon (n=5,559 pellets) % No. | Oregon % Biomass | Total (n=6,328 pellets) % No. | Total % Biomass | Total No. |
|---|---|---|---|---|---|---|---|
| Vertebrates | (17.1) | (89.9) | (8.4) | (86.7) | (9.6) | (87.3) | (3,592) |
| *Sylvilagus nuttallii* | <0.1 | 1.9 | 0.2 | 10.0 | 0.2 | 8.5 | 72 |
| *Thomomys talpoides* | 1.1 | 19.8 | 0.7 | 20.4 | 0.8 | 20.3 | 286 |
| *Perognathus parvus* | 10.5 | 44.9 | 5.1 | 32.7 | 5.8 | 35.0 | 2,167 |
| *Dipodomys ordiis* | 0.0 | 0.0 | 0.4 | 8.7 | 0.4 | 7.1 | 136 |
| *Peromyscus maniculatus* | 1.6 | 6.2 | 1.6 | 9.8 | 1.6 | 9.1 | 604 |
| *Lagurus curtatus* | 1.4 | 6.1 | 0.0 | 0.0 | 0.2 | 1.2 | 69 |
| *Microtus montanus* | 0.0 | 0.0 | 0.3 | 4.6 | 0.3 | 3.8 | 105 |
| Other vertebrates | 2.5 | 11.1 | 0.1 | 0.5 | 0.3 | 2.5 | 153 |
| Invertebrates | (82.9) | (10.1) | (91.6) | (3.3) | (90.4) | (12.7) | (33,839) |
| Scorpionida | 3.7 | 1.0 | 0.5 | 0.2 | 1.0 | 0.4 | 360 |
| Solpugida | 1.0 | 0.1 | 0.5 | <0.1 | 0.5 | <0.1 | 201 |
| Araneida | 2.7 | 0.1 | 0.0 | 0.0 | 0.4 | <0.1 | 137 |
| Acrididae | 0.8 | 0.1 | 8.7 | 2.5 | 7.6 | 2.0 | 2,856 |
| Tettigonidae | 8.5 | 6.5 | 12.1 | 3.3 | 11.6 | 3.9 | 4,345 |
| Gryllacrididae | 6.3 | 0.8 | 13.0 | 5.2 | 12.1 | 4.3 | 4,538 |
| Carabidae | 9.2 | 0.2 | 9.8 | 0.2 | 9.7 | 0.2 | 3,644 |
| Silphidae | 4.5 | 0.5 | 4.3 | 0.7 | 4.3 | 0.7 | 1,623 |
| Scarabaeidae | 14.2 | 0.4 | 14.5 | 0.3 | 14.5 | 0.4 | 5,422 |
| Tenebrionidae | 27.5 | 0.4 | 24.3 | 0.8 | 24.8 | 0.7 | 9,269 |
| Other invertebrates | 4.5 | <0.1 | 3.9 | 0.1 | 3.9 | 0.1 | 1,456 |
| Total numbers and estimated biomass (g) | 5,031 | 6,685 | 32,400 | 28,584 | 37,431 | 35,269 | 37,431 |

burrows. In support of this, over 80 hr of feeding observations by the senior author failed to note any direct feeding on these insects. The beetles are probably attracted to the cool moist burrows and nest litter contained within.

Large Orthoptera were the only invertebrates of which individual taxa contributed >1 percent of the total biomass. In Washington, the coulee cricket (*Apote notabilis*) was by far the most important invertebrate prey, contributing 6.5 percent of the biomass. Coulee crickets were also the largest insect prey averaging over 1 g (dry weight). The most important invertebrate prey in Oregon was the Jerusalem cricket (*Stenopelmatus fuscus*—5.2% of the biomass) followed by the migratory grasshopper (*Melanoplus sanguinipes*—2.5%), the coulee cricket (1.7%), and *Steiraxys* sp. (1.7%). Jerusalem crickets (*Stenopelmatus* spp.) have been reported to be important in the diet of other burrowing owl populations (Maser *et al.* 1971, Thomsen 1971, Gleason and Craig 1979, Brown *et al.* 1986). Other important invertebrate prey included the burying beetle (Silphidae; *Nicrophorus* sp.—0.7% of the total biomass), several species of darkling beetles (Tenebrionidae; *Eleodes* spp.—0.6%), and scorpions (0.4%). Overall, the insect families Carabidae, Scarabaeidae, and Tenebrionidae contributed over 30 prey species and 49 percent of the individuals consumed but only 1.3 percent of the total biomass.

Diets of burrowing owls elsewhere (reviewed by Gleason and Craig [1979]) have shown, as in this study, that these raptors feed predominantly on arthropods and small mammals. Our overall vertebrate:arthropod ratio (10:90%) is very similar to Marti's (1974) results (8:92%) from Colorado; however, prey species composition was quite different. Much higher percentages of vertebrates were found in burrowing owl diets in California (29.3%, Jaksic and Marti 1981; 31.4-41.2%, Thomsen 1971) and Chile (20.0%, Jaksic and Marti 1981). Jaksic and Marti (1981) surmised that the greater proportion of vertebrate prey at their California and Chile study sites compared to the Colorado site reflected differential prey availability rather than differential selection.

We too attribute the differences between Oregon and Washington owl diets to differential prey availability, which in turn are affected by habitat differences (including soil type), annual variations in rainfall on summer estivation patterns of rodents, and the annual variation of insect populations. For instance, at the Oregon site in 1980, vertebrates comprised 12.6 percent of the diet even though grasshoppers (Acrididae – 26.4%) were at epidemic population levels and the proportion of vertebrates in the diet had dramatically decreased from 49 percent in April to less than 5 percent in August (Green and Anthony 1989). In contrast, the composition of vertebrates and grasshoppers in the Oregon diet in 1981 decreased to 7.0 percent and 2.8 percent, respectively, with a corresponding increase in coleopteran prey from 23.3 percent to 62.7 percent; suggesting significant annual variations in diet. Furthermore, O'Farrell *et al.* (1975) determined that annual rainfall in the Columbia Basin and its effect on seed production governed the density and aboveground activity of Great Basin pocket mice. In their study, pocket mice had five-fold changes in population size and 30-day differences in above-ground activity between wet and dry years. Because the Oregon and Washington studies were not conducted during the same years, annual variation in rainfall may have contributed to differences in diet composition.

In addition, differences in vertebrate prey composition between Washington and Oregon were influenced by differences in soil type. Edaphic factors such as depth, texture, and strength have been found to affect populations of small mammals (Best 1969, Kritzman 1974, Feldhammer 1979). Within the Washington and Oregon study sites, two basic soil types were present, loamy-sand and silty-loam. Within the loamy-sand sites pocket mice clearly dominated both the percent number and percent biomass of the mammalian prey at both sites (Table 2). While at the silty-loam sites in Oregon, deer mice (*P. maniculatus*), northern pocket gophers, and Great Basin pocket mice were found in nearly equal numbers, but pocket gophers provided most of the biomass (Table 2). In Washington, pocket gophers also dominated the biomass on silty-loam sites, although pocket mice represented 36 percent of the biomass. In terms of numbers at the Washington silty-loam sites, pocket mice and sagebrush voles were most common. Consequently, dietary composition between Oregon and Washington at the loamy-sand sites were very similar, while at the silty-loam sites the dominance of deer mice in Oregon was replaced by sagebrush voles in Washington. Because sagebrush voles occur in the Columbia Basin of Oregon, their absences in the Oregon diets may be a result of habitat differences other than soil types between the Oregon and Washington sites.

TABLE 2. Composition of mammalian prey of burrowing owls nesting in loamy-sand and silty-loam soils in the Columbia Basin of Washington (1977-78) and Oregon (1980-81).

| | Loamy-sand Soil | | Silty-loam Soil | |
|---|---|---|---|---|
| Prey Species | % No. | % Biomass | % No. | % Biomass |
| **Washington** (n=333) | | | | |
| *Perognathus parvus* | 80.2 | 77.2 | 44.7 | 36.0 |
| *Peromyscus maniculatus* | 15.6 | 12.2 | 5.0 | 3.2 |
| *Thomomys talpoides* | 1.6 | 9.0 | 9.2 | 44.4 |
| *Lagurus curtatus* | 1.6 | 0.7 | 41.1 | 16.4 |
| Other | 1.0 | 0.9 | 0 | 0 |
| **Oregon** (n=2,689) | | | | |
| *Perognathus parvus* | 66.4 | 41.1 | 26.4 | 10.5 |
| *Peromyscus maniculatus* | 16.6 | 11.7 | 31.1 | 14.0 |
| *Thomomys talpoides* | 5.0 | 15.5 | 28.8 | 57.1 |
| *Dipodomys ordii* | 4.7 | 10.7 | 6.1 | 8.9 |
| *Microtus montanus* | 3.9 | 6.2 | 4.0 | 4.0 |
| Lagomorphs | 2.8 | 14.5 | 1.3 | 4.0 |
| Other | 0.6 | 0.4 | 2.3 | 1.5 |

Feldhammer (1979) found a positive correlation between population densities of Great Basin pocket mice and the percentage of sand in the soil, which may aid their digging efforts, and a negative correlation between percent sand and deer mice densities and speculated that deer mice were avoiding the more arid, sandy soils. The same may be true for northern pocket gophers, although Miller (1964) found that this species occupied the widest range of soil types of the four species of pocket gophers he studied in Colorado.

The shift from vertebrate to orthopteran prey in 1980 and the subsequent shift to coleopteran prey by 1981 in Oregon indicates an opportunistic foraging behavior by burrowing owls. The presence of a wide variety of prey taxa and sizes, including ichneumon wasps, blow fly pupae, juvenile muskrats (*Odonatra zibethicus*), and crayfish (*Pacifastacus* sp.) further exemplifies opportunistic foraging. The vast difference in mean prey size (<4 mg to >40 g) and the presence of items killed but not eaten (Great Basin spadefoot toad, [*Scaphiopus intermontanus*]) suggests burrowing owls will pursue any potential prey they can physically handle. Schlatter *et al.* (1980) drew the same conclusion based on their study of burrowing owl diets in central Chile.

Over 90 percent of the vertebrate prey and the major insects such as the Jerusalem cricket and burying beetle were nocturnal species. Their presence in the diet indicates that burrowing owls feed nocturnally. Studies by the senior author also revealed intense feeding activity during the crepuscular hours for predominantly ground-dwelling beetles and grasshoppers; little direct feeding activity was observed during the daylight hours.

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# Nesting success and abundance of Long-billed Curlew in the Columbia Basin

A synthesis of results from monitoring efforts conducted on the Naval Weapons Systems Training Facility, Umatilla National Wildlife Refuge, and Hanford Reach National Monument

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## INTRODUCTION

Long-billed Curlews (*Numenius americanus*) are considered a federal species of conservation concern (U.S. Fish and Wildlife Service 2008). They were classified as a highly imperiled species in the United States shorebird Conservation Plan (Brown et al. 2001) due both to apparent population declines and a relatively small estimated global population size. This status was due, at least in part, on a 2001 population estimate of 20,000 (±50%). That estimate, however, was based primarily on expert opinion and derived from surveys conducted during nonbreeding seasons. More recent population estimates from a systematic range-wide survey were 164,515 (SE = 42,047) in 2004, and 109,533 (SE = 31,060) individuals in 2005 (Stanley and Skagen 2007). These more recent and larger estimates have led to the suggestion that the highly imperiled status assigned by the United States Shorebird Conservation Plan may be unwarranted (Stanley and Skagen 2007). Approximately 12% of the 1.7 million km2 breeding range falls within eastern Oregon and Washington (Dugger and Dugger 2002). The state of Oregon considers them a sensitive species, with a classification of “vulnerable” in the Columbia Plateau and adjacent ecoregions, but not in the Basin and Range ecoregion of southeast Oregon (Oregon Department of Fish and Wildlife 2008). They are not classified as a sensitive species in the state of Washington, but their status is monitored suggesting some level of vulnerability (Washington Department of Fish and Wildlife 2005).

In the Columbia Basin, curlews nest primarily in annual grasslands, meadows within shrubsteppe, bunchgrass grasslands, and to a lesser degree in agricultural croplands or planted grasslands such as crested wheatgrass (Allen 1980, Pampush 1993, Holmes and Geupel 1998). Nesting densities tend to be higher in grasslands with a mix of cheatgrass (*Bromus tectorum*) and Sandberg’s bluegrass (*Poa sandbergii*) than in pure stands of cheatgrass, or in cheatgrass stands with tall forbs such as tumble mustard (*Sisymbrium altissimum*) (Pampush 1980, Allen 1980). Native bunchgrass communities dominated by Needle-and-thread grass (*Heperostipa comata*) and/or bluebunch wheatgrass (*Pseudoroegneria spicata)* are also used, but at lower densities relative to grasslands with a lower vertical profile (Pampush 1980, Holmes and Geupel 1998). Threats to breeding populations include the loss and fragmentation of habitat through conversion of land to agriculture, as well as encroachment of woody vegetation into grassland and prairie habitats (Pampush and Anthony 1993, Samson and Knopf 1994). During the 1970’s a significant amount of grassland and shrubsteppe vegetation was converted to circle-pivot irrigation within the region – including over 100,000ha in the general area that is the focus of this report (Muckleston and Highsmith 1978). Although agricultural development has slowed considerably since that time, recent discussion within the state of Washington have raised the possibility of expanding irrigated lands by up to 30% within the boundaries of the Columbia Basin Project (Bloodworth and White 2008), which would result in additional conversion.

Cropland irrigation in Morrow and Umatilla Counties, where much of the water comes from wells as opposed to rivers, has likely had long-term indirect landscape scale effects on remaining habitat as a result of the depletion of shallow aquifers and the associated lowering of water tables (Norton and Bartholomew 1984). This has contributed to the drying up of wet meadows and seasonal wetlands, which may, in turn, contribute to landscape level degradation of habitat quality. Emergent wetlands within the larger context of grassland habitat were identified as important features for Long-billed Curlews in a recent rangewide analysis of habitat selection (Saalfeld et al. 2010).

This report was developed as a result of discussions among a number of wildlife biologists that have been involved in research or monitoring efforts in the Columbia Basin. Our original intent was to compare nest survival rates across both space and time and to investigate the importance of vegetation type on productivity. We were unable to acquire the raw data from studies that occurred prior to the mid-1990's, however, which precluded the development of a unified model that included data across all the years and locations that data have been collected. Variation in the methods that have been used to document vegetation surrounding nests further precluded a detailed analysis of nest survival in relation to local habitat features. Despite the aforementioned difficulties, this report aims to provide a useful summary of information on the abundance and nest survival of curlews in the Columbia Basin. I present the results of 2 novel analyses – one on nest survival using data from multiple studies, and the second is an analysis of curlew density on portions of the Hanford Reach National Monument that have not been reported previously. Results from these analyses are discussed in the context of previously reported work. There have been a number of projects investigating habitat use and/or nesting success of Long-billed Curlews have taken place within the Columbia Plateau region of Oregon and Washington over the past 3 decades (Table 1). Some of this information has been published in the primary literature and some of it has been reported in unpublished technical reports that are not readily available – here I provide pertinent information on density and nest survival from these various efforts.

Table 1. Summary of research and monitoring projects from major breeding locations in the Columbia Bherasin of Oregon and Washington between 1976 and 2009.

| | Location | | | | |
|---|---|---|---|---|---|
| Years of data collection | NWSTF Boardman | Hanford | Umatilla Army Depot | Umatilla NWR | Citation |
| 1976-1977 | | X | | | Allen 1980 |
| 1978-1979 | X | | X | X | Pampush 1980; Pampush and Anthony 1993 |
| 1995-1997 | X | | | | Holmes and Geupel 1998 |
| 2004-2006 | | X | | | Earnst and Holmes 2010; Earnst and Holmes 2012 |
| 2007-2008 | | X | | X | Stocking et al. 2009 |
| 2009 | X | | | | Kagan et al. 2011 |

**1. Nest Survival**

Methods

I estimated survival rates using program MARK (Rotella 2005). Data were gathered from 1996 and 1997 on the NWSTF Boardman (Holmes and Geupel 1998), and from 2007 and 2008 at the Hanford Reach National Monument and the Umatilla National Wildlife Refuge (Stocking et al. 2009). I did not include nests from the NWSTF that were monitored in 1995 because they tended to be located later in the season, and there is some question about how success was assigned upon nest termination. Details of the monitoring methods can be found in the original reports. I coded nests with covariates that represented the year they were monitored, their location, and the dominant vegetation type within 5 m of the nest. Vegetation types were 1) cheatgrass grassland, 2) bunchgrass grassland, and 3) cropland. Nests located in bunchgrass habitats also contained varying amounts of cheatgrass, but the taller bunchgrasses typified the structure and resulted in a higher vegetation profile. Nests in croplands were from the Umatilla NWR and included fields planted to timothy and alfalfa. Sample sizes ranged from 6 to 49 for each location and year (Table 2). Sample sizes for each of the vegetation types were 103 for cheatgrass, 15 for bunchgrass, and 5 for cropland. I developed a set of 8 *a priori* models that represented meaningful combinations of the covariates and a null model of constant daily nest survival. A sine-link function was used for the constant DSR model and a logit-link function for models that incorporated covariates (Dinsmore et al. 2002). Models were ranked and compared using ΔAIC*c*; models with ΔAIC*c* ≤ 2 were considered equally plausible (Burnham and Anderson 2002).

Table 2. Number of nests used in survival analysis by year and location

| | Year | | | |
|---|---|---|---|---|
| Location | 1996 | 1997 | 2007 | 2008 |
| NWSTF Boardman | 38 | 49 | 0 | 0 |
| Hanford Reach National Monument | 0 | 0 | 6 | 6 |
| Umatilla NWR | 0 | 0 | 9 | 15 |

Results

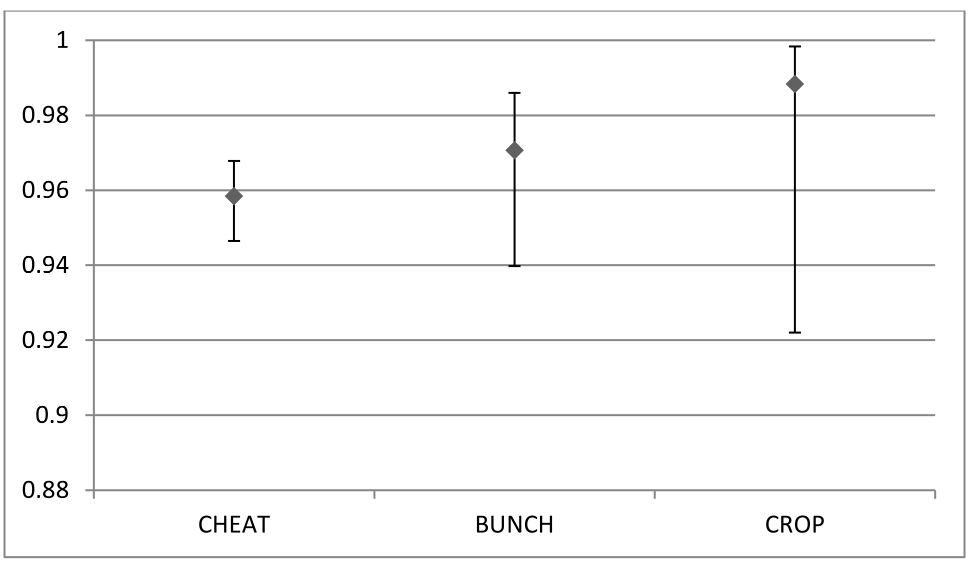
Six of the 9 models I estimated were considered equally plausible based on ΔAICc values < 2 (Table 3). There is very limited support for variation among the habitat types since a number of the models with the greatest weight included various approaches to partitioning habitats (i.e. cropland versus other types, or cheatgrass versus other types). Given the small sample sizes for cropland nests, these results should be viewed with caution. Likewise, the small sample size from Hanford Reach National Monument may contribute to the lack of support for the models that differentiate survival rates among locations. It should also be noted that the model differentiating the NWSTF from the other locations also reflects a partitioning of the samples based on a decade and thus cannot differentiate spatial from temporal effects.

Despite the lack of clear support for one model over another, predicted values for DSR differed only marginally, because of this, and because model averaging may not improve precision of estimates I chose not to use it, but instead report results from the constant survival model, and for the different habit types. The constant survival model estimated DSR as 0.9617 with 95% confidence intervals of 0.9514 to 0.9698. Using a nest period length of 29 days these estimates correspond with an overall success rate of 32% (24% - 41%). The habitat type model suggests slightly higher (but not significantly different) estimates for success in the taller structured habitats (cropland and bunchgrasses) than in cheatgrass grasslands (Figure 1). Small sample sizes and an uneven study design, however, suggest that caution should be exercised in the interpretation of results.

Table 3. Model selection set and rankings based on AIC*c*

| Model | AIC*c* | Δ AIC*c* | AICc Weights | Model Likelihood | Num. Par | Deviance |
|---|---|---|---|---|---|---|
| Cropland vs. other habitats | 386.53 | 0 | 0.2 | 1 | 2 | 382.52 |
| Cheatgrass vs. other habitats | 386.62 | 0.09 | 0.19 | 0.95 | 2 | 382.62 |
| Constant survival | 386.88 | 0.35 | 0.16 | 0.83 | 1 | 384.8 |
| Habitat type | 387.67 | 1.14 | 0.11 | 0.56 | 3 | 381.66 |
| Bunchgrass vs. other habitats | 388.23 | 1.7 | 0.08 | 0.42 | 2 | 384.22 |
| NWSTF vs. other locations | 388.4 | 1.86 | 0.07 | 0.39 | 2 | 384.39 |
| Hanford vs. other locations | 388.61 | 2.08 | 0.07 | 0.35 | 2 | 384.6 |
| Location | 389.46 | 2.93 | 0.04 | 0.23 | 3 | 383.45 |
| Year | 389.92 | 3.39 | 0.03 | 0.18 | 4 | 381.9 |

Figure 1. Daily nest survival rates for cheatgrass grasslands (Cheat, n = 103), bunchgrass grasslands (n = 15), and croplands (n = 5).



Discussion

Small sample sizes make it difficult to estimate DSR with precision for individual locations and years. The lack of support for the models, therefore should be interpreted with caution as there simply may not be enough information to discern such differences if and where they occurred.

A previous analysis of the data collected at the NWSTF suggested that nests with taller vegetation adjacent to the nest had higher success (Holmes and Geupel 2008). Results of this analysis suggest slightly higher success in bunchgrass and croplands than in cheatgrass, but are inconclusive. Taller vegetation surrounding the nest may provide better concealment from predators and ultimately translate into reduced losses of nests. Probable nest predators at these locations include badger (*Taxidea taxus*), coyote (*Canis latrans*), common raven (*Corvus corax*), American crow (*Corvus brachyrhynchos*), Black-billed Magpie (*Pica pica*) and gopher snake (*Pituophis catenifer*) (Pampush 1980, Allen 1980, personal observation).

Pampush and Anthony (1993) report much higher success from the region during the late 1970's, with overall estimates of nesting success of 69% in 1978 and 65% in 1979. The only major land-use in the Boardman area during those decades was the establishment of the large hybrid poplar tree plantation immediately to the east of the NWSTF. American Crows nest around the edges of the plantation (personal observation) which may have resulted in an increased presence on the NWSTF, and the trees may also provide roost sites for non-breeding ravens. At the time Pampush did his work on the NWSTF, Common Raven were reportedly less common than they are now (G. Green, personal communication). Breeding Bird Survey data show a significant increase in Oregon, and in the intermountain West region as a whole with trends of 2-3% annually depending on the region being analyzed (Sauer et al. 2011). Pampush and Anthony (1993) also reported that nest predation rates were lower in cheatgrass than in other habitats. While the data presented here is inconclusive, it suggests a trend in the opposite direction.

**2. Abundance of Long-billed Curlew**

Methods

Between 2004 and 2006 surveys were conducted on the Wahluke Slope and Saddle Mountain portions of the Hanford Reach National Monument as part of an effort by the USFWS, PRBO Conservation Science, and the USGS, to generate baseline information on landbird use, develop habitat association models, and to evaluate vegetation sampling approaches. Habitat use models were developed using an index to abundance and are reported elsewhere (Earnst and Holmes 2012). Here, I use program DISTANCE v5.1 (Thomas et al. 2010) to estimate the density and population size of curlews based on detections of birds on 318 survey stations distributed among annual grasslands dominated by cheatgrass, perennial grasslands dominated by needle-and-thread grass and bluebunch wheatgrass, and big sagebrush shrublands with either annual or perennial understory.

There are three critical assumptions in distance sampling: 1) Birds at the point are detected with certainty, 2) Birds are detected at their initial location, and 3) Measurements of bird-to-observer distances are exact. The first assumption is of much less concern in shrubland or grassland communities than it would be in forests where birds at the point but above the observer in the canopy may not be detected with 100% certainty. Surveys were conducted with the aid of a laser rangefinder, which should help reduce the possibility of bias associated with assumption 3, although any systematic under-estimation of distance would result in an upward bias in the resultant density estimates. While unadjusted counts of birds have been widely criticized as mere indices, it has also been pointed out that meeting all the assumptions of distance sampling, as well as controlling for all sources of bias in detection probability is difficult. These limitations should be recognized, and density estimates from program DISTANCE may best be thought of as indices themselves (Johnson 2008).

Data was first assessed visually in conjunction with models with no truncation based on distances to detection. Ultimately, a truncation distance of 275m was decided on for analysis based on the shape of detection functions. Following selection of a truncation distance, I evaluated model fit both visually and using the $\chi^2$ goodness-of-fit test (Buckland et al. 2006).

Results

Within 275m of the observers, a total of 57 detections were made at annual grass survey points (n = 86), 4 detections in perennial grassland (n = 35), 7 detections in sagebrush shrublands with an annual understory (n = 168), and 2 detections in sagebrush shrublands with perennial understory (n = 29). There were too few data to estimate detection functions independently for each of the habitat types, so models were restricted to global models, post-stratified by the above mentioned habitat classifications. Select model output is provided in Appendix A. Total population size for the Wahluke slope area was estimated to be 160 (74-278; confidence intervals were generated through a non-parametric bootstrapping procedure and correspond to the 2.5% and 97.5% quantiles). Density was highest in the cheatgrass grasslands (Figure 2).

It is important to note that habitat classification were based on vegetation data collected within 100m of the survey point, and thus, detections may have occurred at the periphery, or outside of the designated classification.

## Discussion

I estimated the population of curlews nesting in the Wahluke Slope and Saddle Mountain portions of the Hanford Reach National Monument to be 160 individuals. This is not very different from Allen's (1980) estimate of 200 individuals for the Wahluke Slope, although her methods for arriving at that number are not well documented.

Any models that estimate density based on surveys of birds (rather than nests) is likely to underestimate density due to the fact that one of the adults is on the nest most of the time (Allen 1980). Thus, estimates may be as little as half of the true density of breeding adults, but more likely, fall somewhere in between that and the true density due to nests that may have failed prior to surveys being conducted, and due to non-breeding individuals (Allen 1980). Curlews are not thought to breed until they are several years old (Dugger and Dugger 2002). Density estimates derived from thorough systematic searches of plots likely yield more accurate estimates if repeated searches are needed to detect the full complement of nests initiated during a season.

Figure. 2. Estimated Density (# per $km^2$) of Long-billed Curlew on the Wahluke Slope portion of the Hanford Reach National Monument based on surveys conducted between 2004 and 2006.

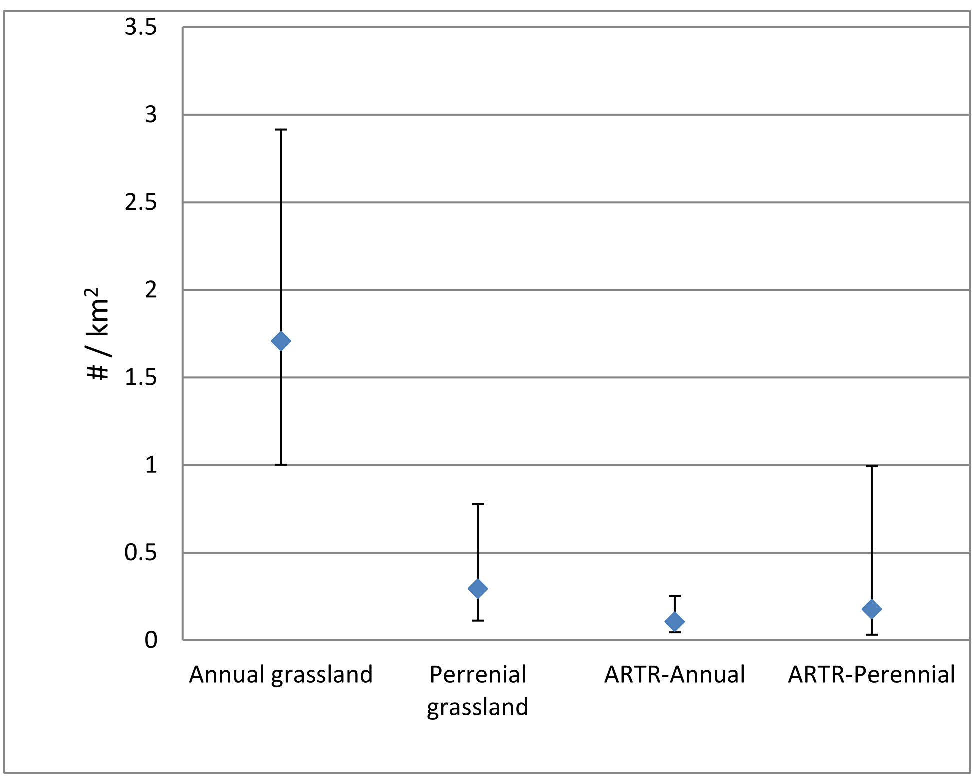


Figure 3. Mean relative abundance (±SE) of Long-billed Curlews at 100-m fixed radius point counts in four cover types (sagebrush with bunchgrass understory, sagebrush with cheatgrass understory, bunchgrass grasslands and cheatgrass). Points were classified by the cover type most common within a 100-m radius; points comprised primarily of other shrub overstory (rabbitbrush and bitterbrush) are not considered in this descriptive analysis. Statistical tests from one-way ANOVA followed by Fisher's LSD for post-hoc tests. Cover types sharing a letter do not differ significantly in relative abundance. Number of points dominated by sagebrush-bunchgrass cover type was 16, sagebrush-cheatgrass 168, bunchgrass grassland 24, and cheatgrass grassland 69 (Reproduced from Earnst and Holmes 2012)

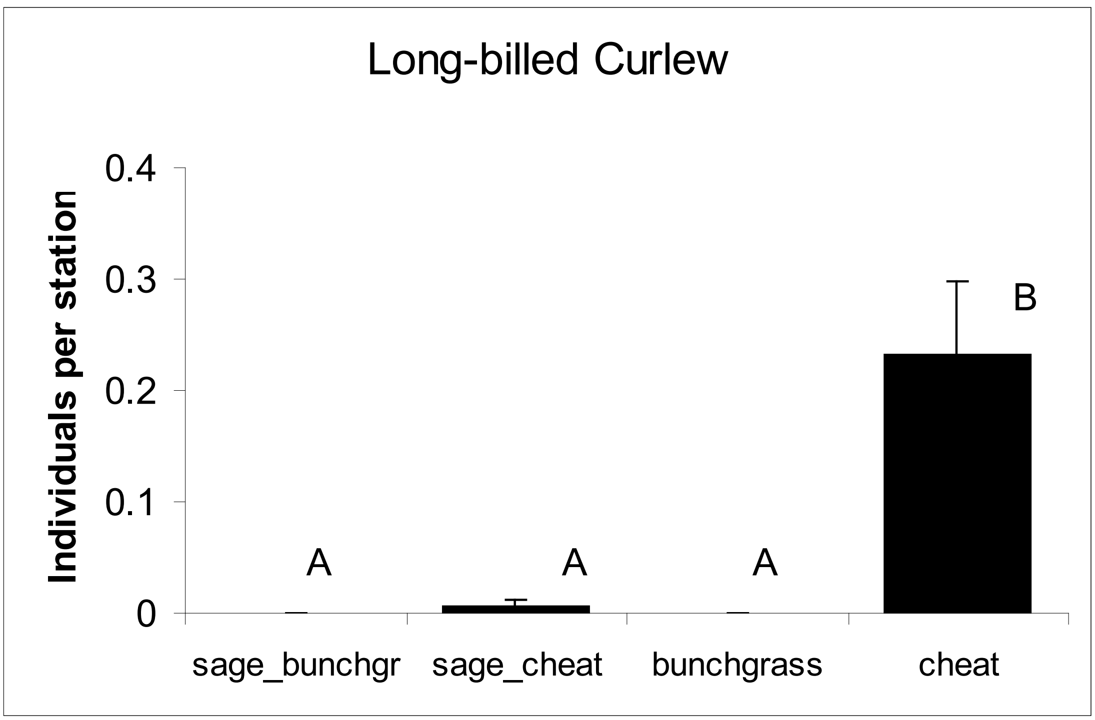


Figure 4. Mean relative abundance (±SE) of Long-billed Curlew in relation to percent sagebrush cover in 100-m fixed-radius point counts. Sagebrush cover was a significant predictor of abundance. Number of point count stations in the four sagebrush cover categories reported on the x-axis was 99, 99, 60, and 60, respectively (Reproduced from Earnst and Holmes 2012).

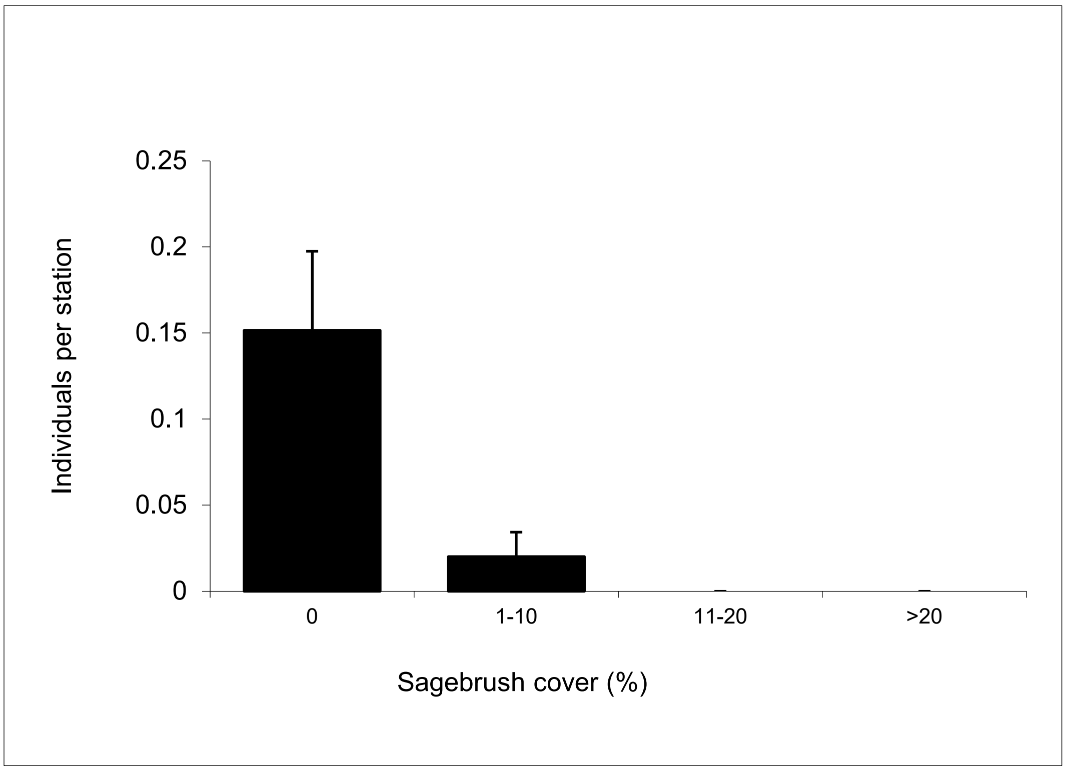


Figure 5. Locations of point count stations on the Wahluke and Saddle Mountain management units on HRNM that were sampled in 2004, 2005, and 2006 (Reproduced from Earnst and Holmes 2004).

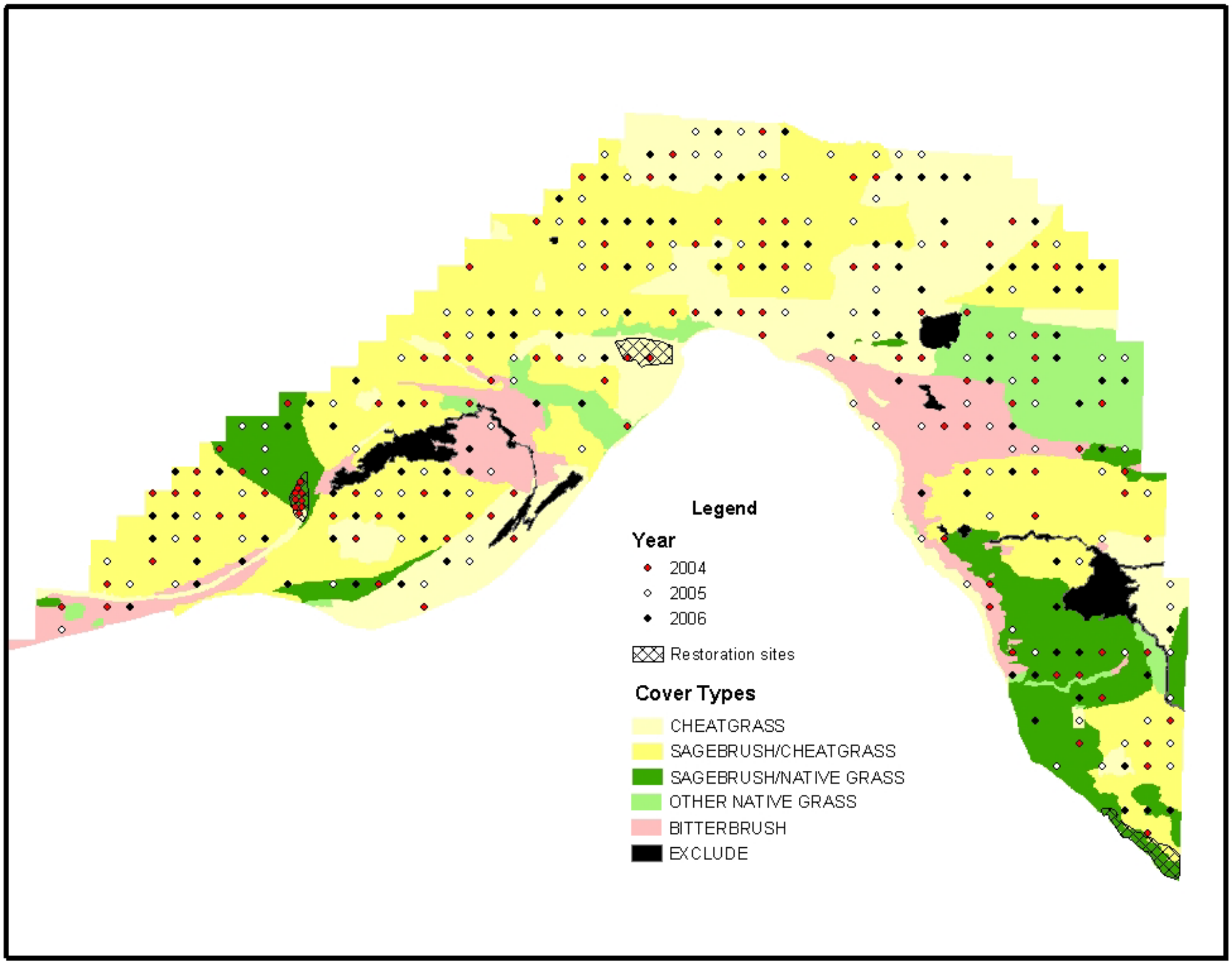
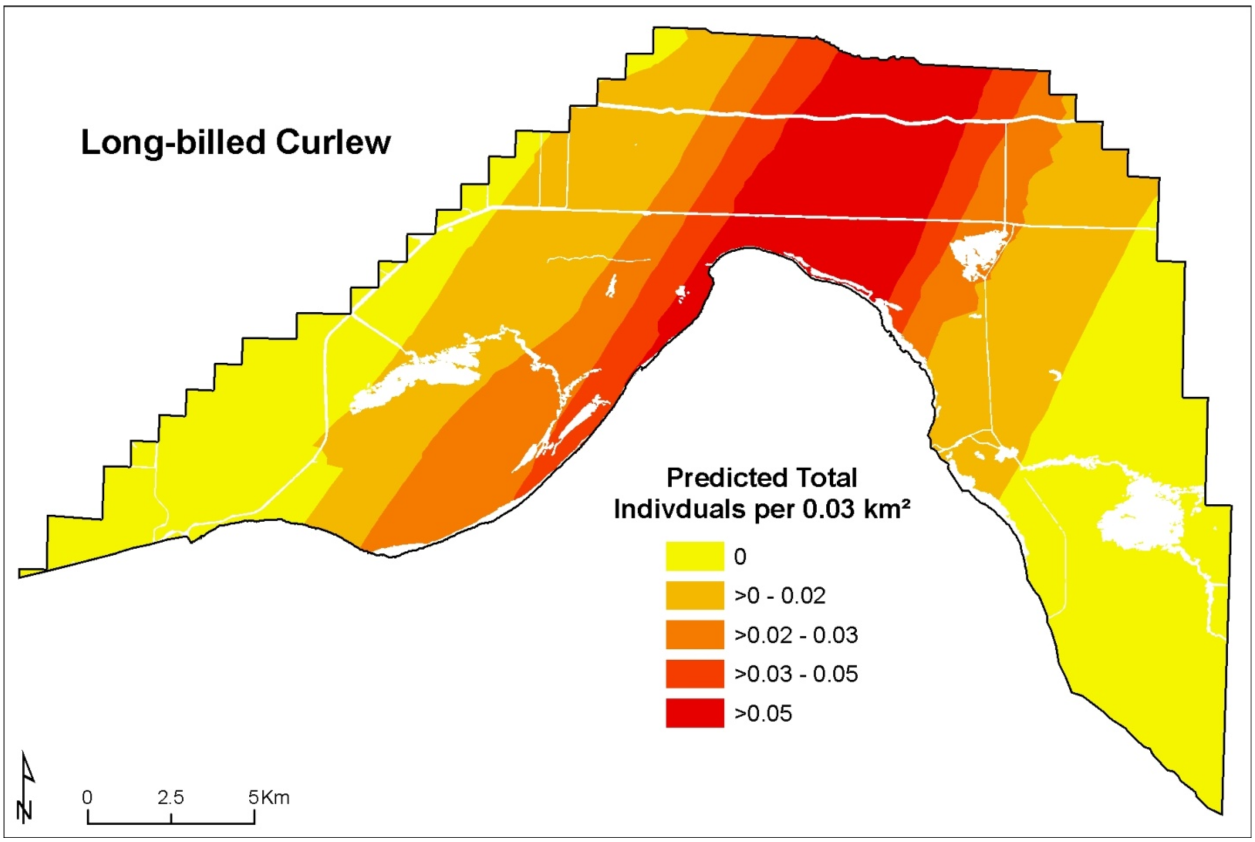


Figure 6. Relative density of Long-billed Curlew. Density polygons were based on number of individuals counted within a 5-minute point count of 100-m radius (0.03 $km^2$) at 318 points and were produced using ordinary kriging and the K-Bessel (Matern) model within ArcMap 9.2 Geostatistical Analyst. See Earnst and Holmes (2012) for details of bird survey methods (Reproduced from Earnst and Holmes 2010).



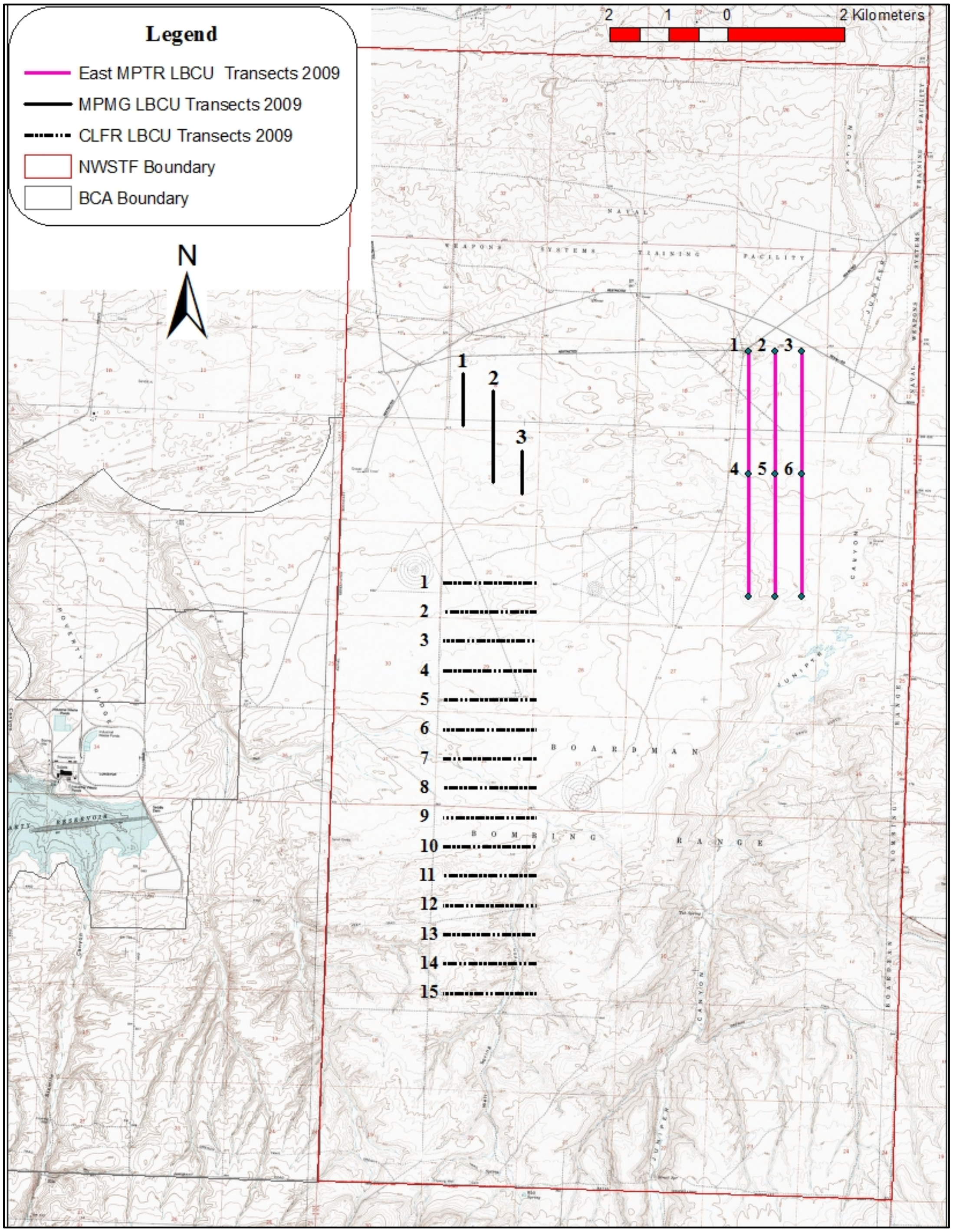
The pattern of preferentially using cheatgrass habitats over buchgrass, and shrublands was reported previously from a different analysis of the Hanford data that relied only on detections made within 100m of the observer (Figures 3 - 6). This pattern is also similar to what was reported from the region during the late 1970s (Pampush 1980, Pampush and Anthony 1993), and from the NWSTF during the 1990's (Holmes and Geupel 1998). Recent estimates using distance sampling were also developed for portions of the NWSTF that is being considered for expanded military use (Figure 7; Kagan et al. 2011). Details of model development (done by this author) can be found in Kagan et al. (2011), but the authors of that report apparently failed to include the actual density estimates in their report so I present them here (Table 4; see Figure 7 for locations of the 3 surveyed portions of the NWSTF). The estimated density for the CLFR training area was similar to that developed for Hanford Reach National Monument.  The estimates for other portions of the NWSTF were higher, which is in line with my observations at the various field locations. Pampush reported densities based on occurrence of nests in 40ha plots that corresponded to an average of 9 nests (18 adults) per $km^2$ for cheatgrass habitats.  This is higher than the estimates based on the 2009 surveys in Boardman, but considering the caveat that survey based estimates are almost always underestimates based on some birds being unavailable for detections while sitting on nests, they are not unreasonably different.

Elsewhere in their breeding range, reported densities vary considerably. In Utah, densities were reported as 0.59-2.36 pair/$km^2$ at 2 locations over several years of study (Paton and Dalton 1994). In Idaho, Redmond et al. (1981) reported densities of 5.94-6.42 males per km2, while reported densities from British Columbia were lower at 2.08-2.13 pair/$km^2$ (Ohanjanian 1987) and 0.46-0.80 pair/$km^2$ (Hooper and Pitt 1996).

Table 4. Density estimates from survey work conducted on the NWSTF in 2009 as described (but not reported) in Kagan et al. (2011).

| | | | | 95% confidence interval | |
|---|---|---|---|---|---|
| MODEL | Training area | Density (# per $km^2$) | % CV | low | High |
| 1 | CLFR | 1.8372 | 24.61 | 1.1157 | 3.0252 |
| | MPMG | 6.4168 | 36.86 | 2.5499 | 16.148 |
| | MPTR | 8.7876 | 23.05 | 5.1574 | 14.973 |

Figure 7. Location of transects surveyed for Long-billed Curlew on the NWSTF Boardman in 2009 and used in development of density estimates in program DISTANCE (Reproduced from Kagan et al. 2011)



ACKNOWLEDGMENTS

I would like to thank Elise Elliot-Smith for providing data from 2007 and 2008 for inclusion in the nest survival model and her assistance with the analysis. Susan Earnst was the Co-Principal Investigator for the Hanford data used in the density analysis. This effort was supported by a contract with The Nature Conservancy with funds from the Department of Navy. This effort came about through discussions with Kent Livezey, Elise Elliot-Smith, and Heidi Newsome.

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APPENDIX A: Select model output from analysis of density on Hanford Reach National Monument:

Figure 1. Half-normal detection function showing attenuation of detection probability as a function of distance from the observer.

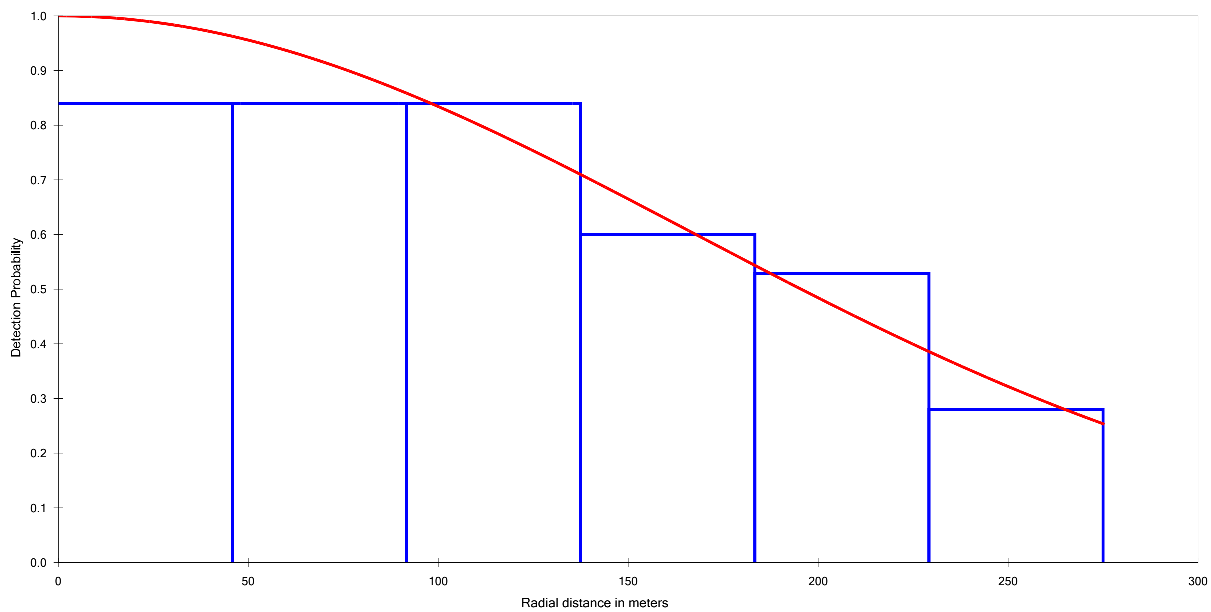


Figure 2. Probability density from Half-normal detection function

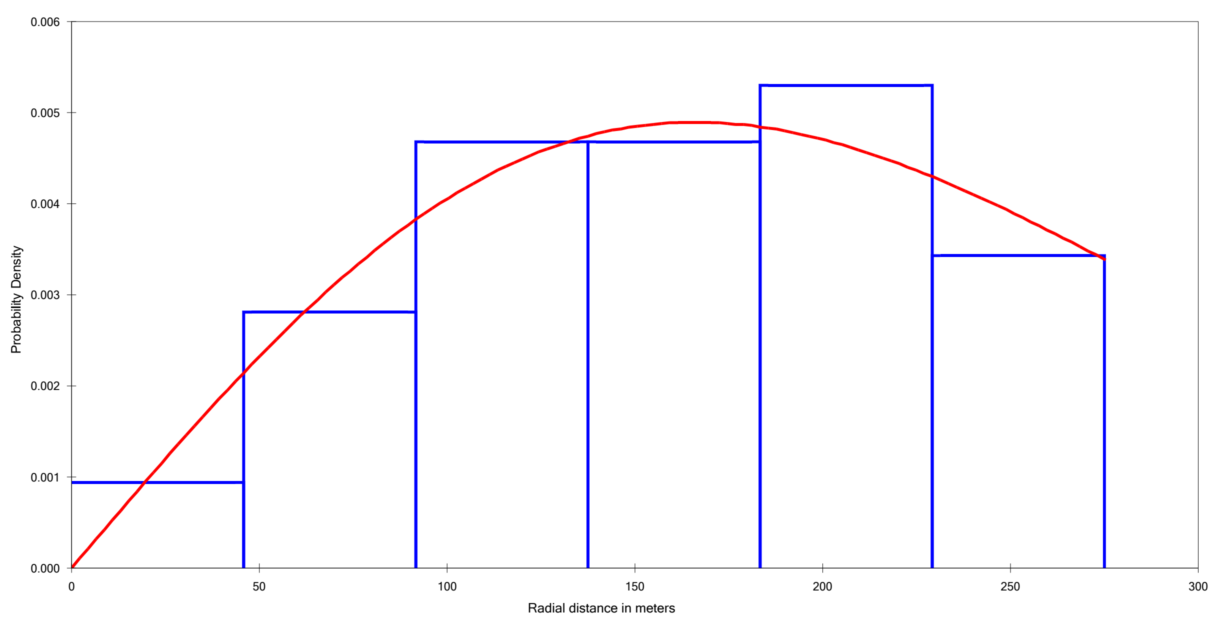

Table 1. $\chi^2$ goodness-of-fit test for the Half-normal detection function density model

| Cell i | Cut Points | | Observed Values | Expected Values | Chi-square Values |
|---|---|---|---|---|---|
| 1 | 0.000 | 45.8 | 3 | 3.51 | 0.073 |
| 2 | 45.8 | 91.7 | 9 | 9.75 | 0.058 |
| 3 | 91.7 | 138. | 15 | 13.97 | 0.076 |
| 4 | 138. | 183. | 15 | 15.58 | 0.022 |
| 5 | 183. | 229. | 17 | 14.80 | 0.327 |
| 6 | 229. | 275. | 11 | 12.39 | 0.156 |

Total Chi-square value = 0.7114 Degrees of Freedom = 4.00

Probability of a greater chi-square value, P = 0.94991

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# Avian Population Studies at Naval Weapons Systems Training Facility Boardman, Oregon

Final Report to the Department of Navy
and Oregon Department of Fish and Wildlife

Aaron L. Holmes and Geoffrey R. Geupel

December 1998

A report of the
Point Reyes Bird Observatory
4990 Shoreline Highway
Stinson Beach, CA 94970

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**Prepared by**

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**Appendix 7**

## Executive Summary

Shrubsteppe habitat of the Columbia Basin Ecoregion has been greatly reduced by conversion to agriculture. Many once common shrubsteppe and grassland bird species are now listed as species of concern by state and federal agencies (ODFW 1997, USFWS 1995). Land managers and biologists are faced with the formidable task of identifying causal factors threatening populations, reversing declines of populations before species are listed as threatened and endangered, and identifying and protecting remaining healthy populations.

In 1995, the Department of the Navy, Point Reyes Bird Observatory, and Oregon Department of Fish and Wildlife implemented a 3-year inventory and monitoring program of the avian communities found on the Naval Weapon Systems Training Facility (NWSTF) Boardman, Oregon (the Bombing Range). Our primary objectives were to: 1) provide an accurate and quantifiable inventory of birds in each specific habitat type; 2) assess specific habitat requirements for successful nesting (habitat-specific productivity) of as many breeding species as possible; 3) determine relative abundance and in some cases densities of key species using point count censuses, flush mapping, and adaptive sampling; 4) identify habitat and vegetation conditions associated with the occurrence and abundance of as many species as possible; 5) evaluate the effects of grazing on bird populations; and 6) provide management recommendations to protect, enhance, and restore shrubsteppe bird populations. Standardized protocols were implemented whenever possible to allow repeatability and integration with national and regional programs. The inclusion of demographic monitoring will help to identify source and sink populations and relate habitat conditions and vegetation to population health.

The program has documented the importance of the Bombing Range as a breeding area for many species of concern. Demographic information suggests that habitats of NWSTF Boardman may be functioning as population sinks for several open-cup nesting species. Despite their high abundance, Loggerhead Shrike reproductive success was among the lowest ever reported for this species. Other common species Horned Lark, Lark Sparrow, and Western Meadowlark also have low nest success. Habitats in more pristine condition, such as native bunchgrass and lightly grazed upland sagebrush, appear to support healthy populations of some key species, such as Grasshopper Sparrow and Sage Sparrow respectively. Other species which appear to have productive populations on the Bombing Range include Long-eared Owl and Burrowing Owl.

We identified habitat and vegetation variables, which could explain presence and absence, as well as abundance of dominant species, and developed multivariate predictive models. Distribution, and abundance of Grasshopper Sparrows was determined largely by presence of bunchgrass cover and amount of shrub cover. Horned Larks were also positively correlated with bunchgrass cover, as well as open ground. Long-billed Curlews were most abundant within parts of the Bombing Range that have been converted to annual grassland, and responded negatively to native bunchgrass and shrub cover. Within bunchgrass habitats, curlews were found almost exclusively in grazed areas. Burrowing Owls nested in the annual grass and grazed bunchgrass habitats, as well as in grassy openings within sagebrush. They nest in ungrazed bunchgrass within the Research Natural Area (RNA) system. Both Sage and Brewer's Sparrow were positively associated with sagebrush cover and open ground, but were negatively correlated with sagebrush height. Our results demonstrate the importance of maintaining a shrub/grass mosaic on the Range, with some bird species acting as shrub obligates, and others relying on open grassland.

## Background and Introduction

In recent years, concern has grown over the widespread declines of numerous songbird populations, particularly of neotropical migrant species (Robbins et al. 1989). During the last 25 years, grassland species have declined more drastically than any other guild of North American species (Knopf 1994). In Oregon and Washington, many non-game bird species inhabiting shrub steppe/grassland have declined significantly (Sauer et al. 1996, Andleman and Stock 1994 a, b). However, the cause of these declines remains poorly understood, and current monitoring programs do not adequately sample most species occurring in these habitats (Carter and Barker 1993). During the last eight years, an unprecedented international effort has been promoted and coordinated through the Partners in Flight Program (PIF) to protect non-game birds and their habitats (for review see Finch and Stangel 1993).

Cheatgrass, an exotic annual grass, threatens up to 25 million ha of shrubsteppe habitat in the western U.S. (Rich 1996). While the effects of cheatgrass conversion and subsequent high intensity burns on bird populations have been poorly documented, Rich (1996) found that cheatgrass burns have a serious negative impact on many bird species in south-central Idaho (e.g., Loggerhead Shrike, Sage Thrasher, Sage Sparrow, Brewer's Sparrow, and Western Meadowlark). The Oregon/Washington PIF working group has prioritized shrubsteppe as bird habitat of high risk and concern (Andelman and Stock 1994 a, b).

The shrubsteppe/grassland plant communities of the Naval Weapon Systems Training Facility (NWSTF) Boardman (the Bombing Range) and adjacent Boeing State Lease lands are one of the largest remaining blocks of this habitat type in the Columbia Basin Ecoregion. In Oregon, the Columbia Basin Ecoregion is second only to the Willamette Valley in the percentage of landscape converted to non-native habitats and human uses (Defenders of Wildlife, 1998). The 19,020 ha of the NWSTF Boardman property includes 2045 ha of land, jointly managed with The Nature Conservancy as Research Natural Areas (RNAs) that are free from livestock grazing and serve as a standard or baseline for comparisons with areas more heavily influenced by humans. When the RNA system was established in 1979, significant portions of the included area had been free from livestock grazing for over 25 years. Slightly more than 50% of the RNA system is the target for inert bombing practice, and so was excluded from this study. In addition, NWSTF Boardman leases 97 ha for agricultural production and is bordered by agricultural lands managed by other agencies. Portions of these agricultural lands are being converted from central pivot irrigation (for cash crop production) to drip irrigation (for wood pulp production), resulting in the net loss of shrub and grass habitats. The state owned lands adjacent to the Western boundary were leased to the Boeing Corporation in 1961 for 71 years to allow for the construction of a space industrial park. Instead, Boeing has been sub-leasing the property and developing it for agriculture. The future status of this land remains uncertain; as much as 12,100 ha of grass and shrubland may be plowed for agricultural use (Morgan, ODF&W, pers. Comm. 1998).

In 1995, the Department of the Navy (Kent Livezey), Point Reyes Bird Observatory (PRBO, Geoff Geupel and Aaron Holmes), and Oregon Department of Fish and Wildlife (Russ Morgan) implemented a 3-year bird survey and monitoring project to assess the birds utilizing the NWSTF Boardman. The project objectives were:

1) Provide an accurate and quantifiable inventory of birds in each specific habitat type.

2) Assess specific habitat requirements for successful nesting of as many breeding species as possible.

3) Determine relative abundance, and in some cases densities, of key species using point count censuses, flush mapping, and adaptive sampling,

4) Identify habitat and vegetation conditions associated with the occurrence and abundance of as many species as possible.

5) Evaluate the effects of grazing on bird populations.

6) Provide management recommendations to protect, enhance, and restore shrubsteppe bird populations.

In this report, we summarize findings from 3 years of data collection and describe protocols and study design for the 1995-1997 field seasons. The first section of results summarizes data on secondary population parameters such as abundance, diversity, and species richness, between habitat types. Species for which we have adequate data are treated in full species accounts. In the interest of completeness, all other species known to have bred on the Bombing Range during the study are treated in the anecdotal accounts that follow. Complete accounts contain data on status and population trends, abundance and distribution on the Bombing Range, nest location and nest success, and management recommendations. Some accounts also contain a section on habitat and vegetation associations. A list of all bird species encountered during the 3 years of the study, their breeding status by habitat type, and migratory behavior are presented in Appendix 1, Table 1. All common names are current as published in the AOU checklist (1983) and supplements to the checklist (AOU 1987, 1997). Oregon Department of Fish and Wildlife (ODF&W) sensitive species status are from ODF&W (1997), and U.S. Fish and Wildlife Service (USFWS) species of concern are from USFWS (1995). Standard names for mammal species mentioned in this report are given in Appendix 9, Table 1. Standard names for Reptile and amphibian species mentioned in this report are given in Appendix 9, Table 2. Common and standard names of plant species, as well as codes used in data entry are presented in Appendix 9, Table 3.

## Study Area

NWSTF Boardman is located in northern Morrow County, Oregon, which is characterized by hot, dry summers and cold, moist winters. Most of the precipitation occurs from November through May with November, December, and January being the wettest months. The average annual precipitation for Boardman is 22 cm. Fog, common during the wet winter months, results in additional unmeasured precipitation. The frost-free period is approximately 180 to 200 days. Southwesterly winds prevail most of the year, and wind velocities exceeding 40 km an hour are common from March to July. Located on the Umatilla Plateau in the central Columbia River Basin, the elevation of the 19,020 ha training facility rises from 122 m at the northern boundary to 274 m at the southern. The northern two-thirds of the Bombing Range is characterized by flat terraces with 2 to 10 percent slopes and primarily Quincy-Koehler soil associations, while the southern third can be described as rounded hillsides, and valleys with slopes of 5 to 20 percent. Soil associations in the central and southern parts of the Bombing Range vary from Sagehill-Taunton to Warden (McClelland and Bedell, 1987).

Most vegetation has been drastically altered by decades of intensive grazing. The southern part of the study area includes areas dominated by basin big sagebrush / bluebunch wheatgrass . Moving northward, as soils grade from loamy to sandy, the habitat is increasingly dominated by rabbitbrush/needle-and thread grass, and areas of rabbitbrush / cheatgrass, with lesser amounts of needle and thread grass, and snowy buckwheat. The northwestern-most part of the facility is dominated by bitterbrush with lesser amounts of rabbitbrush. Further details of the study area are in Green (1983).

## Methods

### Site selection

Five structurally unique, general habitat types were chosen for investigation and comparison. The five habitats were annual grassland (cheatgrass/Sandberg's bluegrass), perennial grassland (needle-and-thread / bluebunch wheatgrass), open-low shrubland (rabbitbrush), bitterbrush shrubland, and sagebrush shrubland. We sub-classified the sagebrush and bunchgrass habitats into grazed and ungrazed treatments. In 1996 we added upland sagebrush as a sub-classification, further delineating the sagebrush habitat and yielding 8 habitat/treatment classifications (see Table 1). These additional plots were located in upland sagebrush with little to moderate grazing.

We selected study plots in 1995 by dividing the entire Range into 100-m grids, and creating numbered coordinates. We then generated a list of numbers from a random table, and using a Global Positioning System (GPS) we located the selected coordinates on the ground. If a plot could be classified as a distinct habitat type, the selected coordinates became the SW corner of a plot. If the plot could not be classified, the plot was rotated so that the selected coordinate became the NE corner. If it still could not be classified we went on to the next coordinate on the list. This process continued until we had selected 3 plots in each habitat/treatment type. Several plots in the RNA (ungrazed treatments) are odd shaped, and others are adjacent, due to the shape of RNA B, and the distribution of sagebrush in RNA C. In 1996, new plots were randomly selected within the upland sagebrush stratification, a habitat that was not well sampled in 1995.

To provide a basic inventory, general habitat affinities of species, and future long-term trends, an extensive point count survey was implemented in 1996. This consisted of 57 roadside census stations spanning all habitat types, which were spaced along the road at 800 m intervals and located 100 m off the road. The UTM locations of all the extensive stations were recorded using a GPS unit and entered into a database.

### Point Counts

Bird monitoring methods followed modified Breeding Biology Research and Monitoring Database (BBIRD) guidelines (Martin and Conway 1995). Bird abundance and diversity were measured using point count censuses (Ralph et al. 1993) at 9-10 stations per 40-hectare plot, at 15 stations per 80-hectare plot (upland sagebrush), and at the 57 roadside stations, for a total of 277 stations (190 in 1995). Figure 1 shows the location of plots and the extensive point count route. Figure 2 shows the locations of study plots and the distribution of the general habitat types. Each station within the plots was censused for 5 minutes on 3 different mornings at least a week apart between late April and June each year. The extensive route was censused twice between 8 May and 19 June 1996, and once between 18 May and June 10 1997. All birds detected and the type of detection (visual, song, call) were recorded in fixed radii of 50 m, 50 to 100 m, or 100 to 200 meters. On the extensive route, the 200-meter cut-off was extended to include detections at unlimited distance from the observer.

TABLE 1. General habitat type for study plots.

| Habitat | Abbreviation | Plot Numbers |
|---|---|---|
| antelope bitterbrush | BB | 01, 02, 03 |
| annual grass | AG | 04, 05, 06 |
| grazed sagebrush | GS | 07, 08, 09 |
| grazed bunchgrass | GB | 16, 17, 18 |
| open low shrub | OS | 10, 11, 12 |
| ungrazed bunchgrass | NB | 19, 20, 21 |
| ungrazed sagebrush | NS | 22, 23, 24 |
| upland sagebrush (lightly grazed) | US | 25, 26 |

### Vegetation assessment

**Nests and intensive point counts:** Micro-habitat surrounding the nest may influence nest success and nest site selection (Martin 1993). Upon termination of a nesting attempt, variables associated with the nest site were recorded. Measurements were made using modifications of the method described in Martin and Conway (1995 pp. 21-26, which is a modification of James and Shugart 1970). Vegetation measurements were taken at each nest site, and in 1995-1996 for all species except Burrowing Owl at a "non-use" site. Non-use sites were selected in a randomly chosen direction approximately 35 meters from the nest and centered on the same or a similar substrate type. In addition, measurements were taken at 3 locations around each station. These were used with bird abundance data to model occurrence and abundance in relation to vegetation and habitat variables, to typify the habitat around the points, and to compare with vegetation around nests.

In summary, vegetation is quantified by using 2, 10 m ropes centered on the nest that divide the area into 4 quadrants (NE, NW, SE, SW). Cover estimates for all vegetation were made in each quadrant. Litter depth was measured using a plastic ruler at 10 points along the ropes (2 in each direction and 2 within 20

FIGURE 1. Locations of study plots, roadside point count stations, and RNA boundaries.

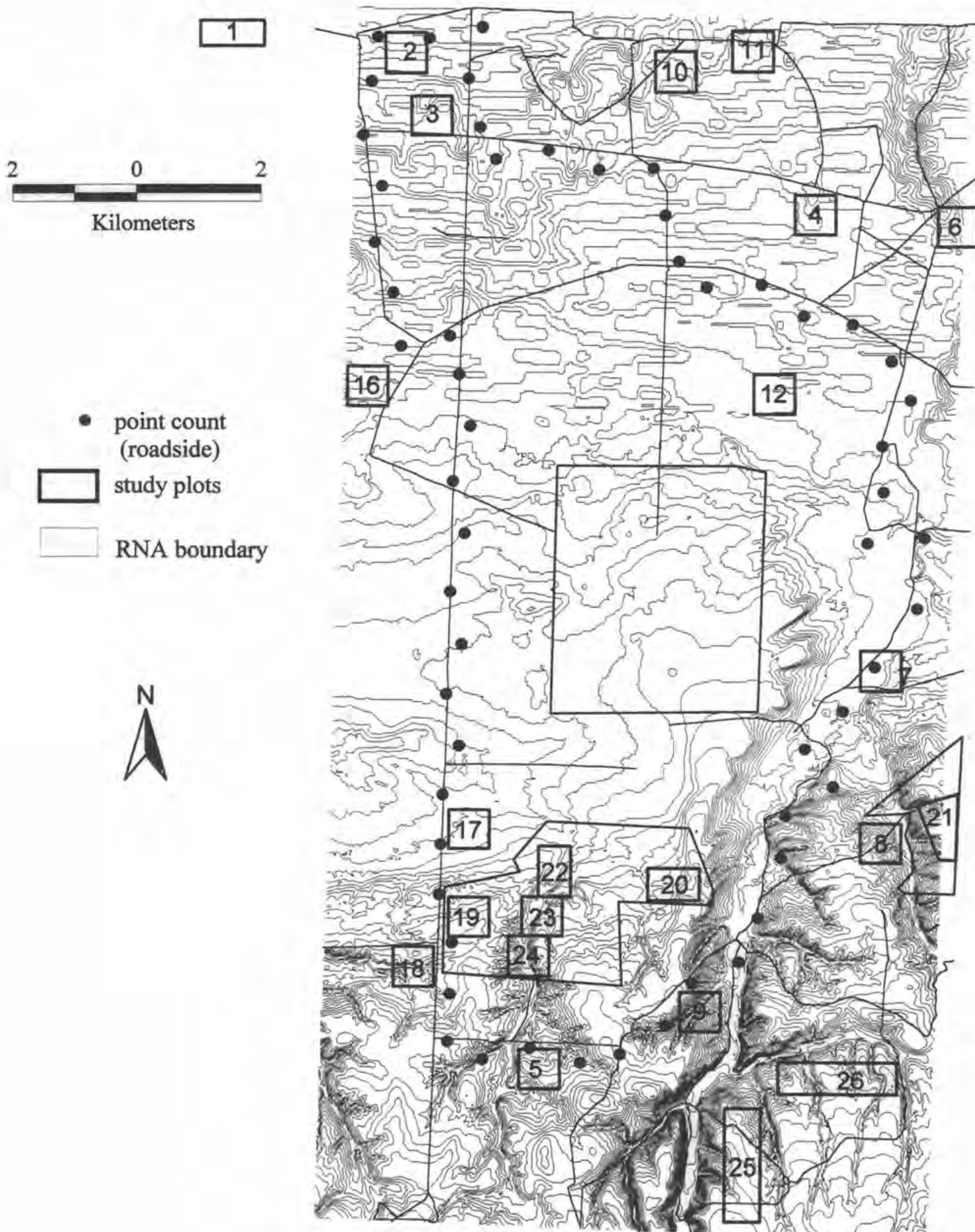
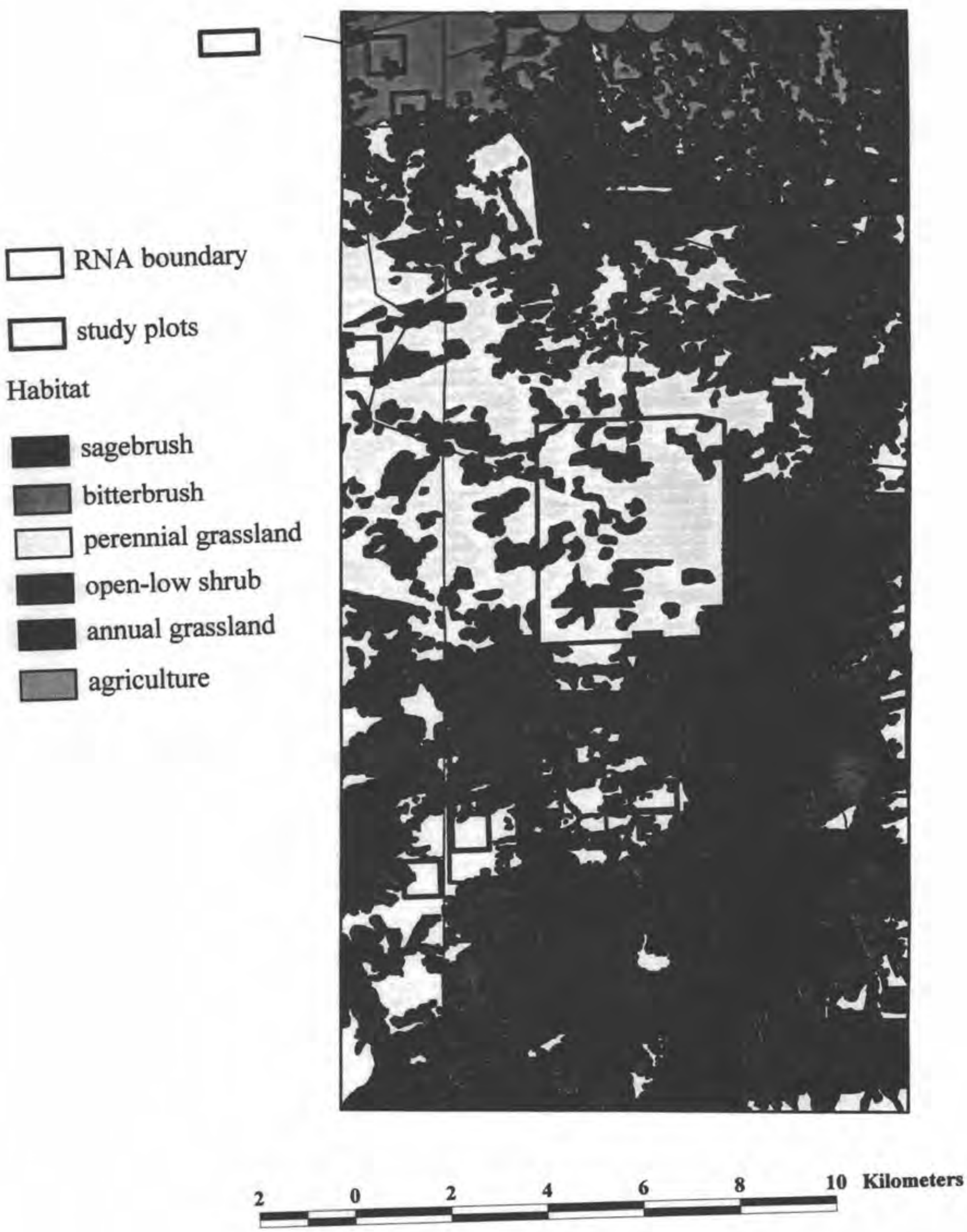


FIGURE 2. General habitat types of the NWSTF with locations of study plots.



cm of the center). Horizontal density was measured for grasses and forbs using a modified version of the point contact method (Wiens 1969). These measurements were taken 1 m from the center in the four cardinal directions, and at points 2.5 meters from the center on each transect line, for a total of 20 contact points in each vegetation plot. Using a wooden rod, 60 cm in length and 6 mm in diameter, the number of contacts at <10 cm, between 10 and 50 cm, and >50 cm were recorded for each point, and summed within the 5, 2 m diameter sub-plots. The maximum forb and grass heights within the 5 sub-plots, as well as slope and aspect, were also recorded.

**Ground cover:** Five types of ground cover were estimated (0 - 100%) for each quadrant: shrubs (less than 40 cm), total green herbaceous cover, cryptobiotic crust, litter, and bare ground.

**Herbaceous cover:** Grass and forb cover (0 - 100%) and percent composition by species were recorded in each quadrant.

**Stem density:** Shrub cover as a whole, and for each species, was estimated (0 - 100%) for each quadrant. The numbers of shrub stems less than 2.5 cm in diameter and greater than 2.5 cm (at 10 cm high) were also recorded for each species.

**Shrub cover, density, and height:** In addition to the ocular estimation done at the point for comparison with nests, we measured shrub characteristics using 200 m of shrub intercept at each point. A 50 meter measuring tape was extended from the point outward in the cardinal directions. For every shrub intercepted we recorded species, height, and decadence (0-25%, 25-50%, etc). All shrub density variables are the number of shrubs intersected along 200 m of transect. In addition, distance to the closest perch and effective height of vegetation in the four cardinal directions were recorded at Burrowing Owl nests. Effective height was defined as 90% coverage of a 30 cm wide board placed 10 m from the nest, and viewed at one m height from the nest burrow.

The means, standard deviations and ranges of select habitat variables for each habitat type are presented in Appendix 7, Tables 1-8.

For nests built in Junipers, the ground cover estimates and horizontal density were not measured. Additional measurements for tree nests were recorded on a form provided by Russ Morgan (ODF&W).

**Extensive point count stations:** Vegetation at extensive point count stations were assessed using a releve, a plot of 25 to 50 m radius (depending on habitat homogeneity) centered on the census point, following the procedures outlined in Ralph et al. (1993). Thus, where habitat is fairly homogenous, the plot radius is 25 m, but where habitat is heterogeneous a larger plot is used to incorporate different habitats to which birds might respond. General habitat characteristics of the site were recorded and cover, abundance, and height of each vegetation stratum (shrub, herb, and ground) estimated. Within each vegetation stratum the species composition was determined and each dominant species' relative cover recorded, as a percent of total cover for that stratum.

**Nest-searching and monitoring**

Because few nests were found on BBIRD plots in 1995, we adopted a protocol targeted at key species for the 1996 field season. Nest-searching occurred both on and off of the BBIRD plots for the following target species: Burrowing Owl, Grasshopper Sparrow, Loggerhead Shrike, Long-billed Curlew, Sage Sparrow, and Sage Thrasher. When a target species was encountered on a plot during a point count census, an observer would return to the area to actively search for nests. Due to difficulties locating nests of Horned Larks and Western Meadowlarks, observers would spend no more than 10 minutes searching for their nests. Except as noted below, observers searched for and monitored nests of all breeding avian species except raptors and Long-billed Curlew using methods described in Martin and Geupel (1993). Nests were located at various stages using behavioral cues and less often by random searches. Once located, nests were checked systematically (every 2-4 days) and carefully to minimize human induced mortality, until the outcome was determined. Nest-searching normally began within a half an hour of sunrise and continued throughout the morning, weather permitting, 5 days per week. Numerous variables (e.g., nest height, plant species and height, concealment, number of support branches) were recorded upon termination of each nesting attempt. Species-specific methods and areas of focus for target species are outlined below.

**Tree nesting species** (Swainson's Hawk, Ferruginous Hawk, Long-eared Owl, Western Kingbird, Black-billed Magpie, Common Raven, Bullock's Oriole): All of the 188 juniper trees located in and around Juniper Canyon were numbered, and permanently marked. Nests were monitored in every Western Juniper tree of the Juniper Canyon area. Trees were checked for occupancy no less than once every 2-3 weeks. Most Junipers were checked more frequently (once or twice a week) when the observer was in the vicinity checking active nests.

**Sagebrush obligate species** (Brewer's Sparrow, Sage Sparrow, Sage Thrasher): Point count census data and casual observation in 1995 suggested that Sage Sparrow distribution on the NWSTF was limited primarily to the upland sagebrush habitat type, a habitat type not adequately sampled by BBIRD plots selected at random in 1995.

Therefore, in 1996, with input from the participants of the annual BBIRD meeting (March 1996, San Francisco, CA), we initiated a new "target species sampling" (TASP) protocol to concentrate on these 3 species in their preferred habitat of upland sagebrush. We attempted to sample all upland sagebrush tracts larger than 85 ha on the Bombing Range. Six such areas were located and established as plots. TASP was conducted on all 6 plots at least once between April and the first week of May of 1996.

The TASP protocol is an adaptive sampling technique modified from the "strip adaptive cluster sampling" described by Thompson (1992) that incorporates flush-mapping on three days to delimit territories. In summary, sampling was conducted with 2 or 3 observers, starting within a half hour of sunrise and lasting 4-5 hours, weather permitting. Observers walked parallel transects at approximately 75-100 m apart, depending on terrain. When a target species was encountered no less than 20 minutes was spent attempting to track the individual. If territorial behavior (e.g. singing) was observed, the territory boundaries were delimited using a flush mapping protocol (Reed 1985). After mapping, a wire flag with a unique number identifying the territory was placed in the perceived center of the territory. After a territory was marked, all adjacent areas (4 areas the size of the original territory) were searched for other conspecific territorial birds. The 20-minute flush-mapping and territory marking was repeated until no territorial birds were located in adjacent areas. At this time observers would return to the original encounter and resume walking the predetermined transect.

All mapped (known) territories were revisited at least twice during May and June, with at least 7 days between visits. During revisits, territorial birds were again pursued for a minimum of 20 minutes. If birds were present, territorial boundaries were again delimited using flush mapping and on most occasions some effort was made to locate a nest. Territories were considered confirmed if territorial birds could be followed for over 20 minutes on 3 visits. The vegetation within confirmed territories was quantified during late June and July using 3, 5-m diameter plots (see description above). These were located 35 m from the perceived center at 0, 120, and 240 degrees. If nests were located on the territory, vegetation at 2, 20-m shrub intercept transects centered on the nest and at a non-use site was assessed. For each shrub intercepted, height, maximum width, perpendicular width, and percent alive were recorded.

**Grassland species:** In efforts to locate nests of Grasshopper Sparrow and other grassland species (e.g., Horned Lark, Western Meadowlark), rope-dragging was implemented in 1996 on plot 16 (grazed bunchgrass) and plot 19 (ungrazed bunchgrass). Attempts were made to cover plots 18 and 21 in 1996 as well, but were logistically difficult due to occasional shrub cover. Plot 16 was grazed during the dormant season, but not during the growing season. As a result, substantial growth occurred prior to the onset of Grasshopper Sparrow nesting. In contrast, a 17.5-ha plot (numbered 28) was established immediately west of plot 19 for rope-dragging. This plot was chosen subjectively based on proximity to plot 19, shrub cover, and terrain. It was grazed during the growing season, and probably a better representation of the targeted habitat/treatment type than plot 16. In 1997, the Navy restricted access to the areas surrounding plot 16, and although we were able to conduct point counts, rope-dragging was not possible. We rope-dragged plot 19 and 28 multiple times in 1997, while plots 5 and 21 were rope dragged once.

We used a 32 m long, 2.5 cm thick trucker's polypropylene rope with 2 m of 1.75 cm nylon rope attached to either end that could be tied into a harness. A swath approximately 20 m wide was covered on each pass. Two people pulled the rope with 1 or 2 observers following behind. When a bird flushed, a search was initiated at the flush location and radiated outward several meters. One person pulling marked the pass with a series of wire flags which were retrieved by the other person on the subsequent pass. Typically we covered the 17.5 ha inside the point count grid, although plot 19 was also split into halves, 20 ha each, which were covered on consecutive days. Plot 5 was dragged once in 1997, plot 16 was dragged 5 times in 1996, plot 18 was partially covered in 1996, plot 19 was covered 5 times in 1996, and 6 times in 1997, plot 21 was covered once each year, and plot 28 was covered twice each year. We were able to increase the effectiveness of our efforts in 1997, by focusing them on late May, and stopping June 1st. In total, 14 days were spent rope dragging in 1996, and 8 days were spent in 1997. In 1997.

**Burrowing Owl:** During the last 3 weeks of April 1996 and 1997, approximately 915 ha identified by Greg Green (Parametrix Inc.) were surveyed for active Burrowing Owl sites. Selection was based on previously established habitat parameters (Green 1983) or on historical occupancy. The survey area included approximately 800 ha of annual grassland with intermittent areas of rabbitbrush, 82 ha of bitterbrush, and 31 ha of sagebrush with low canopy cover and an annual grass under-story. The area was divided into plots, and systematically walked by 2-6 observers spaced 20-60 meters apart depending on vegetation density. We tried to regulate the inter-observer distance to maximize coverage efficiency while still being able to detect at least 90% of the burrows. The "leading edge" observer would drop wire flags on his/her outside, and pick them up again on the following pass, as the next line was dropped. Middens were marked with a shoe-print to prevent double counting. All Washington ground squirrel detections were mapped and reported to the researcher studying this species, Eric Green. Burrows within patches of rabbitbrush were recorded separately, as we did not increase our search effort enough to accommodate the reduced delectability. The abundance, and availability status of badger burrows were recorded within each plot. Soil type was also recorded. These data may be used to establish and compare burrow availability and owl density (Green and Anthony 1989). Owls were located as they flushed from burrows or by signs of activity at burrows. Monitoring of active burrows began 4 April and continued through the end of July. Nest burrows were identified by one or more of the following criteria: egg-shell fragments outside the burrow entrance (Green and Anthony 1989), larger debris ring (Rich 1986), or by repeatedly flushing the female from the burrow. A sample of 40 burrows used by owls in 1995 was tracked through the 1996 and 1997 breeding season. A sample of 71 burrows which included 13 from the 1995 sample were tracked through 1997. When trampled, burrows were considered destroyed if they were subsequently abandoned, and altered if owls continued using them.

Vegetation measurements were taken at every nest site at the end of July of the first year for which we knew it to be occupied. In addition, for all nest and accessory burrows used by owls in 1996 ($n = 79$), UTM location, slope of ground, aspect of slope, aspect of burrow entrance, soil type, and slope of burrow were recorded. The slope of the ground was recorded using a clinometer, while the burrow data was collected using a 1.6 mm metal probe to measure the depth of the soil above the tunnel at 20, 40, and 60 cm from the entrance. All of the Burrowing Owl field data collection was carried out under the direction of Greg Green.

**Long-billed Curlew:** We located nests through a variety of methods. These were systematic searches carried out concurrently with badger hole/Burrowing Owl surveys ($n = 37$), systematic searches conducted by volunteer high school and middle school classes ($n = 32$), rope-dragging ($n = 6$), and either flushing an adult or simply seeing an incubating adult ($n = 29$). Searches conducted by students were conducted each year on annual grass plots 4 and 6, but were not done on the same dates each year. Observers walked slowly, 4 m apart (holding on to markings, every 4 m, on a long rope to keep the observers spaced apart) scanning for and flushing incubating adults, with flags regularly placed along the leading edge. When the line of observers reached the predetermined boundary, the entire group shifted laterally and walked back on the far side of the flags, picking them up as they returned while simultaneously the person at the leading edge marked the new pass. Long-billed Curlew nests were considered successful if we observed starring, pipping, or hatching eggs (or hatchlings). Nests were also classified as successful if observed empty and undamaged near the predicted hatch date (when clutch completion was known), or if the nest was undisturbed with few to many small egg shell fragments (too small to be removed by adults) found in or just outside the nest (Pampush pers. Comm. 1995).

**Black-billed Magpie**: Efforts to monitor nests were greatest in the juniper trees, where we located every nest in 1996, and 1997. We monitored as many nests in sagebrush that we could each year, but did not monitor nests in Bitterbrush except in 1995. We attributed nest predation to ravens when the hood of the nest was removed, ripped open, or if the entranceway had been enlarged substantially during the depredation. We attributed predation to coyote when tracks were located at the nest, when the structure was forcibly opened from the side, and/or hair was caught in the bark of the nest shrub.

**Loggerhead Shrike:** Approximately 2550 ha were surveyed systematically and intensively for breeding shrikes. Typically, 250 ha were covered in a morning (5-6 hours) by walking slowly with frequent stops to scan the surrounding vegetation until the boundary of a pre-selected area was reached. The observer would then double back, walking at a parallel distance of 150-250 meters depending on vegetation density and terrain. The entire survey area was covered twice between 15 April and 23 May, 1996, and once between 15 April and 15 May, 1997. Every known breeding territory from the previous year was searched for shrike activity. Additional territories were discovered while observers were on their way to and from nest checks. Selection of a non-use site (sampled in 1995-1996) for vegetation measurements was consistent with Poole (1992). In summary, the non-use site was located 200 m from the nest in a randomly selected direction. A 50 m radius was searched for any old shrike nests. If an old nest was located, the process was repeated 200 meters from the nest at 180 degrees from the randomly selected direction. The location of all shrike nests was recorded using a GPS unit.

In 1997 we tracked fates of fledglings to 13-16 days out of the nest. We did not include nests that fledged prematurely (at day 12-15 of the nestling stage) in the analysis, because these nests are believed to have fledged early as a result of a partial, or failed depredation attempt by a nest predator. Due to limited access to the study site on weekends, we were not always able to count broods on day 14. Fledged broods were located, and observed for a minimum of 30 minutes, (observations were usually over one hour), 13 to 16 days after fledging. After observing food carries to locate where fledglings were perched, we approached and flushed the young at each location noted. If the entire brood was not accounted for, we flushed and counted the young a second time, often the following day, and the higher count was used.

### Wildlife Observations

Observations of all wildlife listed in Appendix 8 were recorded on forms provided by Greg Green (Parametrix Inc.) for use with a GIS. Behavior, habitat type, and location within a 400 m by 400 meter grid system were noted.

### Statistical Analysis

Point count census data yielded information on relative abundance, species richness and species diversity. Species richness is the total number of species detected within 100 m. The mean index is the mean richness per point within a plot or habitat type. Species diversity measures ecological diversity based on the number of species detected within 100 m, weighted by the number of individuals of each species. A high score indicates high ecological (species) diversity. Species diversity was measured using a transformation of the usual Shannon-Weiner index, which is symbolized by H' (also called

Shannon-Weaver index or Shannon index; Krebs 1989). This transformed index, which was introduced by MacArthur (1965) is $N_1$ where $N_1 = 2^{H'}$. The advantage of $N_1$ over H' is that $N_1$ is measured in terms of species, whereas H' is measured in terms of bits of information. Thus, $N_1$ is more easily interpreted, and species diversity (measured as $N_1$) and richness can be compared. We looked at 2 richness indices; cumulative and mean. The cumulative index considers all species seen on a given plot or within a given habitat type. All analyses of richness and diversity were restricted to species of confirmed or suspected breeding status.

Habitat type for point count analysis is the same as the plot habitat classification with the following exceptions. Census points 5 and 6 on plot 20 (ungrazed bunchgrass) were treated as ungrazed sagebrush because of the extensive cover of sagebrush around them. Census points 1, 5, 6, and 7 on plot 8 (grazed sagebrush) were treated as upland sagebrush due to differences in vegetation structure around them (sagebrush with lower vertical aspect, and extensive ground coverage by cryptogam/Sandberg's bluegrass association). With these corrections of habitat type around specific points we now realize that only 4 census points were actually in the upland sagebrush habitat type in 1995.

We examined nest success in 2 ways (after Martin 1992): nesting success as the proportion of nests that fledge and Mayfield (1975) estimates of survivorship. Mayfield estimates are better estimates of nest survivorship in that they take into account the number of days nests are under observation, thus eliminating the potential under-estimation of losses. This method consists of summing the number of days which nests were observed and at risk of failing and dividing by the number of nests known to have failed. This provides an estimate of daily nest mortality and is used to estimate nest survivorship for a particular stage of nesting, or for the entire nesting period. We defined the entire nesting period as beginning on the day of laying the first egg, and ending on the day of departure of the first nestling. We estimated variance as recommended by Johnson (1979). We used a two-tailed Z test (Johnson 1979) to test for difference between years and periods. When survivorship for the entire nesting period did not differ significantly between years, we combined years. Unless otherwise stated, all significance levels are $P < .05$.

We used logistic regression to investigate habitat affinities for 5 species, Grasshopper Sparrow, Horned Lark, Lark Sparrow, Long-billed Curlew, and Sage Sparrow, from vegetation and habitat characteristics at points where a species was detected, compared to those where they did not occur. Logistic regression is used to model the effects of independent variables on a binary response (such as presence/absence and successful/unsuccessful) (McCullagh and Nelder 1989). We developed predictive models using stepwise multiple logistic regression (Stata Corp. 1997). Terms that were significant in univariate regressions were entered into a stepwise elimination strategy. We used the likelihood ratio statistic to test hypotheses, which is analogous to sums of squares in ANOVA. In multiple logistic regression models, independent terms are reported using the Likelihood Ratio Statistic. We examined non-linearity by testing for the significance of quadratic terms (Zar 1996). Where quadratic terms were significant, we tried replacing the variable with its quadratic term, and adopted their use if the model could be improved. All models presented here were tested using a goodness of fit $x^2$ test ($P > 0.4$). There was no significant difference in patterns of presence/absence between years for any of the 5 species.

The predictive rates we present with the models are based on a 50% probability. If the model predicts occurrence of a given species or success of a given nest at greater than 50% probability based on the independent variables, then that record is classified as successful.

We used linear regression to model abundance of the same 5 species as above (with the addition of Western Meadowlark) in relation to vegetation around the point. We included every point at which that species had been detected at least once in the 3 years (9 independent census days). To allow comparison between plots 25 and 26, which were only censused in two years, we used the sum of annual means divided by the number of years. We tested for differences in abundance between years using ANOVA.

We used logarithmic transformations to normalize dependent variables (number detected within 100 m). Multiple regression models were estimated using a stepwise elimination procedure. We tested residuals of multivariate models for approximation to normality (Skewness and Kurtosis test for Normality of Residuals (Stata Corp. 1997). We examined the assumption of homoscedasticity of residuals using the Cook-Weisberg test as described by Stata Corp. (1997). In no model presented here was there significant heteroscedasticity (all $P > 0.1$). When tests failed we tried square-root transforming dependant variables, and adopted their use where improvements were made to the model.
We investigated whether changes in any variable were correlated with date of clutch initiation for Long-billed Curlew and Loggerhead Shrike. We corrected for differences in chronology between the three years by adding 10 days to all shrike nests in 1997, and subtracting one day from nests in 1996, so that median lay dates were equal to the 1995 median (17 April) in all years. For curlews we subtracted 4 days from nests in 1995, and added 5 days in 1997, so that the median lay date in each year was 13 April.

**Personnel**

In 1995, 2 PRBO staff biologists, and 5 intern biologists conducted points counts and searched for nests. In 1996 and 1997, each observer (1 PRBO staff biologist both years with 6 intern biologists in 1996 and 5 intern biologists in 1997), was assigned a target species, or suite of species, and was responsible for the duties outlined in the methods for those species. In addition, 4 observers were responsible for conducting the 3 point count censuses. All personnel participated in the badger hole/Burrowing Owl census. Journals of daily activities and pertinent natural history notes were compiled. An herbarium of plants collected on the study sites was compiled for aiding in plant identification.

All field technicians entered their own nest, vegetation and census data into a dbase file by 1 August and made initial proofs. Point count and nest data was further checked for errors and corrected with proofing programs at PRBO in the fall. All original data forms and data files are stored at the Navy's Engineering Field Activity NW in Poulsbo, WA. Copies of all data-forms as well as all computer data bases are on file at PRBO.

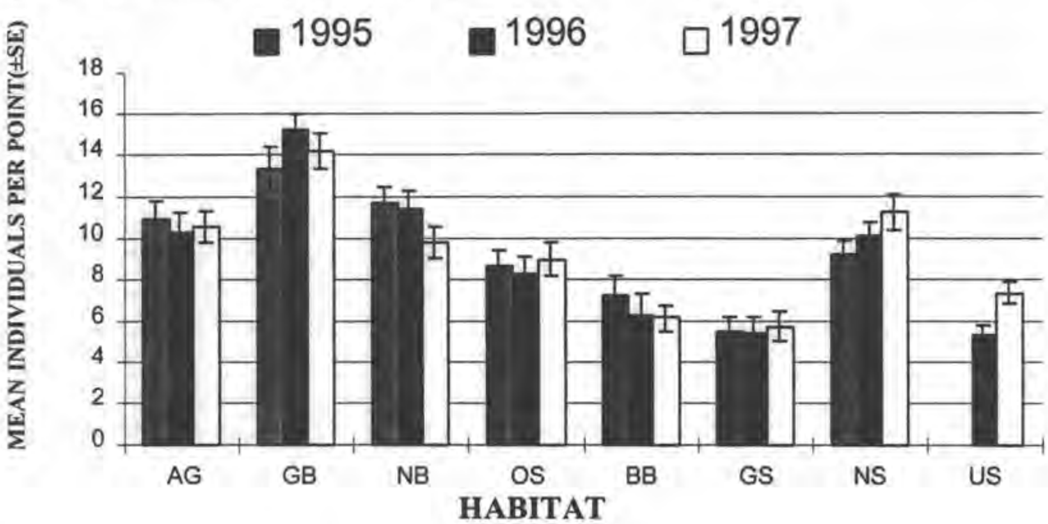
## Results and Discussion

### Point count census data

The number of individuals observed within 100 m during point count censuses are listed for each species by general habitat type in Appendix 1 (Table 2 = 1995, Table 3 = 1996, Table 4 = 1997).

**Site comparisons:** Data from standardized censuses allow comparisons of secondary population paramaters such as abundance, species richness, and diversity between sites. Summaries of total individuals per station as well as both cumulative and mean species diversity and richness are presented for each habitat/treatment and year in Appendix 2, Tables 1a-1c. A summary of the cumulative species diversity, species richness, and total individuals per station is presented by plot in Appendix 2, Table 2 for 1995, Table 3 for 1996 and Table 4 for 1997. The relative abundance of breeding species in terms of mean number of individuals per point is presented for each habitat/treatment type and year in Figure 3.

FIGURE 3. Relative abundance (all breeding species) among general habitats/treatments 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush




Within a habitat type, only the upland sagebrush had a significant difference in total landbird abundance between years ($t_{67}$=3.21, $P$ = 0.002, ANOVA). In general, the grassland habitats have a higher abundance of breeding birds than the shrub habitats. Grazed bunchgrass had the highest abundance each year, with the mean individuals per point varying from 13.4 to 15.2 across the years (sum of 3 visits). The 3 year mean of mean point abundance, species richness, and species diversity is presented in table 2. While the difference between annual grass and ungrazed bunchgrass was not significant, abundance was significantly higher in the grazed bunchgrass (grazed vs. ungrazed bunchgrass: $t_{51}$ = 3.74, $P < 0.001$; annual vs. grazed bunchgrass: $t_{53}$ = 4.39, $P < 0.001$). The livestock-free sagebrush plots, located in RNA C, had the greatest abundance of landbirds among the shrub habitats. The bird community in this habitat was most similar to that in the bunchgrass, and the increased abundance relative to other shrub plots was due largely to greater numbers of Horned Larks and Grasshopper Sparrows. Abundance was higher in the ungrazed sagebrush than the other sagebrush plots (grazed vs. ungrazed sagebrush: $t_{51}$ = 5.56, $P < 0.001$; upland vs. ungrazed sagebrush: $t_{62} = 5.6$, $P < 0.001$).

TABLE 2. Mean annual abundance, species richness, and species diversity per point, by habitat. Means that are not followed by the same capital letter are significantly different at the .05 level, using the bonferroni adjustment for multiple comparisons.

| **Habitat** | Mean abundance (SD) | Mean species richness (SD) | Mean diversity (SD) |
|---|---|---|---|
| Annual grass | 10.74 (2.9) A | 3.31 (.52) A | 2.90 (.44) A |
| Grazed bunchgrass | 14.31 (3.07) | 3.29 (.54) A | 2.85 (.41) A C |
| Ungrazed bunchgrass | 11.19 (2.95) A | 2.83 (.49) A D | 2.52 (.40) A C |
| Open low shrub | 6.73 (2.19) A C | 2.34 (.66) D E | 2.02 (.52) C |
| Bitterbrush | 7.11 (3.32) B C | 1.65 (.72) B | 1.43 (.44) B |
| Grazed sagebrush | 5.97 (2.81) B | 2.01 (.69) B C | 1.84 (.54) B D |
| Ungrazed sagebrush | 10.21 (2.66) A | 2.97 (.57) A D | 2.55 (.47) A C |
| Upand sagebrush | 6.73 (2.19) B C | 2.31 (.67) C E | 2.01 (.52) D |

Comparison of indices of species richness and diversity provides a measure of the eveness of species abundance within the community. When richness is equal to diversity, all species are detected in equal numbers. The mean richness of points in the bitterbrush habitat varied from 1.54 to 1.75, while mean point diversity varied from 1.38 to 1.45. Cumulative species richness varied from 7 to 10 across the years, while cumulative diversity varied from 2.16 and 3.13. Both of these indexes and comparisons offer insight into the bitterbrush community. The mean indices suggest a relatively even distribution with a mean of 1.5 -1.8 species per point. The cumulative species richness index, however, shows that there are from 7-10 species of birds detected in this habitat each year. The disparity between the cumulative richness and diversity indices demonstrates that species were detected in low numbers or at only several of the points. In annual grassland the mean richness at each point is about twice that found in the bitterbrush, and the disparity between the cumulative and mean richness is much reduced. Figures 4 and 5 show the mean and cumulative richness of breeding species in each habitat and year. The shrub habitats tended to have higher cumulative richness, while grassland plots generally had greater mean richness. Cumulative richness, on which single detections of uncommon species exert

FIGURE 4. Cumulative species richness among habitats and treatments, 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush

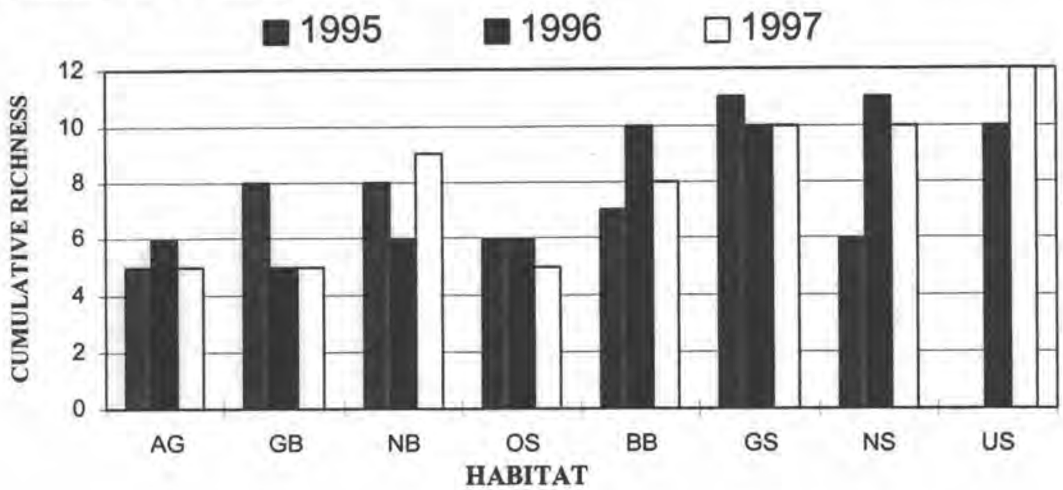
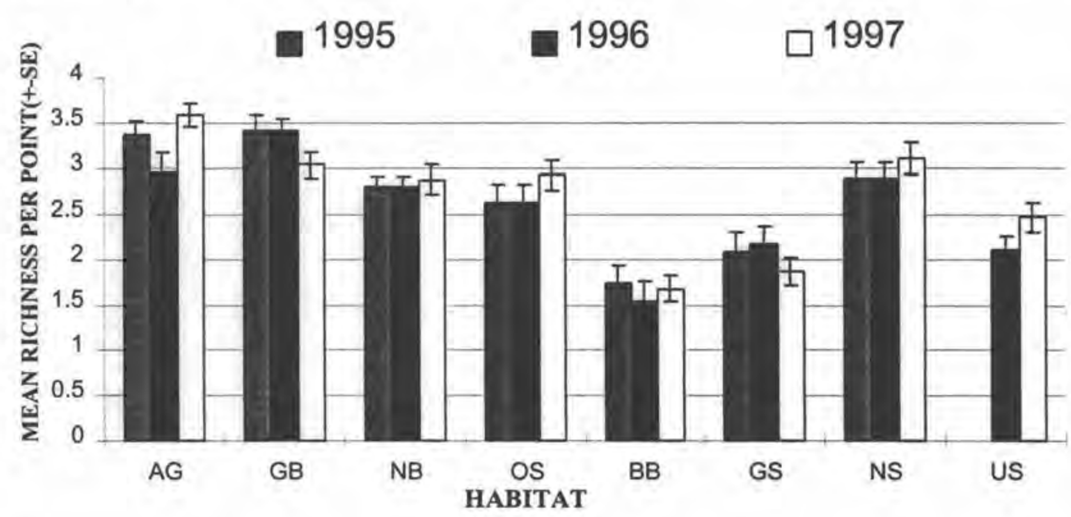



FIGURE 5. Mean species richness among habitats and treatments, 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush.




strong influence, shows much more within-habitat, between-year variation. The pattern of mean species richness between habitats is less erratic among years and shows similarities to patterns of abundance. Mean species richness varied significantly between years only in the annual grass habitat. Among sagebrush habitat types, ungrazed sagebrush had the highest mean species richness (grazed vs. ungrazed: $t_{51} = 5.29$, $P < 0.00$; ungrazed vs. upland: $t_{62} = 4.18$, $P < 0.01$).

**Community composition:** Western Meadowlark was the most abundant species in every habitat type except bunchgrass. In both grazed and ungrazed bunchgrass, Grasshopper Sparrow was the most abundant species. In the open-low shrub, ungrazed sagebrush and all grassland habitats, Horned Lark, Grasshopper Sparrow, and Western Meadowlark are the 3 most common species, and make up the bulk of detections. The percent of all detections made by select species is presented for each habitat type in Figure 6. Detectability will influence the percentage of total detections a given species makes, and therefore these results should be interpreted cautiously. Appendix 3, Table 1 summarizes the number of detections of Grasshopper Sparrow, Horned Lark, and Western Meadowlark in each plot and year. Appendix 3, Table 2 summarizes the percent of points in each habitat and year where meadowlarks, Horned Larks, and Grasshopper Sparrow were detected and Appendix 3, Table 3 summarizes the percent of total detections made by the same 3 species by plot and year.

FIGURE 6. The percent of all detections made by dominant species in each habitat/ treatment, 1995-1997.

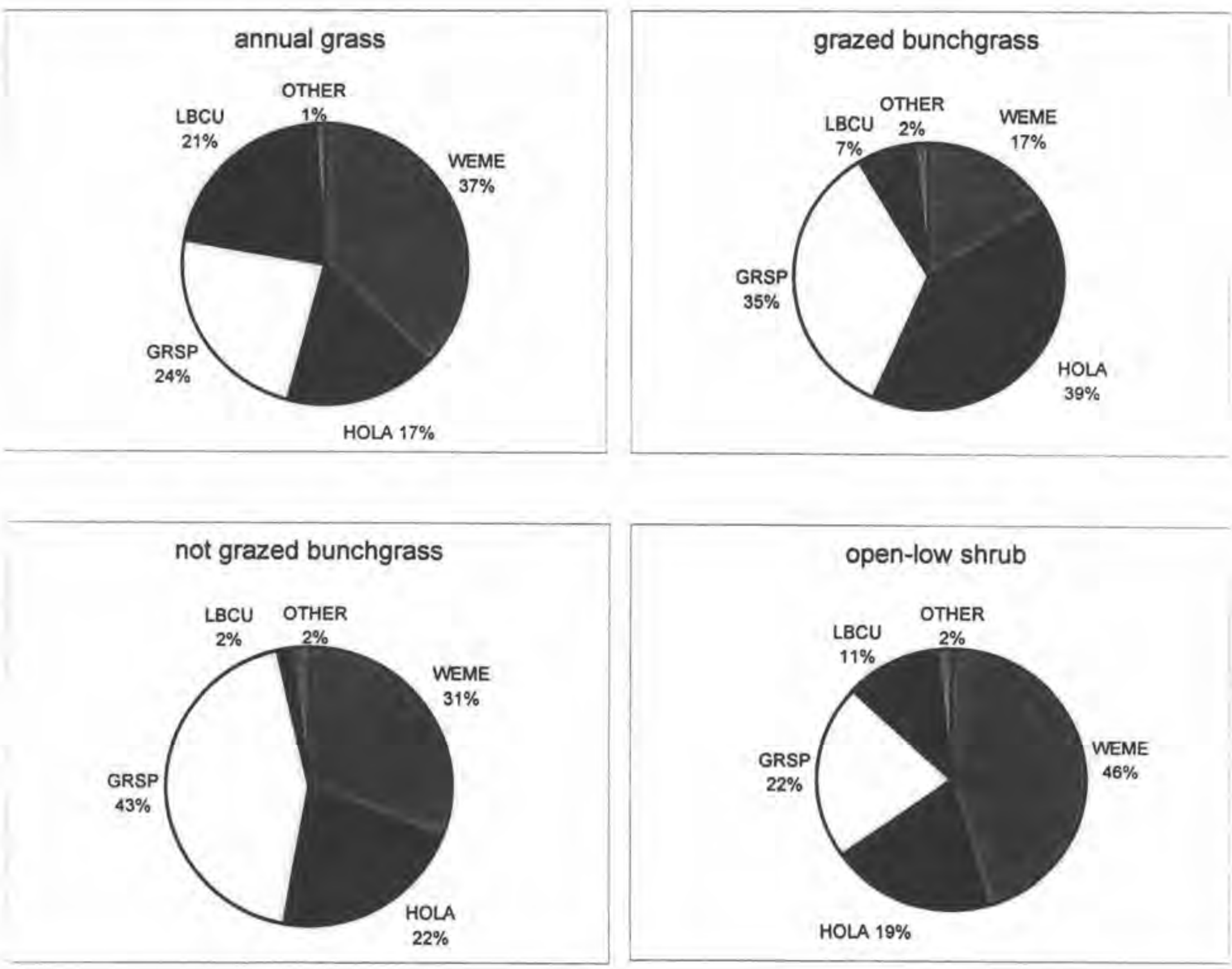
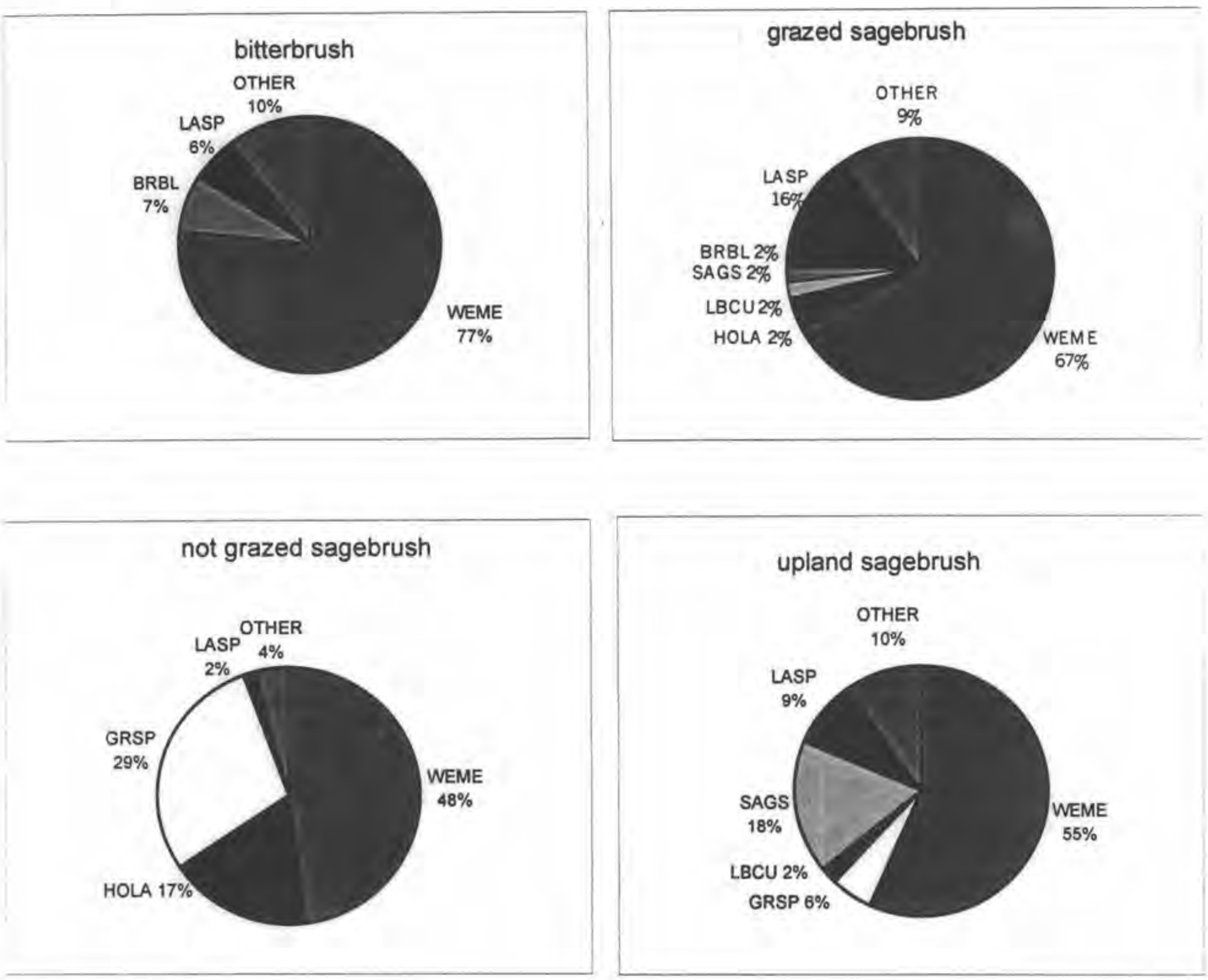


FIGURE 6, continued




## Nest Data

The changes in protocol and procedures adapted in 1996 and 1997 yielded 65 and 72 more nests with known outcome, respectively, than in 1995 (Table 3). These changes can be partially explained by the nests monitored in the Juniper trees. Although fewer nests were found on BBIRD plots, only 2 species, Horned Lark and Western Meadowlark, had substantially fewer nests found in 1996 vs. 1995. In conclusion, we feel a target species approach yielded more nests per effort and allowed observers to locate and map territories of uncommon species.

Proportional success did not differ much between years. Overall, 213 of 519 (41%) nests of open-cup nesting passerines fledged young. This percentage was the same if corvid nests were excluded (168 of 408, 41%). Open-cup nesting passerines in the Juniper trees fared slightly better than the average (35 of 75, 47%) (Table 4).

TABLE 3. Number of nests for each species with known outcome and proportion successful (%S) in each year, and for all years combined.

| Species | 1995 | | 1996 | | 1997 | | 1995-1997 | |
|---|---|---|---|---|---|---|---|---|
| | n | %S | n | %S | n | S | n | %S |
| Barn Owl | 0 | - | 0 | - | 1 | 100% | 1 | 100% |
| Black-billed Magpie | 16 | 25% | 44 | 52% | 45 | 31% | 105 | 39% |
| Brewers Blackbird | 10 | 30% | 6 | 0 | 7 | 0 | 23 | 13% |
| Bullock's Oriole | 0 | - | 4 | 50% | 3 | 100% | 7 | 71% |
| Burrowing Owl | 28 | 61% | 37 | 65% | 34 | 47% | 99 | 58% |
| Common Raven | 1 | 100% | 2 | 100% | 3 | 67% | 6 | 83% |
| Grasshopper Sparrow | 10 | 70% | 14 | 64% | 13 | 54% | 37 | 62% |
| Ferruginous Hawk | 0 | - | 2 | 50% | 3 | 67% | 5 | 60% |
| Horned Lark | 15 | 40% | 7 | 29% | 6 | 50% | 28 | 39% |
| Killdeer | 2 | 100% | 1 | 100% | 0 | - | 3 | 100% |
| Loggerhead Shrike | 43 | 49% | 49 | 38 | 61 | 46% | 152 | 45% |
| Long-eared Owl | 1 | 0 | 10 | 100% | 19 | 63% | 30 | 73% |
| Long-billed Curlew | 17 | 94% | 39 | 54% | 48 | 378 | 104 | 53% |
| Lark Sparrow | 11 | 27% | 7 | 43% | 1 | 0 | 19 | 32% |
| Mourning Dove | 4 | 25% | 6 | 50% | 7 | 29% | 17 | 35% |
| Sage Sparrow | 4 | 25% | 6 | 33% | 2 | 50% | 12 | 33% |
| Sage Thrasher | 1 | 0 | 2 | 0 | 0 | - | 3 | 0 |
| Swainson's Hawk | 0 | - | 7 | 71% | 7 | 100% | 14 | 86% |
| Western Kingbird | 4 | 25% | 10 | 70% | 22 | 48% | 36 | 50% |
| Western Meadowlark | 37 | 48% | 17 | 18% | 26 | 15% | 80 | 28% |
| **Totals** | **204** | **50%** | **269** | **54%** | **309** | **42%** | **782** | **48%** |

TABLE 4. Number of nests monitored (number successful), and proportion successful in Juniper trees, 1996 and 1997.

| Species | Number of nests 1996 | Proportion successful | Number of nests 1997 | Proportion successful |
|---|---|---|---|---|
| Black-billed Magpie | 30 (16) | 53% | 20 (7) | 35% |
| Bullock's Oriole | 4 (2) | 50% | 3 (3) | 100% |
| Common Raven | 2 (2) | 100% | 3 (2) | 67% |
| Ferruginous Hawk | 2 (1) | 50% | 3 (2) | 67% |
| Loggerhead Shrike | 1 (0) | 0 | 3 (1) | 33% |
| Long-eared Owl | 10 (10) | 100% | 19 (12) | 63% |
| Mourning Dove | 0 | -- | 3 (2) | 67% |
| Swainson's Hawk | 6 (4) | 67% | 6 (6) | 100% |
| Western Kingbird | 7 (5) | 71% | 16 (6) | 38% |
| **Totals** | **61 (40)** | **66%** | **76 (41)** | **54%** |

**1996 Sage Sparrow /sagebrush obligate species census:** A total of 49 Sage Sparrow and 3 Brewers Sparrow territories were confirmed or suspected on NWSTF in 1996. However, persistent high winds and infrequent singing made Sage Sparrows difficult to detect and some territories may have been missed. Only 1 census area (the "South-east Plot") contained Brewer's Sparrows and Sage Thrashers (point count plot 26 is included within this area). However, point count censuses usually were completed when Sage Thrashers arrived on the study site in mid June. The numbers of confirmed and suspected territories located within each census area are presented in Table 5.

TABLE 5. The number of confirmed and suspected Sage Sparrow and Brewer's Sparrow territories in 6 upland sagebrush study plots.

| | Sage Sparrow | | Brewer's Sparrow |
|---|---|---|---|
| Census Area | Number of confirmed territories | Number of suspected territories | Number of suspected territories |
| Hey Rd. plot | 19 | 0 | 0 |
| Spurlock plot | 14 | 0 | 0 |
| South-east plot | 7 | 2 | 3 |
| Foot plot | 6 | 0 | 0 |
| Johnson plot | 1 | 0 | 0 |
| Zalaco plot | 0 | 0 | 0 |

**Rope dragging:** We had limited success locating grassland nests through rope-dragging. Tables 6a and 6b show the numbers of nests located through rope-dragging by plot and species for 1996 and 1997. We conclude from our limited success in locating Grasshopper Sparrow nests that a modified rope be used if these efforts are repeated.

TABLE 6a. Number of nests located through rope-dragging by plot in 1996.

| Species | Plot 16 | Plot 18 | Plot 19 | Plot 28 | TOTAL |
|---|---|---|---|---|---|
| Grasshopper Sparrow | 4 | 0 | 4 | 0 | 8 |
| Horned Lark | 1 | 0 | 1 | 0 | 2 |
| Long-billed Curlew | 2 | 1 | 0 | 0 | 3 |

TABLE 6b. Number of nests located through rope-dragging by plot in 1997.

| Species | Plot 5 | Plot 19 | Plot 28 | TOTAL |
|---|---|---|---|---|
| Grasshopper Sparrow | | 6 | | 6 |
| Horned Lark | | 1 | 2 | 3 |
| Long-billed Curlew | 1 | 2 | | 3 |
| Short-eared Owl | | 1 | | 1 |
| Western Meadowlark | 1 | 2 | | 3 |

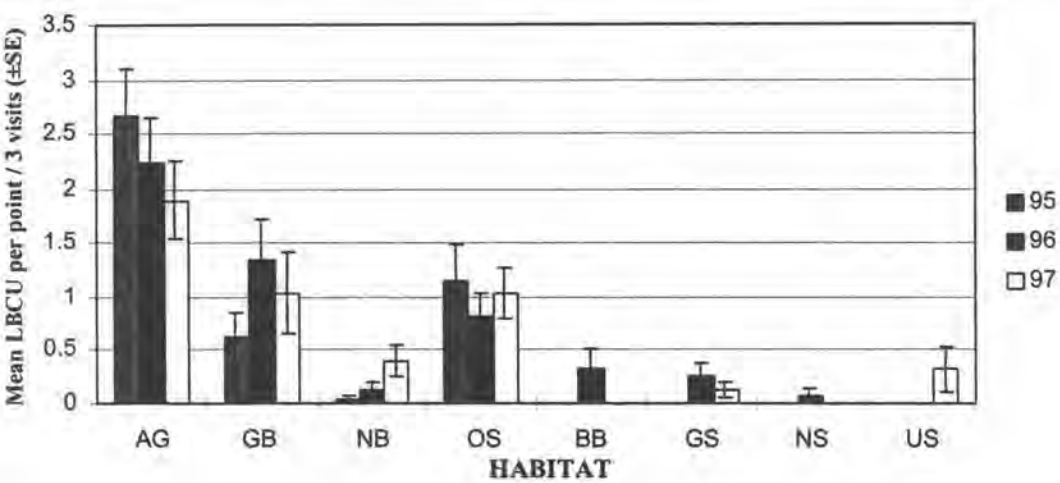
## Species Accounts

### Long-billed Curlew

**Status:** Breeding Bird Survey data shows a 5.1 percent annual increase for curlews from 1968 to 1994 in the Columbia basin ($P < 0.01$). Long-billed Curlews are on the USFWS Region 1 species of concern list. Gabrielson and Jewett (1970) wrote in 1940, of finding curlews "in small numbers" in Morrow County.

**Distribution / Relative Abundance:** Curlews were most abundant in the annual grass habitat, and were also found in the grazed bunchgrass and open-low shrub habitats in lesser numbers. Every other habitat had at least 1 detection in 1996, 1997, or in both years. There were no detections in shrub habitats other than open low shrub in 1995. In 1997, 2 pairs nested on plot 19 in RNA C, which resulted in increased the number of detections for ungrazed bunchgrass. Relative abundance among habitats and years is presented in Figure 7. The mean annual abundance was significantly higher at the 27 grazed bunchgrass points than at the 25 ungrazed bunchgrass points ($t_{51} = 3.57$, $P < 0.001$). The mean abundance was significantly greater in annual grass than grazed bunchgrass ($t_{53} = 3.86$, $P < 0.001$).

FIGURE 7. Relative abundance of Long-billed Curlew within habitats and treatments of the NWSTF, 1995-1997. Error bars are standard error. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush.




**Habitat Associations:** Within grassland habitats, curlews were detected at 67% of the points ($n = 79$). We used logistic regression to identify variables that were significantly correlated with the occurrence of curlews. The means and standard errors of significant variables at points where curlews were either present or absent, in grassland habitats, are presented in Table 7. In summary, curlews occurred in areas with vegetation of a lower vertical profile. Cover of annual grass (cheatgrass), and Sandberg's bluegrass were greater at points where they occurred, and taller perennial bunchgrass (needle-and-thread, and blue-bunch wheatgrass) occurred in greater amounts where they were absent. Litter and bare ground were positively associated with the occurrence of curlews, whereas cryptobiotic crust was negatively associated. Cryptobiotic crust and perennial grass were strongly correlated (r = .71), and both can generally be interperated as indicating lesser amounts of disturbance from livestock (Yenson 1981). Rabbitbrush cover, density, and height were also positively associated with occurrence of curlews, but mean cover was less than 1 percent in each set of points, and rabbitbrush variables were not correlated with curlew abundance. We entered 10 significant variables into a stepwise procedure, resulting in a 2 term model for curlew occurrence in grassland (presented in Table 8). Perennial grass is strongly negatively associated with the occurrence of curlews, presumably because of its effective height. Rabbitbrush height was the other variable retained in the final model. This model classifies curlew occurrence correctly at 84.8% of the points. We modeled curlew abundance using linear regression with data at the 90 points where curlews were detected at least once (across habitat types). There was no significant difference in curlew abundance among years at points where they occurred. Thirteen significant variables (Appendix 6, Table 3) were entered into a stepwise elimination procedure. The final, 4 variable model is presented in Appendix 5, Table 9. At points where curlews were present, sagebrush cover has the strongest negative relationship with abundance, followed by perennial bunchgrass and shrub density. A slight positive association with sagebrush stems greater than 2.5 cm may reflect sampling points adjacent to open fields of cheatgrass which were used by curlews.

TABLE 7. The means, standard errors, and significance levels of different vegetation and habitat variables related to Long-billed Curlew occurrence in grassland habitats of the NWSTF.

| Variable | Grassland points with LBCU (n=53 ) | Grassland points without LBCU (n=26 ) | *P* |
|---|---|---|---|
| annual grass cover (%) | 12.17 ± 1.89 | 2.03 ±.46 | .000 |
| Perennial grass cover (%) | 8.06 ± 1.36 | 23.59 ±1.44 | .000 |
| Sandberg's bluegrass bluegrasscover (%) | 3.09 ± .44 | 1.81 ± .34 | .043 |
| forb cover (%) | 10.78 ± 1 | 4.02 ± .77 | .000 |
| bare ground (%) | 34.31 ± 3.30 | 21.07 ± 5.14 | .024 |
| cryptobiotic crust (%) | 19.33 ± 3.11 | 46.33 ± 5.79 | .000 |
| litter (%) | 30.06 ± 3.03 | 9.95 ± 1.82 | .000 |
| rabbitbrush cover (%) | .97 ± .20 | .14 ± .10 | .000 |
| rabbitbrush density (#) | 3.85 ± .78 | .54 ± .39 | .000 |
| rabbitbrush height (cm) | 30.96 ± 3.16 | 9.08 ± 4.37 | .000 |

TABLE 8. Logistic regression model for probability that a Long-billed Curlew will be present at a grassland point count station.

Number of points = 79
LRS (2) = 54.86
$P > chi^2 = 0.0000$
Pseudo $R^2 = 0.5481$

Dependent term: presence of LBCU

| Term | $P$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| perennial grass cover | 0.000 | -0.205 | 0.052 |
| log (rabbitbrush height) | 0.000 | 0.712 | 0.203 |

TABLE 9. Linear regression of Long billed curlew abundance (log transformed) in relation to perennial grass cover, sagebrush cover and density of large sagebrush stems using 90 points across habitats where curlews were detected at least once.

Number of points =90
F (3, 86) = 9.09
$P > F = 0.0000$

$R^2 = 0.2407$
$R^2a = 0.2142$

Dependent term: Long-billed Curlew abundance (log-transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| perennial grass | -3.417 | 0.001 | -0.023 | 0.007 |
| sagebrush cover | -3.685 | 0.000 | -0.083 | 0.023 |
| sagebrush stems > 2.5 cm | 2.354 | 0.021 | 0.017 | 0.007 |

**Nest Data:** Of 104 nests in which we observed a complete clutch, there were 95 (91.3%) nests with a clutch of 4 eggs, 8 nests (7.7%) with 3 eggs, and 1 nest (0.9 %) with 5 eggs (mean=3.93). The mean clutch initiation date is given for each year in Table 4.

TABLE 10. Mean clutch initiation date for Long-billed Curlew by year.

| Year | Number of nests | Mean clutch initiation | Range |
|---|---|---|---|
| 1995 | 17 | April 19 | April 3 - May 5 |
| 1996 | 39 | April 14 | March 29 - May25 |
| 1997 | 49 | April 16 | March 31 - May 10 |

For failed nests that were first located with a complete clutch, we estimated clutch completion as the day prior to finding, and consequently these data may be skewed towards later dates. The latest clutch initiation date we recorded, 25 May, was estimated for a nest that failed, apparently due to abandonment, between 17 and 19 June. If the eggs were viable, this nest was initiated no earlier than 22 May. Another late nest in 1996 hatched on 11 June. These dates are slightly later than what was reported by Pampush and Anthony (1993), who found the latest hatch date for the Bombing Range in 1978 and 1979 to be June 4th.

Nest survivorship of Long-billed Curlews was significantly higher in 1995 (88%, $n = 16$) than Mayfield estimates for 1996 (31%, $n = 37$), and 1997 (21%, $n = 48$) ($P < .01$). Mayfield survivorship estimates are presented in Table 11. Proportional success varied from 38% in 1997 to 96% in 1995. Pampush and Anthony (1993) reported Mayfield estimates of nest survivorship on the Bombing Range as 69% in 1978 ($n = 40$) and 65% in 1979 ($n = 61$). Probable nest predators include Common Raven, American Crow, Badger and coyote. California, and Ring-billed Gulls were observed in breeding areas and, contrary to other observations (Redmond and Jenni 1986, Allen 1980), were regularly mobbed by Long-billed Curlews when in flocks. Of 43 depredation events we recorded in 1996 and 1997, 13 (30%) were attributed to badger or coyote, 12 (28%) were considered avian, 3 (7%) were trampled by livestock, and 15 (35%) were unclassified. The nests we did not classify had no evidence of predation, and we therefore tend to believe that the predators were avian.

TABLE 11 . Number of nests and days of observation used for analysis, total survivorship, daily survivorship, and standard error for Long-billed Curlew nests in each year and 1996-1997 combined.

| Year | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|
| 1995 | 16 | 255 | .880 | .996 (.004) |
| 1996 | 37 | 454 | .312 | .965 (.009) |
| 1997 | 48 | 615 | .208 | .953 (.009) |
| '96-'97 | 85 | 1069 | .247 | .958 (.006) |

We investigated the effects of laying date, nest concealment from above and from the side, and plant height on nest success using logistic regression. There was a significant negative correlation between the date of the first egg and nest success ($ß = -.0657$, $SE(ß) = .0206$, $P < .001$, $n = 104$, logistic regression). This was true only for 1996 when we looked at each year independently, but was still significant for the entire study when we controlled for yearly differences in success ($P < .001$, likelihood ratio test). We also found that plant height and nest concealment from the sides were positively correlated with nest success. Substrate height varied significantly between years ($P < .001$, ANOVA), and its effect on nest success was not significant when we controlled for year effect ($P = .067$, likelihood ratio test). The mean ($\pm$ SE) substrate height for successful nests was $23.3 \pm 1.3$ cm ($n = 50$). Unsuccessful nests had a mean substrate height of 16.2 cm ($\pm$ 1.4 , $n = 44$). Side concealment of the nest averaged 18% more at successful nests ($29.9 \pm 4$, $n = 50$) than at unsuccessful ones ($11.9 \pm 2.2$, $n = 46$). The final model presented in table 12 correctly classifies success or failure at 74 % of the nests.

TABLE 12. Logistic regression model of Long-billed Curlew nest success in relation to clutch initiation date, nest concealment from the sides, and year.

Number of nests = 96
LRS (3) = 31.32
$P > chi^2 = 0.0000$
Pseudo $R^2 = 0.2357$

Dependent term: Success of LBCU nest

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| clutch initiation date (julian) | .0008 | -0.0732 | 0.0246 |
| nest concealment (side) | .0073 | 0.0088 | 0.0035 |
| year | .0154 | -0.8841 | 0.3735 |

**Management:** Long-billed Curlews benefit from large areas of short grass. Grazing prior to their arrival and onset of nesting will create favorable habitat. Nests are, however, vulnerable to trampling by livestock, and our data shows that both the concealment of the nest from the sides, and grass height are positively correlated with nest success. We recommend removing livestock from at least parts of the annual grasslands on the Bombing Range by late March when the curlews arrive, perhaps on a rotational basis. This will reduce trampling, and allow grass to grow and provide concealment, once nests are initiated. Consistent with the goal of increasing overall bunchgrass cover, areas with remnant stands of native grass within the cheatgrass should be targeted for removal of livestock and allowed to go to seed. In perennial grassland on the Bombing Range, curlews were found primarily in grazed areas. We feel this is a response to grass height during March through early May. Both Long-billed curlews and Burrowing Owls would benefit from winter and early spring grazing in perennial grasslands, which reduces the effective height of bunchgrass. Reynolds and Trost (1981) found that curlews responded negatively to moderate grazing of big sagebrush / bluebunch wheatgrass in Idaho.

**Swainson's Hawk**

**Status:** Breeding Bird Survey data shows no population trend for Swainson's Hawk in the Columbia River Basin from 1968-1994. They are listed as vulnerable on the Oregon Department of Fish and Wildlife sensitive species list.

**Distribution / Relative Abundance:** Swainson's Hawks were restricted to the sagebrush and juniper habitats for nesting, but were observed foraging in adjacent habitats including open low shrub, bunchgrass, and agricultural fields.

**Nest Data:** Swainson's Hawk arrived in mid-April, and some began building nests within a few days. We monitored 7 nests in both 1996 and 1997. Six nests each year were in juniper trees; the other nest was built on a nest platform in 1996 and used both years. Including the platform nest, 3 (43 %) of the nests used in 1996 were reused in 1997. Clutches were initiated between the last week of April and the third week of May in both years, and successful nests fledged young from mid-July to early August.

Nests that were still active but close to fledging when we left the study area at the end of July were assumed to have fledged at least one young, but mortality during the branching stage, just prior to fledging, would have been missed. Nest success was 71.4% in 1996, when two of seven nests failed; one due to an unknown cause, and one due to structural failure in high winds. In 1997 success was 100%. Combining both years, 12 of 14 (85.7%) nests fledged at least one young. The range of nest success, reported from 8 studies (England et al. 1997), is 55-82%, with 81% from nearby southeastern Washington. The nest that failed in high winds was constructed of lightweight materials, primarily Jim-hill Mustard.

**Management:** Swainson's Hawks may be limited on the Bombing Range by availability and spacing of nest-sites. We recommend managing for no net loss of mature juniper trees. Nesting platforms currently in place should be monitored, and as long as they are not usurped by Red-tailed Hawks may eventually provide nest sites on the north end of the Bombing Range. In a review of the effects cattle grazing by migratory landbirds breeding in shrubsteppe, Saab et al (1995) reported two studies where Swainson's Hawks responded negatively to heavy and variable grazing. Reynolds and Trost (1981) reported a positive response to moderate grazing in Idaho shrubsteppe.

### Ferruginous Hawk

**Status:** Data from the Breeding Bird Survey show no population trend for Ferruginous Hawk in the Columbia River Basin from 1968 through 1994 (Saab and Rich 1997). Ferruginous Hawk is listed as a USFWS Region One species of concern, and an ODF&W sensitive species for the Columbia Basin.

**Distribution / Relative Abundance:** Ferruginous Hawks were observed foraging in every habitat type except bitterbrush, which was most likely a function of the distance of this habitat from any nest site. A pair which may have nested on the adjacent Boeing state lease lands was observed regularly above grazed bunchgrass along the western boundary of the Bombing Range in both 1996 and 1997.

**Nest Data:** In 1996, 2 pairs nested in juniper trees on the Bombing Range. One nest, in juniper 160 failed, apparently because of high winds on 22 May. The other, in juniper 88 of the Juniper forest fledged 2 young in the second week of June. A third pair was observed several times in early April, once perching on an existing nest structure In 1997, three pairs attempted nests; the nest in juniper 160 was rebuilt and just before fledging 2 of 3 "branchers", the nest slid out of the tree. A nest in juniper 147 also fledged 2 of 3 young, and that nest as well blew out of the tree, while the young were "branchers". The runt was found dead under the nest tree. The third nest, in juniper 121 failed while incubating at least 2 eggs. Winds in excess of 40 miles per hour on 19 April blew the nest from the tree. This pair was observed rebuilding in the same spot on 28 April, using the old nest remnants as a base. The nest was completely built, lacking only lining, but the pair was not seen again. Weather accounted for the 2 nest failures we observed. The 3 successful nests each fledged 2 young. The 2 nests in 1996 were approximately 2.4 km apart. In 1997, the 3 nests were 1.75, 2.4, and 4 km apart. The mean distance between active nests ($n = 4$) was 2.6 km.

**Management:** The limiting factor for Ferruginous Hawks on the Bombing Range may be nest-sites, and we recommend managing for no net loss of mature juniper trees. Nesting platforms currently in place should be monitored, and as long as they are not usurped by Red-tailed Hawks may eventually provide nest sites on the north end of the Bombing Range. Reynolds and Trost (1981) reported a negative response to moderate grazing in Idaho shrubsteppe. Nest sites should be given a buffer zone of no activity. Suter and Joness (1981) recommend a 1 km buffer zone for drilling and construction activities. We recommend this be implemented for any future ground exercises. In 1997 a group of Boy Scouts walked around a nest, prior to egg-laying. Disturbance of this nature should be avoided.

**Mourning Dove:**

**Status:** Data from the Breeding Bird Survey show a 2.2 percent annual decline of Mourning Doves in the Interior Basin from 1968 to 1994 ($P < 0.01$, Saab and Rich 1997).

**Distribution / Abundance:** On standardized point counts, we detected doves 13 times in sagebrush habitats, and twice in bunchgrass. Although point counts are probably not a suitable method for doves, we feel these numbers indicate the relative abundance between habitats. They were also seen on occasion in open low shrub habitats.

**Nest Data:** We observed 18 nests, of which 11 (61.1%) were underneath and 2 (11.1%) were in sagebrush, 3 (16.7%) were in juniper trees, one (5.5%) was under blue-bunch wheatgrass. The last was not associated with any vegetation, being built on a shelf in the wall of a washed out drainage. Proportional nest success varied from 25% in 1995 ($n = 4$), 50% in 1996 ($n = 6$), to 29% in 1997 ($n = 7$). The earliest clutch initiation date we recorded was 11 April in 1995 and the latest was 15 July, 1997.

**Management:** In a review of the effects cattle grazing by migratory landbirds breeding in shrubsteppe, Saab et al. (1995) compiled data from 3 studies which included lightly grazed and fall-grazed treatments. They found Mourning Doves were 36% less abundant in grazed treatments. On the Bombing Range, Mourning Doves were observed primarily in grazed sagebrush.

**Long-eared Owl:**

**Status:** Long-eared Owl populations appear to be stable in most of North America (Marks et al. 1994). They are not listed federally or in any state with shrubsteppe habitat.

**Distribution / Relative Abundance:** On the Bombing Range, these owls are primarily restricted to areas with juniper trees.

**Nest Data:** Long-eared Owls nested in the juniper trees of Juniper Canyon, as well as the trees near the Western boundary of the Bombing Range. Because we did not monitor nests in the juniper trees in 1995, we have data from only one nest, which was built in a large sagebrush overhanging a sandy blow-out. We monitored 10 nests in 1996, and 19 in 1997. We found no less than 10 breeding pairs in 1997. Clutch initiation dates (through back-dating for the nests active when we arrived on the study area) ranged from 12 March to 11 May in 1996, and 27 February to 16 May in 1997. Although we may have missed several short-lived nests, we located every nest that produced young in the 188 trees monitored. Nests initiated late in the season are either second attempts, or first attempts from pairs who had not yet nested, possibly due to a lack of available nest sites.

The one nest we observed in 1995 was initiated 31 March, and was depredated by a coyote between 5 and 9 May. In 1996 we observed 10 nests in the juniper trees, all of which fledged young, producing 3.9 young per nest. In 1997, 12 of 19 (63%) nests fledged young, producing 3.75 young per successful nest and 2.37 young per attempt. Combining 1996 and 1997, proportional success was 78%, with 3.81 young fledged per successful nest, and 2.90 young per attempt. The majority of successful nests fledged young by mid-May, with the latest nest active until 10 July.

Nest success on the Bombing Range in 1996 and 1997, at 78% ($n = 29$), was higher than reported for southwestern Idaho shrubsteppe (46%, $n = 112$; Marks 1986). Nest success elsewhere in western North America range from 70%, to 100% (Marks et al. 1994). The number of young produced per nest on the Bombing Range was similar to numbers from Marks (1986), who reported a minimum and maximum estimate of 3.73 and 4.15 fledglings, respectively, per successful nests, and 1.54 to 1.72 fledglings per attempt. Average number of young per successful nest from 4 studies across the U.S. range from 3 to 4.5 (Marks et al. 1994).

Long-eared Owls do not build their own nests, but typically use stick nests built in trees by other species of birds (Marks et al. 1994). At the Bombing Range, 28 (93.3%) of the nests were located in old magpie nests, typically with the hoods at least partially open. In addition, an old Swainson's Hawk, and a Ferruginous Hawk nest were each used on one occasion.

We attributed the failure of the sagebrush nest in 1995 to coyote, due to the observed tracks leading to and from the base of the shrub. For the other 7 nests that failed, the predator is unknown, although we strongly suspect Common Ravens. In 1996, a dead adult was found in an old magpie nest, with a Great-horned Owl feather below the tree as the only clue. Great-horned Owls were never observed on the Bombing Range during this study.

**Management:** Availability of suitable nests, or spacing of available sites, could be limiting factors influencing the number of breeding Long-eared Owls on the Bombing Range. We observed roosts of non-breeding adults each year. In 1997, 3 nests initiated in May were in magpie nests that had been active earlier in the season. One of these nests had failed only a week before the first owl egg was laid.

**Burrowing Owl:**

**Status:** Burrowing Owls in the Columbia Basin show no population trend from 1968-1994 (Saab and Rich 1997). They are listed as an USFWS region one species of concern, and as an ODF&W sensitive species.

**Distribution / Relative Abundance:** On the NWSTF Burrowing Owls were known to nest in annual grass, grazed bunchgrass, and grazed sagebrush habitats.

**Nest Data**: Proportional nest success was 60.7% in 1995 ($n = 28$), 64.9% in 1996 ($n = 37$), and 47.16% in 1997 ($n = 34$), and did not differ significantly among years ($P > .05$, Likelihood ratio $chi^2$). Overall success for 99 nests with known outcome was 57.6%. Green and Anthony (1989) report success of 57% and 50% in Morrow and adjacent counties in 1980 and 1981. The majority of nests were located in Juniper Canyon, which was divided into 3 sections corresponding roughly with soil type; North, Middle, and South. In general, the soil becomes sandier as you move northward in the canyon. The North, and Middle sections were divided by Page Road, and the south section began just north of the horse corral known as Lonesome Dove. In addition, there were several nests in the Well Spring Canyon area (annual grassland plot #5), and in the annual grassland west of North Juniper Canyon referred to as the Valley Sector. A summary of nests with known outcomes is presented for each sector and year in Table 13. Abandonment was the primary cause of nest failure accounting for 64.3% of nest failures. Depredation by badgers, and in one case by coyote, account for 28.6% of failures, and trampling by livestock for 7%.

Availability, status, and fate of 1995 owl holes is presented in Appendix 4 Tables 1a, and 1b for 1996 and 1997, respectively. Appendix 4, Table 1c summarizes the status and fate of 1996 holes in 1997. Appendix 4 Tables 2a and 2b summarize the re-occupancy rates of available burrows for each sector in 1996 and 1997.

**Badger hole use/availability:** We looked at use and availability of badger burrows in sandy soils of the northern part of the Bombing Range, and to a lesser degree, in the loamy soils of Southern Juniper Canyon. We found that 31% of all badger burrows in 1996 and 18% of burrows in 1997 within our sampling area were damaged as a result of livestock trampling. In 1996, 57% and in 1997 61% of burrows unavailable to owls had been damaged by cattle. Density, use, and percent of burrows damaged by cattle are presented in Appendix 4, Table 3.

**Management:** These results suggest that availability of burrows may be a factor limiting owl density within some sections of the Bombing Range. A primary cause of burrow destruction in sandy soils during the breeding season was trampling by cattle. In loamy soils, trampling of burrows by livestock was minimal. A reduction in the number of days cattle are present in areas with sandy soil (such as the northernmost pasture in Juniper Canyon) will benefit owls by reducing the trampling rate, and allowing badger burrows to accumulate. Saab et al. (1995) summarized results from 4 studies of Burrowing Owl in shrubsteppe. Two of these studies found owls responded positively to variable grazing in various shrub habitats, one found a mixed response in big sagebrush / bluebunch wheatgrass, and one found a negative response in big sagebrush. Burrowing Owls do not appear to use bunchgrass on the Bombing

Range that is not grazed, which is likely a function of grass height (Green and Anthony 1989). Native grassland where owls are concentrated, such as the area between the sheep camp and the horse corral known as "Lonesome Dove" should be grazed to control grass height during the spring, at least in some years. Predator control programs on the Bombing Range should be carried out so that no badgers are killed. Management for populations of small mammals such as Great Basin pocket mice will benefit Burrowing Owls. Some researchers feel that livestock grazing is important to maintaining small mammal populations (Green, pers. Comm.).

TABLE 13. Summary of Burrowing Owl nests with known outcomes.

| Year | Sector | Number of nests | Successful | Abandoned | Trampled | Depredated |
|---|---|---|---|---|---|---|
| **1995** | North Juniper | 13 | 7 (53.8%) | 6 | 0 | 0 |
| | Middle Juniper | 7 | 7 (100%) | 0 | 0 | 0 |
| | South Juniper | 6 | 2 (33.3%) | 4 | 0 | 0 |
| | Valley Sector | 2 | 1 50%) | 1 | 0 | 0 |
| | **Total** | **28** | **17 (60.7%)** | **11 (39.3%)** | **0** | **0** |
| **1996** | North Juniper | 8 | 4 (50%) | 2 | 2 | 0 |
| | Middle Juniper | 13 | 9 (69.2%) | 3 | 1 | 0 |
| | South Juniper | 12 | 8 (66.6%) | 3 | 0 | 1 |
| | Valley Sector | 3 | 2 (66.6%) | 0 | 0 | 1 |
| | Well Spring | 1 | 1 (100%) | 0 | 0 | 0 |
| | **Total** | **37** | **24 (64.9%)** | **8 (21.6%)** | **3 (8.1%)** | **2 (5.4%)** |
| **1997** | North Juniper | 6 | 1 (16.6%) | 1 | 0 | 4 |
| | Middle Juniper | 9 | 5 (55.5%) | 2 | 0 | 2 |
| | South Juniper | 16 | 8 (50%) | 5 | 0 | 3 |
| | Valley Sector | 1 | 0 | 0 | 0 | 1 |
| | Well Spring | 2 | 2 (100%) | 0 | 0 | 0 |
| | **Total** | **34** | **16 (47.1%)** | **8 (20.7%)** | **0** | **10 (29.4%)** |
| **'95-'97** | North Juniper | 27 | 12 (44.4%) | 9 | 2 | 4 |
| | Middle Juniper | 29 | 21 (72.4%) | 5 | 1 | 2 |
| | South Juniper | 34 | 18 (52%) | 12 | 0 | 4 |
| | Valley Sector | 6 | 3 (50%) | 1 | 0 | 2 |
| | Well Spring | 3 | 3 (100%) | 0 | 0 | 0 |
| | **Total** | **99** | **57 (57.6%)** | **27 (27.3%)** | **3 (3%)** | **12 (12.1%)** |

**Western Kingbird:**

**Status:** Breeding Bird Survey data show no population trend for Western Kingbird in the Columbia Basin from 1968-1994.

**Distribution / Relative Abundance:** Point count censuses did not adequately sample kingbirds on the Bombing Range. Western Kingbird distribution was determined largely by location of nesting structures such as juniper trees, buildings, and signs.

**Nest Data:** On the Bombing Range, kingbirds were observed nesting in juniper trees (66.7%), and structures such as buildings, fences, signs, hawk nest platforms, and observation tower scaffolding (27.8%). One nest was also built inside an old Black-billed Magpie nest in a bitterbrush, and one in the branches of a sagebrush (5.5%). Clutches were initiated between 20 May and 27 June. Nest success was 25% in 1995 ($n = 4$), 70% in 1996 ($n = 10$), and 48% in 1997 ($n = 22$). Overall, 50% of 36 nests fledged young. Proportional nest success reported elsewhere (Gamble and Bergin 1996) include 40.9% in Texas ($n = 71$), 49.0% in New Mexico desert ($n = 47$), 85% in New Mexico riparian ($n = 13$), and 53% in Western Nebraska ($n = 94$).

**Management:** Kingbirds on the Bombing Range will nest in a large variety of man-made structures, and nest success at the NWSTF is not low. The removal of observation towers and the yellow warning signs that mark the perimeter of the Bombing Range will reduce available nest sites. Consider leaving these signs, and other non-obtrusive structures as nest sites.

**Horned Lark**

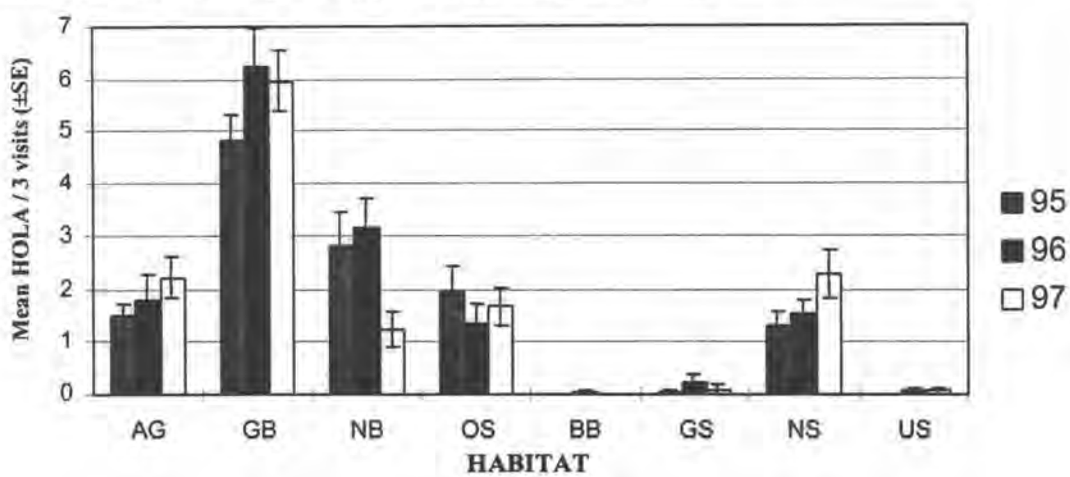
**Status:** Breeding Bird Survey data shows a 2.9% annual decline of Horned Larks in the Columbia River basin between 1968 and 1994 ($P < .05$).

**Distribution / Relative Abundance:** Point count data yielded information on the relative abundance of Horned Larks. Figure 8 shows the mean annual detections of Horned Larks within 100 m, by habitat, and year. Horned Larks were most abundant in the grazed bunchgrass, and were rare or absent in the grazed sagebrush, upland sagebrush, and bitterbrush. It has been reported elsewhere that population densities are highest in the most heavily grazed areas, and that Horned Larks are the most abundant of any species in grazed areas (Kantrud and Kologiski 1983, Bock and Webb 1984). Within bunchgrass habitats, mean annual abundance of Horned Larks was significantly higher at points in the grazed plots ($t_{51} > 2.5$, $P < 0.02$, ANOVA). Abundance did not differ significantly different between ungrazed bunchgrass and annual grass plots in any year of the study. There were no significant difference within habitats among years in the sagebrush habitats, and we found abundance to be higher in areas without livestock ($t_{51} = 5.465$, $P < 0.001$).

Detections were made at 96% of the annual grassland points, 100% of the grazed bunchgrass, 64% of the ungrazed bunchgrass, 90% of the ungrazed sagebrush and 78% of the open-low shrub points. Horned Larks were never detected on plot 21 (ungrazed bunchgrass, RNA B) which is at the Eastern boundary of the property, and is bordered by shrub habitat, and farmland.

**Habitat Associations:** We modeled the occurrence of Horned Larks using 2 sets of point count locations: 75 sagebrush points with greater than 5% shrub cover (larks occurred at 26 sites), and across habitats, using all 220 points (larks occurred at 123 sites). Significant habitat variables that differentiated between presence and absence of larks are presented in Appendix 6, Table 1 for the sagebrush points, and Appendix 6, Table 2 across habitats. The means and standard errors of variables that differentiated between occupied and unoccupied sites in sagebrush are presented in Table 14. Within sagebrush, Horned Larks were selecting habitat with greater perennial and total grass cover, lesser shrub cover, and shorter shrub height. The final multi-habitat model is presented in Table 16, and the final sagebrush model is presented in Table 17.

FIGURE 8. Relative abundance of Horned Lark among the general habitat types of the NWSTF, 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush




To investigate how variance in abundance is influenced by habitat characteristics, we used linear regression with data from the 123 points where at least 1 detection was made. Variables which were significantly correlated with the abundance of Horned Larks are presented in Appendix 6, Table 3. These were entered into a stepwise elimination procedure, which retained 6 of the 15 variables. The final model is presented in Table 18. Where they were present, mean annual detections varied from 0.3 to 9.3. We divided the data into 2 samples; points with less than or equal to the median (2.33) detections, and those with greater than 2.3. The means and standard errors of variables which were significantly different betweem these samples are presented in Appendix 4, Table 14. In summary, points with mean annual detections of greater than 2.3 had: higher coverage of open ground and perennial grass; less shrub cover, shrub density, and litter cover; and a shorter mean shrub height than those with 2.3 or less detections.

TABLE 14. The means and standard errors of different vegetation and habitat variables related to the presence of Horned Lark in sagebrush habitats of the NWSTF in 1995-1997.

| Variable | Sagebrush points with HOLA ($n$ =26) | Sagebrush points without HOLA ($n$ =49) | $P$ |
|---|---|---|---|
| total green (%) | 21.93 ± 2.37 | 13.90 ± .95 | .000 |
| total grass (%) | 16.78 ± 2.50 | 10.80 ± .89 | .008 |
| perennial grass (%) | 7.24 ± 1.84 | .58 ± .21 | .000 |
| Sandberg's bluegrass (%) | 1.53 ± .44 | 4.08 ± .53 | .000 |
| shrub density (#) | 52.04 ± 4.51 | 64.02 ± 4.51 | .028 |
| shrub height (cm) | 75.57 ± 3.72 | 84.31± 2.62 | .001 |
| Sagebrush cover (%) | 18.72 ± 2.58 | 23.61 ± 1.50 | .023 |
| Sagebrush density (#) | 42.65 ± 4.95 | 62.59 ± 4.62 | .001 |
| Sagebrush height (cm) | 78.01 ± 4.55 | 85.86 ± 2.35 | .020 |

TABLE 15. The means and standard errors of different vegetation and habitat variables related to the abundance of Horned Lark at points where they were detected at least once 1995-1997. Points where HOLA occurred were divided into 2 groups based on the median abundance.

| Variable | Mean # HOLA >2.33 annually ($n$ =59) | Mean # HOLA ≤2.33 annually ($n$ =64) | $P$ |
|---|---|---|---|
| perennial grass (%) | 16.13 ± 1.29 | 4.13 ± .90 | .000 |
| forb cover (%) | 5.92 ± .51 | 10.57 ± .95 | .024 |
| open ground (%) | 63.03 ± 2.20 | 55.57 ± 2.47 | .000 |
| litter (%) | 18.87 ± 2.28 | 31.76 ± 2.33 | .000 |
| shrub "snag" density (#) | 3.03 ± .71 | 10.95 ± 2.44 | .000 |
| shrub cover (%) | 3.51 ± .85 | 11.03 ± 1.55 | .000 |
| shrub density (#) | 10.68 ± 2.28 | 28.11 ± 3.48 | .000 |
| shrub height (cm) | 34.05 ± 3.40 | 57.39 ± 3.62 | .000 |
| shrub stems <2.5 cm (#) | 39.14 ± 12.77 | 83.11 ± 12.43 | .011 |
| shrub stems >2.5 cm (#) | 7.53 ± 2.58 | 30.61 ± 5.79 | .000 |
| sagebrush cover (%) | 1.62 ± .63 | 6.81 ± 1.52 | .001 |
| sagebrush density (#) | 3.86 ± 1.19 | 15.48 ± 3.28 | .000 |
| sagebrush height (cm) | 18.92 ± 4.33 | 32.72 ± 5.49 | .050 |
| sagebrush stems <2.5 cm.m | 6.58 ±2.42 | 25.19 ± 8.10 | .015 |
| sagebrush stems >2.5 cm.m | 6.29 ± 2.58 | 24.77 ± 5.94 | .003 |

TABLE 16. Logistic regression model for probability that a Horned Lark will be present at a point count station using all 220 points.

| | |
|---|---|
| Number of points = 220<br>LRS = 119.73<br>P>chi$^2$ = 0.0000<br>Psuedo $R^2$ = 0.3966 | Dependent term: presence of HOLA |

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| total green cover | 0.000 | 0.160 | 0.039 |
| total grass cover | 0.008 | -0.138 | 0.044 |
| perrennial grass cover | 0.000 | .156 | 0.029 |
| cryptobiotic crust | 0.000 | -0.034 | 0.009 |
| bitterbrush height | 0.000 | -0.035 | 0.007 |
| shrub stems < 2.5 cm. | 0.015 | 0.006 | 0.003 |

**Nest Data:** A variety of substrates were used for nesting by Horned Larks. Needle-and-thread grass was used most frequently (59%, $n$ = 27), with nests also associated with rabbitbrush, blue-bunch wheat-grass, snakeweed, snowy buckwheat, Sandberg's bluegrass, and cattle dung. Horned lark nests we monitored were primarily in grassland habitats. Samples were too small to investigate success between habitats. Proportional success was 40% in 1995 ($n$ = 15), 29% in 1996 ($n$ = 7), and 50% in 1997 ($n$ = 6). Combining years, 39% (11 of 28) of the nests fledged at least 1 young. The Mayfield estimate of nest survivorship for all years, 17%, is much lower ($n$=28). Total and daily survivorship, with standard error, and number of observation days is presented for each period in Appendix 3 Table 8.

TABLE 17. Logistic regression model for probability that Horned Lark will be present at a point count station using 75 points in sagebrush habitat with at least 5% shrub cover

| | |
|---|---|
| Number of points =75<br>LRS(2) = 34.90<br>P>chi$^2$ = 0.0000<br>Pseudo $R^2$ = 0.3606 | Dependent term: presence of HOLA |

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| Perrenial grass cover | 0.000 | 0.405 | 0.162 |
| *Poa sandbergii* cover | 0.000 | -0.466 | 0.164 |

TABLE 18. Linear regression model of Horned Lark abundance in relation to 6 vegetation variables at 123 point counts at which Horned Larks were detected.

| | |
|---|---|
| Number of points =123 | $R^2 = 0.5515$ |
| F ( 6, 116) = 23.78 | $R^2a = 0.5283$ |
| P > F = 0.0000 | |

Dependent term: Horned Lark abundance (log-transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| forb cover | -2.155 | 0.033 | -0.022 | 0.01 |
| perennial grass (log transf.) | 4.005 | 0.000 | 0.153 | 0.038 |
| shrub density | 3.663 | 0.000 | 0.015 | 0.004 |
| shrub height | -2.920 | 0.004 | -0.005 | 0.002 |
| artemesia density | -4.872 | 0.000 | -0.024 | 0.005 |
| log (rabbitbrush stems > 2.5 cm) | -5.038 | 0.000 | -0.241 | 0.048 |

TABLE 19. Number of nests, and days of observation used for analysis, total survivorship, daily survivorship and standard error for Horned Lark 1995-1997 (combined). Although samples were small, these species showed no significant difference between years.

| Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|
| Incubation | 21 | 134 | .524 | .948 (.019) |
| Nestling | 20 | 117 | .391 | .915 (.026) |
| **Entire** | **27** | **253** | **.170** | **.933 (.016)** |

**Management:** Saab et al. (1995) summarized results from 2 studies in big sagebrush, both of which reported positive responses by Horned Lark to grazing. Studies in other shrubsteppe habitats reported varying responses. On the Bombing Range, Horned Lark abundance is positively associated with grazing in perennial grasslands, and negatively associated with grazing in sagebrush. In shrub habitats, Horned Lark distribution appears to be regulated by a combination of shrub and perrenial grass cover. Horned Larks would benefit from increased perennial grass cover in sagebrush habitats.

### Black-billed Magpie

**Status:** Magpies are not listed on federal or Oregon state species of concern lists.

**Distribution / Relative Abundance:** Magpies nested in sagebrush, juniper, and bitterbrush habitats. There were few point count detections within 100 m, but within 200 m they were detected in all sagebrush habitats, bitterbrush, and several times in open-low shrub.

**Nest Data:** We monitored magpie nests in bitterbrush ($n$ = 3) sagebrush ($n$ = 50) and juniper trees ($n$ = 52). Mean clutch initiation date was 9 April (SE = 4.4 days, $n$ = 44) in 1996, and 11 April (SE = 2.1 days, $n$ = 44) in 1997. The earliest clutch initiation was 23 March 1996, and the latest was 5 June 1996. Mean nest height with standard error for nests built in sagebrush was 111.3 ± 3.9 cm (range = 58-185, $n$ = 48). Mean sagebrush height for nest shrubs was 191.9 ± 7.6 cm (range = 145-270, $n$ = 48). Nests in Junipers were built at a mean height of 192.4 ± 7.6 cm (range = 104-342, $n$ = 52). Some trees had multiple nest structures, and we did not individually mark shrubs. As a result, nest structures that were used in multiple years are potentially included more than once in the preceding analyses.

Mayfield estimates of total and daily nest survivorship with standard error and number of observer days are presented for each year in Table 20. Estimates of survivorship were 13.7% in 1995 ($n$ = 16), 42.7% in 1996 ($n$ = 42), and 23.1% in 1997 ($n$ = 44). Mayfield were not significantly different between 1996 and 1997. Total survivorship for Black-billed Magpie was highest in 1996, but did not differ significantly between 1996 and 1997. Daily survivorship during the incubation stage differed between years and was significantly greater in 1996 (89%) than 1997 (57%), while survival during the nestling period did not differ (50% vs. 41%). The pattern of greater survival during the Incubation period is significant in 1996 but not in 1997. Although not significant, Mayfield estimates of survivorship for nests in Juniper trees (1996-97 = 37%, $n$ = 47) is higher than that of nests in sagebrush (26%, $n$ = 39) which may help to explain the low success in 1995 where only 2 of 16 nests monitored were in junipers. Proportional success was higher than Mayfield estimates, ranging from 25% in 1995 to 52% in 1996. Overall proportional success was 39%.

TABLE 20. Mayfield estimates of nest survivorship (S) for Black-billed Magpie on NWSTF. Total nest survivorship is shown for each year, survivorship of incubation and nestling stages for the latter 2, and laying incubation and nestling for the latter 2 combined.

| Year | Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|---|
| **1995** | **Entire** | **16*** | **299** | **.137** | **.960 (.011)** |
| 1996 | Incubation | 36 | 435 | .886 | .993 (.004) |
| 1996 | Nestling | 39 | 599 | .501 | .973 (.007) |
| **1996** | **Entire** | **42** | **1094** | **.427** | **.983 (.004)** |
| 1997 | Incubation | 39 | 472 | .568 | .968 (.008) |
| 1997 | Nestling | 29 | 439 | .412 | .966 (.009) |
| **1997** | **Entire** | **44** | **1008** | **.231** | **.970 (.005)** |
| '96-'97 | Laying | 40 | 157 | 1.00 | 1.00 (.000) |
| '96-'97 | Incubation* | 75 | 907 | .704 | .980 (.005) |
| '96-'97 | nestling* | 68 | 1038 | .462 | .970 (.005) |
| **'96-'97** | **Entire** | **86** | **2102** | **.318** | **.977 (.003)** |

*sample size too small to accurately calculate Mayfield estimate

We investigated how 6 nest variables influence outcome using logistic regression. There was no relationship between success and clutch initiation date (or an adjusted clutch initiation where the median in both years was equal), substrate, height from ground, or side concealment of the structure. We found significant positive correlation's with nest success and concealment of the nest-cup from above ($\beta = .0189$, $SE(\beta) = .007$, $P = .0059$), and concealment of the structure from below ($\beta = .0125$, $SE(\beta) = .006$, $P = .035$).

Common Ravens were the principal predators of nests. Of the 61 depredation events we recorded, 37 (60.7%) were attributed to ravens, 3 (4.9%) to coyote, and 21 (34.4%) to unknown predators. In some cases the "unknown" nests had openings that were already large enough for a raven to enter, making predator identification difficult. Other potential nest predators include Gopher Snake, Washington ground squirrel, and Wood Rat.

Inactive magpie nests provide shelter and nesting habitat for a variety of species. Long-eared Owl are dependent upon them for nest sites on the Bombing Range, where 93% ($n = 30$) of the nests we observed utilized inactive magpie nests. Western Kingbird nested in a magpie structure one time, and Loggerhead Shrike twice during this study. Shrikes will also use the magpie nest structures for roosting as evidenced by the senior author's observations of 2 structures with greater than 10 shrike pellets inside. Ferruginous Hawks also appear to require a structure on which to add nest material, usually from nests of corvids or other raptors (Bechard and Schmutz 1995), and may use derelict magpie nests for a base to build upon.

**Management:** Inactive magpie nests are important to many species. High predation rates likely increase the number of nest structures available to Long-eared Owls and other birds which utilize them.

### Common Raven

**Status:** Common Ravens are not listed federally or as an Oregon State sensitive species. Breeding Bird Survey data show a 3.3% annual increase from 1966-1996 ($P < .01$), and a 4.1% annual increase for Oregon between 1980 and 1996 ($P < .1$).

**Distribution / Relative Abundance:** Common Ravens are the primary predator of Black-billed Magpie nests, and are thought to be major nest predators of other birds such as Loggerhead Shrikes. On several occasions a raven was witnessed flying with what appeared to be a Western Meadowlark fledgling or nestling in it's bill. Sightings varied from single birds to several dozen until early June when groups of 100 to over 200 birds were observed regularly. Ravens were seen flying over the northern parts of the Bombing Range on very rare occasion. American Crows were often observed in the bitterbrush and grassland habitats in the northern third of the Bombing Range. Ravens were observed in the sagebrush, and bunchgrass habitats that typify the southern half of the NWSTF. Large groups were often seen at sunrise entering the Bombing Range from the east, approximately 4.5 km north of the SE corner.

**Nest Data:** Two pairs of ravens nested in the Juniper trees in 1996 and 1997. In addition, at least 1 pair nested in the observation towers (tower A) surrounding the impact area. We monitored 5 nests in the trees (2 in 1996, 3 in 1997). Assuming the third nest in 1997 was a re-nest of a pair that had earlier failed, then both pairs fledged a brood each year. Clutch size in the 4 nests where it was accurately observed varied from 4-6 with a mean of 5.25. The cause of failure for the 1 unsuccessful nest is not known.

**Management:** It is possible that ravens congregate on the Bombing Range after the breeding season because it is the highest quality foraging habitat in the area. Further documentation of these large groups of ravens, their roost sizes and locations would be valuable. We recommend monitoring the size and timing of raven groups foraging on the Bombing Range. At least one pair will be displaced by the removal of observation towers associated with the impact area.

**Loggerhead Shrike**

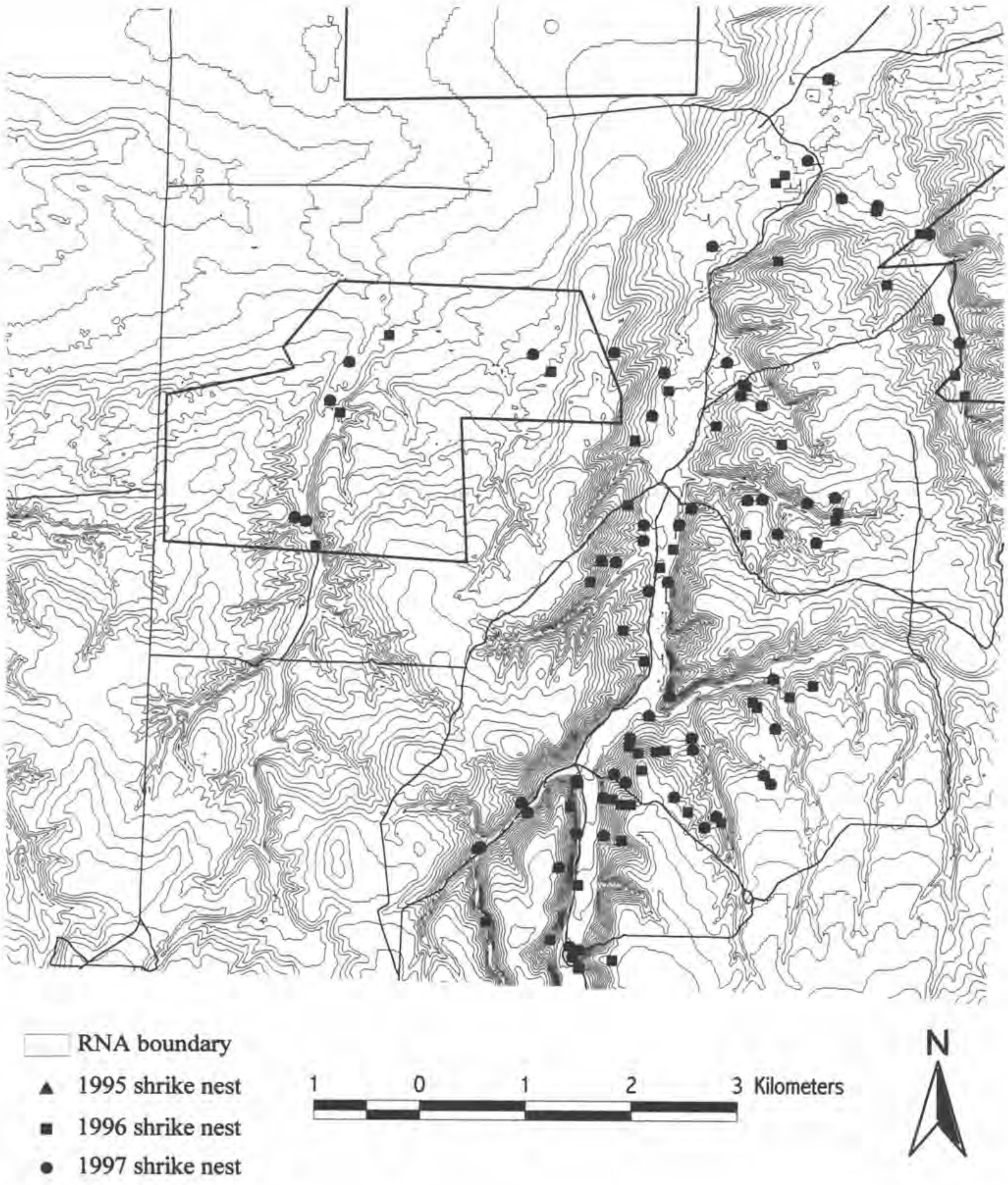
**Status:** Populations in the Interior Columbia River Basin have experienced an annual decline of 2.7% based on Breeding Bird Survey data from 1968-1994 (Saab and Rich 1997). It is a USFWS region one species of concern, and on the ODF&W list of sensitive species. Loggerhead Shrike has been included on the Audubon Society's Blue list of declining species every year since its creation in 1972 (Tate 1986). Many factors have been attributed to the population decline (see Anderson and Duzan 1978), including pesticides, loss of nesting habitat, high winter mortality (Brooks and Temple 1990) and intensive farming practices. Several studies have concluded that reproductive success was normal, and probably not contributing to population declines (Gawlik 1990, Kridelbaugh 1983, Luukkonen 1983, Porter et al. 1975). At the Bombing Range, we found reproductive success to be substantially lower and suggest that poor nest success may be contributing to this species decline in the region.

**Distribution / Relative Abundance:** Shrikes were distributed primarily in the sagebrush and juniper habitats of the Bombing Range. In 1995, a single territory was located in bitterbrush, but this territory was not re-occupied during the second and third years of the study. Locations of shrike nests in Juniper Canyon are shown in figure 9.

**Nest Data:** Shrikes at the Bombing Range began nesting in late March, and some pairs continued into August. Of 113 nests that we located prior to the nestling stage, 22 (19.5%) had a clutch of 5 eggs, 49 (43.4%) had 6, 40 (35.4%) had 7, and 2 (1.8%) had 8 eggs. Mean ($\pm$SE) clutch size of 113 nests was 6.19 ($\pm$ .07) eggs. Clutch size did not differ between years ($P > 0.1$, ANOVA). Initiation dates ranged from 21 March to 16 July. Mean initiation dates were 2 May 1995 ($n = 41$), 4 May 1996 ($n = 48$), and 5 May 1997 ($n = 61$). There was a negative linear relationship between clutch size, and the date of the first egg ($\beta = -.015$, SE ($\beta$) = .002, $P < .0001$), reflecting smaller clutches in second brood and re-nesting attempts.

Of 156 nests located, 143 (91.6%) were built in sagebrush, 4 (2.6%) were built in Russian Thistle, 4 (2.6%) were built in Juniper, 3 (1.9%) were built in a patch of ornamental shrubs, 1 (0.6%) nest was built in Jim Hill Mustard accumulated at the base of a dead sagebrush, and 1 (0.6%) was built in a greasewood. Two nests were built inside the nest-cups of old Black-billed Magpie nests, and 4 (2.6%)

FIGURE 9. Locations of Loggerhead Shrike nests in sagebrush habitats of the NWSTF, 1995-1997.



nests were built on top of shrike nests from previous years. For 3 of 17 (17.6%) second brood attempts, the first-brood nest was re-used.

Nests were generally mid height, and placed well inside a sagebrush. Mean nest height for nests in shrubs was 78.12 cm ($n$ = 151, SD = 24.86, range = 20-163), and mean shrub height was 160.95 ($n$ = 151, SD = 33.83, range = 69-260). Mean distance from the outside edge of the nest shrub was 37.77 cm ($n$ = 147, SD = 17.84, range = 5-115). Shrike nest height at the Bombing Range is similar to the 80 cm mean nest height reported in Idaho (Woods and Cade 1996), and likely reflects the typical nest height in sagebrush habitats. The lowest nest in Boardman, at 20 cm is lower than anything reported in the literature. Nest height was positively correlated with clutch initiation date ($\beta = 0.322$, $P = .0002$, Fig. 10). Distance to the outer edge was negatively correlated with clutch initiation date ($\beta = -0.164$, $P = .0099$, Fig 11). Similar seasonal shifts in nest placement have been shown in South Carolina (Gawlik and Bildstein 1990), and Idaho (Woods and Cade 1996). In Idaho, the relationship between clutch initiation date and nest placement virtually mirrors what is reported here, with regression coefficients for both relationships within 0.04 of our values. Shrikes at the Bombing Range were selecting the SE side of shrubs for nesting (Fig. 12), with over 50% of the nests oriented between 90 and 135 degrees from the shrub center. This may be related to nest microclimate, and may be a compromise between avoiding the SW dominant wind which often blows in excess of 20 miles per hour, and selecting the South side to take advantage of morning heat from the sun.

Loggerhead Shrike nest survivorship in this study is among the lowest ever reported. The Mayfield estimate of Loggerhead shrike nest success on the Bombing Range varied from 27-42%. Mayfield estimates of total and daily nest survivorship with standard error, and number of observer days are presented for each period, and year, as well as all years combined in Table 21. There was no significant difference in nest survivorship between years, so we combined all nests for a survivorship estimate of 36% (n = 146). Proportional success varied from 38-49% for a combined 45% ($n$ = 152). The Mayfield estimate is lower than the 61.4% mean of the 14 studies presented in Table 22 (adapted from Yosef 1994). Success for each year at the Bombing Range is lower than the 57% Mayfield estimate that Poole (1992) reported for shrikes nesting in shrubsteppe of the Columbia Basin, and the 59% proportional success Woods and Cade (1996) reported for shrikes in South-west Idaho shrubsteppe.

We examined relationships between nest success and distance to edge, distance from center, nest height, nest concealment and clutch initiation date. No nest placement variables differentiated between successful and unsuccessful nests. Clutch initiation date however is negatively correlated with success. Mayfield estimates of nest survivorship as they relate to nest concealment and clutch initiation date are presented in Table 23. Nests initiated earlier than the corrected median date (see methods) were significantly more successful (51%, $n$ = 68, mayfield estimate) than those initiated after (27% n=70). To examine the impact of temporal effects further, we modeled the relationship between nest success and clutch initiation date using logistic regression, and found a significant relationship ($\beta$=.025 SE($\beta$) = .008, $P$ = .0012).

TABLE 21. Mayfield estimates of nest survivorship (S) for Loggerhead Shrike on NWSTF, Boardman, 1995-1996

| Year | Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|---|
| 1995 | Incubation | 29 | 311 | .694 | .977 (.008) |
| 1995 | Nestling | 31 | 290 | .405 | .948 (.013) |
| **1995** | **Entire** | **39** | **672** | **.273** | **.967 (.007)** |
| 1996 | Incubation | 38 | 496 | .823 | .988 (.005) |
| 1996 | Nestling | 40 | 507 | .560 | .966 (.008) |
| **1996** | **Entire** | **47** | **1103** | **.424** | **.978 (.004)** |
| 1997 | Incubation | 51 | 624 | .772 | .984 (.005) |
| 1997 | Nestling | 49 | 517 | .494 | .959 (.009) |
| **1997** | **Entire** | **60** | **1294** | **.377** | **.975 (.004)** |
| '95-'97 | Laying | 79 | 326 | .964 | .994 (.004) |
| '95-'97 | Incubation | 118 | 1430 | .771 | .984 (.003) |
| '95-'97 | Nestling | 120 | 1314 | .497 | .960 (.005) |
| **'95-'97** | **Entire** | **146** | **3069** | **.366** | **.975 (.003)** |

TABLE 22. Mayfield estimates of nest success for Loggerhead Shrikes in North America (from Yosef 1994, Poole 1992, and this study).

| State | Percent nest survival | Source |
|---|---|---|
| Alabama | 43 | Siegel 1980 |
| Colorado | 66 | Porter et al. 1975 |
| Florida | 51 | Yosef 1994 |
| Illinois | 80 | Graber et al. 973 |
| Illinois | 72 | Anderson and Duzan 1978 |
| Indiana | 57 | Burton |
| Minnesota | 62 | Brooks and Temple 1990 |
| Missouri | 69 | Kridelbaugh 1982 |
| Oklahoma | 46 | Tyler 1992 |
| South Carolina | 65 | Gawlik 1988 |
| South Carolina | 75 | Gawlik and Bildstein 1990 |
| Virginia | 62 | Luukkonen 1987 |
| Virginia | 55 | Blumton 1989 |
| Washington | 57 | Poole 1992 |
| **Mean of above 14 studies** | **61.4** | |
| **Oregon** | **36.6%** | **Present study** |

TABLE 23. Number of nests, days under observation, total survivorship, daily survivorship, and standard error of Mayfield estimates of Loggerhead Shrike nest survivorship as related to cover above and adjusted Julian date.

| Treatment | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|
| concealment from above < =50% | 60 | 1244 | .318 | .971 (.005) |
| concealment from above >=70% | 59 | 1263 | .459 | .980 (.004) |
| clutch initiation date (julian) < 117 | 68 | 1506 | .507 | .983 (.003) |
| clutch initiaion date (julian) > 117 | 70 | 1412 | .267 | .967 (.005) |

For 24 of the successful nests in 1997, we tracked survivorship of the fledglings to 13-16 days out of the nest. Of 139 young fledged, at least 83 (59.7%) survived to day 14. It has been suggested that Loggerhead Shrike populations may be limited by post-fledging mortality. Many researchers (Smith 1972, Scott 1987, Poole 1992) have reported high rates of juvenile mortality, which may limit population growth (Novak 1989). In the Columbia River Basin, Poole (1992) reported 55% of fledglings disappeared prior to independence, which is slightly higher than the 40% we documented in 1997. High fledgling mortality, coupled with below average nest success rates as reported here, may be a contributing factor to this species' region-wide population decline.

FIGURE 10. Loggerhead Shrike nest height in relation to clutch initiation date (julian)

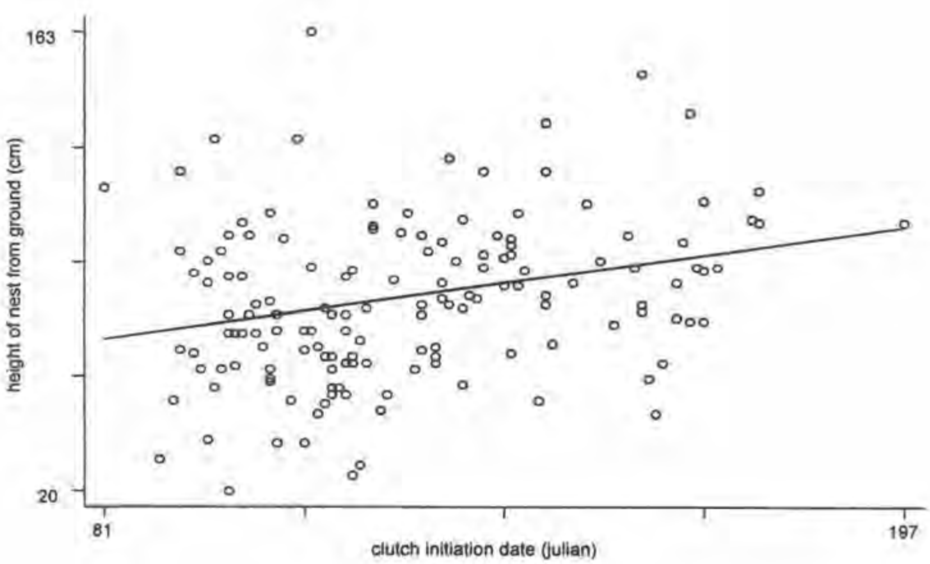


FIGURE 11. Distance to shrub edge for Loggerhead Shrike nests in relation to clutch initiation date (julian).

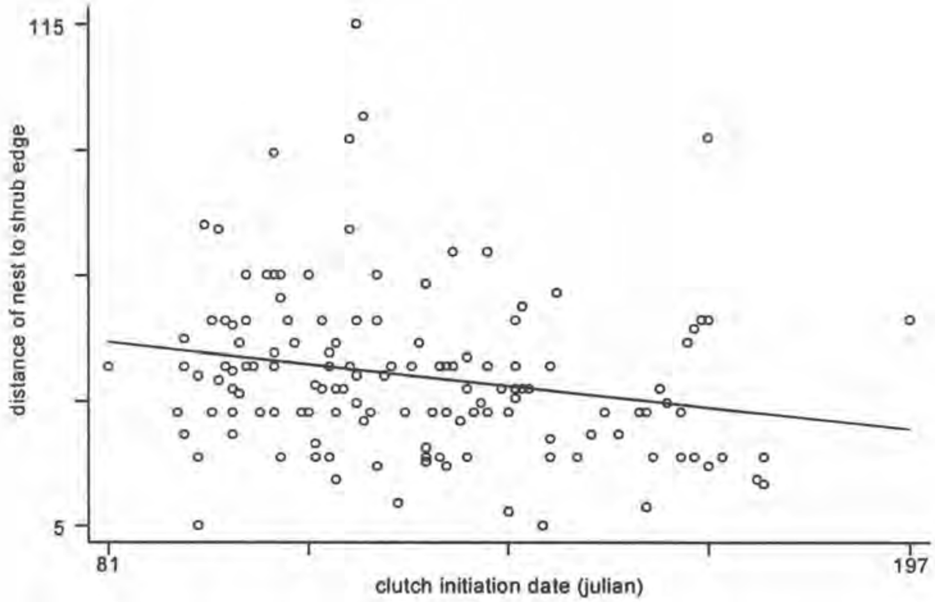
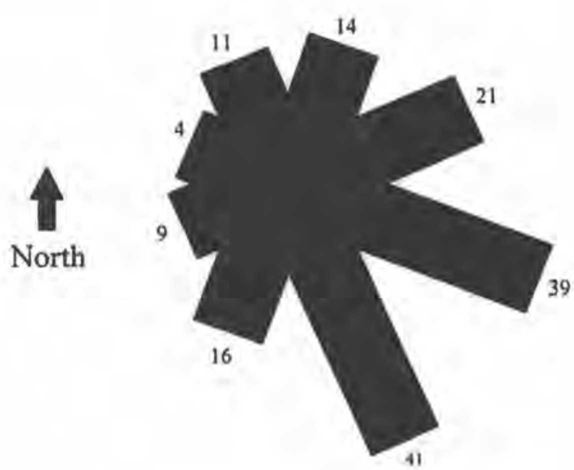



FIGURE 12. Orientation of Loggerhead Shrike nests relative to the center of the supporting shrub. Values are numbers of



**Management:** Other studies report either no response or a positive response to grazing in shrubsteppe habitats (Saab et al. 1995). Light grazing may provide open foraging habitat in areas infested with cheatgrass. Sagebrush in the bottom of Juniper Canyon and the associated side canyons is at risk from fire, due to heavy cheatgrass cover. In these areas, using livestock to reduce the fuel load during the growing season may reduce the threat of fires that would severely reduce sagebrush cover. This strategy would not apply to the upland areas on either side of the canyon where cheatgrass is not dominant, and where cattle grazing should be minimized or eliminated to prevent further degradation of the cryptobiotic crust.

**Sage Thrasher:**

**Status:** Breeding Bird Survey data show no population trend for Sage Thrashers in the Columbia Basin.

**Distribution / Relative Abundance:** Thrashers occurred in low densities within each of the sagebrush habitat stratifications. With the exception of a pair that nested on plot 23 in Well Spring Canyon in 1995, all spring sightings were believed to be individuals moving through the area. The only known breeding pair in 1995 deserted a nest with several-day old nestlings. Each year, however, in June, we began detecting thrashers, primarily in the upland sagebrush. In 1996 we located 2 nests, neither of which fledged young. Very few thrashers were observed in 1997, and no nests were located. Because of late arrivals, Sage Thrashers were not detected by point count surveys.

**Nest Data:** Inactive nests from previous years were located, primarily in the upland sagebrush but also in RNA C, and on plot 8. These numerous old nests, coupled with our observations of annual variation in abundance suggest that occurrence of nesting thrashers on NWSTF is variable. We also believe it highly likely that the birds arriving in June have already attempted a nest at another location, and are dispersing within the breeding season. Typically males seen in June conducted territorial displays. The same locations, several weeks later, were either occupied by a non-displaying mated male, a presumed unmated displaying male, or were not occupied. Further documentation is needed to clarify the extent that Sage Thrashers utilize the sagebrush habitats of the Bombing Range.

**Grasshopper Sparrow**

**Status:** Breeding Bird Survey data show no population trend within the Columbia Basin from 1968-1994 (Saab and Rich 1997), but on a larger regional scale it has documented an annual decline of 4.5% in the west (Peterjohn et al. 1994).

**Distribution / Relative Abundance:** Grasshopper Sparrows were detected at least once at every grassland point-count location. They also occurred at 24 of 27 (89%) open low shrub points, 8 of 28 (29%) of bitterbrush points, 2 of 23 (9%) of grazed sagebrush, and 100% of 29 livestock-free sagebrush points. There was no significant difference in the mean annual abundance of Grasshopper Sparrows between points in the grazed and ungrazed bunchgrass. The mean annual abundance was significantly higher in both of these treatments than in the annual grassland (annual vs. ungrazed bunchgrass: $t_{51} = 6.25$, $P < .001$; annual vs. grazed bunchgrass: $t_{53} = 7.28$, $P$

< .001). The relative abundance of Grasshopper Sparrows between habitats and years is presented in Figure 13.

**Habitat Associations:** Vegetation data collected around each point count were used to compare points where Grasshopper Sparrows occurred with those where they were absent. A correlation matrix of habitat characteristics associated with the occurrence of Grasshopper Sparrows is presented in Appendix 6, Table 1 for sagebrush, and in Appendix 6,Table 2 across habitats. The means and standard errors of vegetation and habitat variables that were significantly associated with the presence or absence of Grasshopper Sparrows in sagebrush habitats are presented in Table 24. In summary, points where they occurred had greater bunchgrass cover, total grass, total green, ground cover, and lesser amounts of open ground than points where they were not detected. Presence of Grasshopper Sparrows is negatively correlated with a suite of shrub variables, including shrub cover and density, sagebrush cover and density, and the number of sagebrush stems greater than 2.5 cm they are, however, positively correlated with sagebrush height.

Perennial bunchgrass cover was the strongest predictor of Grasshopper Sparrows being present at any point on the Bombing Range. In Table 26 we present a multiple habitat model using all 220 intensive sampling points. Grasshopper Sparrows were present at 151 points, and the model correctly classified presence and absence of Grasshopper Sparrows at 201 of 220 points (91%). Other variables included in the model are open ground, shrub cover, sagebrush cover, shrub density, shrub height and shrub density. Using the same sample of points, perennial grass alone predicts correctly 76.4% of the time ($P < 0.0001$). Figure 14 shows the predicted relationship of Grasshopper Sparrow presence in relation to perennial bunchgrass cover. The figure shows that there is a 90% chance of a Grasshopper Sparrow occurring with only 3% bunchgrass cover. From these data, it appears that Grasshopper Sparrow habitat could be managed through re-vegetation of native bunchgrass. We also modeled presence of Grasshopper Sparrows using 75

FIGURE 13. Relative abundance of Grasshopper Sparrows (number detected per point over 3 visits) in each of the general habitat types for each year. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush

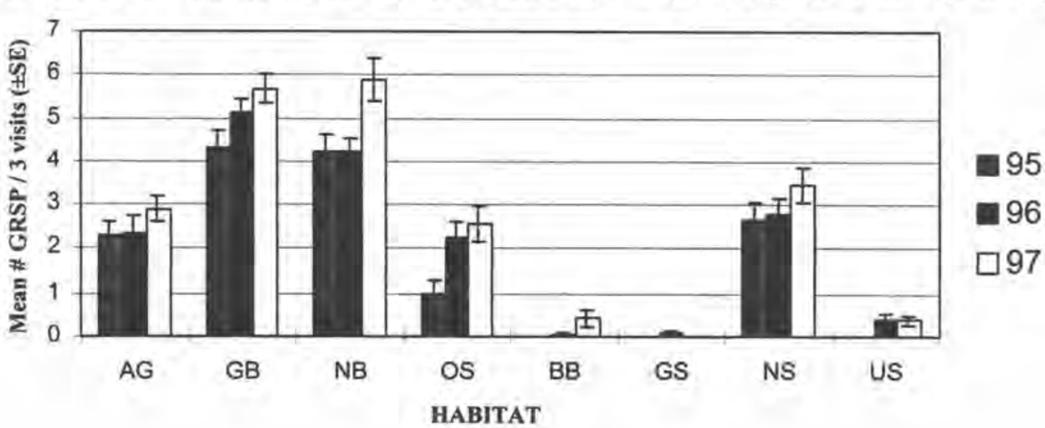


TABLE 24. The means and standard errors of different vegetation and habitat variables related to the presence of Grasshopper Sparrows in sagebrush habitats of the NWSTF in 1995-1997.

| Variable | Sagebrush Points with GRSP (*n*=34) | Sagebrush points without GRSP (*n*=41) | *P* |
|---|---|---|---|
| total green cover (<40cm, %) | 20.40 ± 1.96 | 13.61 ± 1.02 | .001 |
| total grass cover (%) | 16.50 ± 1.95 | 9.87 ± .95 | .001 |
| perennial grass cover (%) | 5.95 ± 1.48 | .36 ± 11 | .000 |
| open ground (%) | 60.48 ± 3.91 | 74.55 ± 3.68 | .009 |
| shrub cover (%) | 19.08 ± 1.83 | 26.77 ± 1.57 | .001 |
| shrub density (#) | 47.41 ± 3.93 | 70.19 ± 4.71 | .000 |
| shrub height (cm) | 85.71 ± 2.87 | 75.94 ± 2.50 | .011 |
| sagebrush cover (%) | 16.12 ± 1.84 | 26.73 ± 1.58 | .000 |
| sagebrush density (#) | 38.5 ± 3.99 | 69.93 ± 4.73 | .000 |
| sagebrush stems >2.5cm (#) | 63.82 ± 7.963 | 98.54 ± 7.93 | .002 |

TABLE 25. The means and standard errors of different vegetation and habitat variables related to the mean annual abundance of Grasshopper Sparrows at points where they were detected at least once 1995-1997. Points where GRSP occurred were divided into 2 groups based on the median.

| Variable | Mean GRSP ≥3.33 annually (*n*=59) | Mean GRSP <3.33 annually (*n*=64) | *P* |
|---|---|---|---|
| total grass cover (%) | 25.10 ± 1.30 | 17.21 ± 1.23 | .000 |
| perennial grass (%) | 15.10 ± 1.18 | 3.49 ± .81 | .000 |
| forb cover (%) | 6.41 ± .58 | 9.52 ± .88 | .002 |
| open ground (%) | 61.84 ± 1.97 | 54.40 ± 2.38 | .015 |
| cryptogamic crust (%) | 34.35 ± 3.35 | 21.44 ± 2.58 | .003 |
| litter (%) | 19.12 ± 2.02 | 35.56 ± 2.58 | .000 |
| shrub "snag" density (#) | 3.17 ± .66 | 12.3 ± 2.54 | .000 |
| shrub cover (%) | 3.87 ± .74 | 11.85 ± 1.33 | .000 |
| shrub density (#) | 12.67 ± 2.24 | 28.94 ± 2.97 | .000 |
| shrub height (cm) | 39.91 ± 3.61 | 59.34 ± 3.05 | .000 |
| shrub stems <2.5 cm (#) | 47.62 ± 11 | 78.03 ± 10.34 | .045 |
| shrub stems >2.5 cm (#) | 9.67 ± 3.77 | 32.9 ± 4.85 | .000 |
| sagebrush cover (%) | 1.46 ± .44 | 6.94 ± 1.30 | .000 |
| sagebrush density (#) | 4.19 ± 1.21 | 15.86 ± 2.93 | .000 |
| sagebrush stems <2.5 cm (#). | 7.59 ± 2.85 | 27.83 ± 7.43 | .003 |
| sagebrush stems >2.5 cm (#) | 7.62 ± 2.77 | 25.07 ± 4.92 | .001 |
| rabbitbrush height (cm) | 24.33 ± 2.74 | 38.85 ± 2.82 | .000 |

points in sagebrush habitat with greater than 5% shrub cover (Table 27). In this model as well, perennial grass cover was the most important deterministic term. Predictive strength was similar to the first model, correctly classifying 69 of 75 points (92%).

Across habitats there were significantly more Grasshopper Sparrows each year ($P < .05$, ANOVA). At points where Grasshopper Sparrows were detected at least once during the study, abundance was most affected by perennial grass cover. Correlation coefficients of Grasshopper Sparrow mean detections and significant habitat variables are presented in Appendix 6, Table 3. A multivariable linear regression model is presented in Table 28.

TABLE 26. Logistic regression model for probability that a Grasshopper Sparrow will be present at a point count station using all 220 points.

Number of points = 220
LRS (9) = 185.84
$P>chi^2 = 0.0000$
Pseudo $R^2 = 0.6791$

Dependent term: presence of GRSP

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| perennial grass cover | 0.000 | 1.483 | 0.559 |
| dead shrub | 0.004 | 0.057 | 0.024 |
| shrub height | 0.000 | -0.061 | 0.019 |
| sagebrush density | 0.000 | -0.071 | 0.021 |
| sagebrush height | 0.012 | 0.039 | 0.017 |
| rabbitbrush height | 0.000 | 0.065 | 0.017 |
| shrub stems > 2.5 cm | 0.000 | -0.065 | 0.022 |
| sagebrush stems > 2.5 cm | 0.011 | 0.057 | 0.024 |
| sagebrush stems < 2.5 cm | 0.041 | 0.010 | 0.005 |

TABLE 27. Logistic regression model for probability that Grasshopper Sparrow will be present at a point count station using 75 points in sagebrush habitat with at least 5% shrub cover.

Number of points =75
LRS (6) = 72.59
$P > chi^2 = 0.0000$ Dependent term: presence of GRSP
Pseudo $R^2 = 0.7026$

| Term | $P$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| perennial grass | 0.000 | 1.870 | 0.745 |
| open ground | 0.004 | -0.076 | 0.032 |
| shrub cover | 0.000 | 5.394 | 2.332 |
| sagebrush cover | 0.000 | -5.233 | 2.287 |
| shrub density | 0.018 | -0.083 | 0.039 |
| shrub height | 0.003 | -0.120 | 0.053 |
| shrub density | 0.018 | -0.083 | 0.040 |

TABLE 28. Linear regression model for abundance of Grasshopper Sparrows (log transformed) as related to 8 vegetation variables retained in a stepwise regression using 151 points where Grasshopper Sparrows were detected at least once in the 3 years.

Number of points = 151
F ( 8, 142) = 32.33 $R^2 = 0.6456$
$P > F = 0.000$ $R^2a = 0.6256$

Dependent term: Abundance of Grasshopper Sparrows (log transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| total grass cover | 4.055 | 0.000 | 0.013 | 0.003 |
| log (perennial grass cover) | 7.913 | 0.000 | 0.175 | 0.022 |
| shrub density | 3.917 | 0.000 | 0.011 | 0.003 |
| sagebrush cover | -3.776 | 0.000 | -0.023 | 0.006 |
| rabbitbrush height | -2.569 | 0.011 | -0.004 | 0.002 |
| bitterbrush density | -4.587 | 0.000 | -0.091 | 0.020 |
| bitterbrush stems > 2.5 cm | 2.920 | 0.004 | 0.032 | 0.011 |
| log (# dead shrubs) | -3.940 | 0.000 | -0.129 | 0.033 |

**Nest Data:** Of 37 Grasshopper Sparrow nests monitored, 36 were built at the base of a perennial bunchgrass, while the other was built in cheatgrass under a gray rabbitbrush. However, given the abundance of these birds in the annual grass habitat it is likely this ratio is biased towards bunchgrass (where we conducted most of our rope dragging). The Mayfield survivorship estimate (Table 29) for Grasshopper Sparrow nests over the 3 years ($n = 35$) is 46%. Proportional success using 37 nests is 62%. The 62% proportion successful for nests on the Bombing Range is higher than the range of success (25-52%) reported for the species (Vickery 1996). Although not significant, the nestling period has higher survivorship than incubation.. Our results suggest that the bunchgrass of the Bombing Range supports a valuable, and healthy population of Grasshopper Sparrows.

TABLE 29. Number of nests, and days of observation used for analysis, total survivorship, daily survivorship and standard error for Grasshopper Sparrow 1995-1997 (combined). Although samples were small, this species showed no significant difference between years.

| Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|
| Incubation | 28 | 127 | .428 | .929 (.023) |
| Nestling | 26 | 193 | .868 | .984 (.009) |
| **Entire** | **35** | **324** | **.400** | **.963 (.011)** |

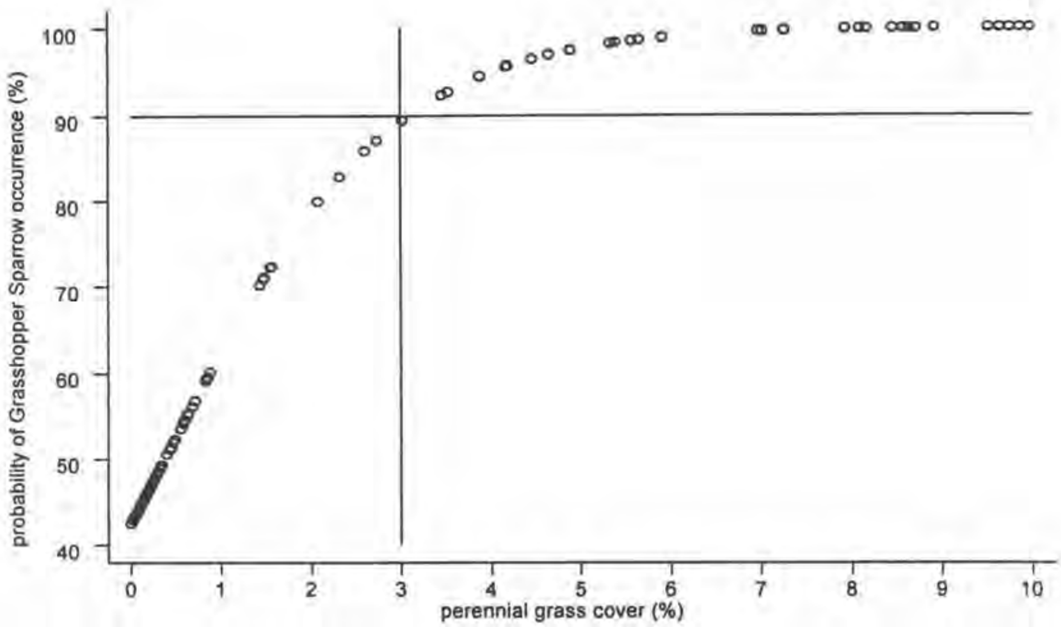
**Management:** Grasshopper Sparrows would benefit from greater distribution of perennial grass within shrub habitats where shrub cover is less than approximately 25%. Our rope-dragging efforts suggest that bunchgrass grazed in the fall and winter, and left alone during the growing season supports similar numbers of Grasshopper Sparrow nests to bunchgrass that has not been grazed in over 20 years. In contrast, we never located a Grasshopper Sparrow nest in the heavily spring-grazed 17.5 ha plot, to the west of plot number 19, suggesting again that Grasshopper Sparrows would benefit from a deferred grazing scheme. A rotational grazing scheme where some pastures are not grazed during the breeding season would reduce trampling of nests and allow perennial grass to set seed.

### Lark Sparrow

**Status:** Breeding Bird Survey data show a 2.9% annual decline for Lark Sparrows in the interior Columbia River Basin from 1968 to 1994. Lark Sparrows are listed both as an ODF&W Columbia Basin sensitive species, and a USFWS Region One species of concern.

**Distribution / Relative Abundance:** Lark Sparrows occurred primarily in the sagebrush and bitterbrush communities of the Bombing Range. They were detected at 14 of 28 (50%) of the bitterbrush points, 18 of 23 (78%) grazed sagebrush, 8 of 29 (28%) ungrazed sagebrush, 18 of 34 (53%) upland sagebrush, and 3 of 52 (6%) of the bunchgrass points. The relative abundance for each year by habitat type is presented in Figure 15. Abundance was greatest in the grazed sagebrush in each year.

FIGURE 14. Probability that a Grasshopper Sparrow will be detected in relation to perennial grass cover. From Logistic regression using all habitat types.




**Habitat Associations:** In the shrub habitats, points where Lark Sparrows occurred had significantly less green ground cover, less grass, and more bare ground than points where they were absent. The means and standard errors of variables associated with the presence of Lark Sparrows in the bitterbrush and sagebrush communities are presented in Table 30. We developed a multivariable logistic regression model for Lark Sparrow occurrence in shrub habitats, which is presented in Table 31. In 1997, with the exception of the upland sagebrush, relative abundance was lower than the previous years. This may be, at least in part a response to greater herbaceous growth after two wet years in a row.

We modeled abundance at the 66 points where Lark Sparrows occurred at least one time during the study using linear regression. There were significant differences in abundance between years. Variables which were significantly correlated with abundance are presented in Appendix 6, Table 3. We present a multivariable linear regression model of Lark Sparrow abundance relative to the cover of sagebrush and bare ground in Table 32. Lark Sparrow abundance was negatively correlated with perennial grass cover, and positively associated with bare ground. The association with bare ground may be related to Lark Sparrows terrestrial foraging strategy.

FIGURE 15. Relative abundance and standard error of Lark Sparrow among general habitat types of the NWSTF, 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush

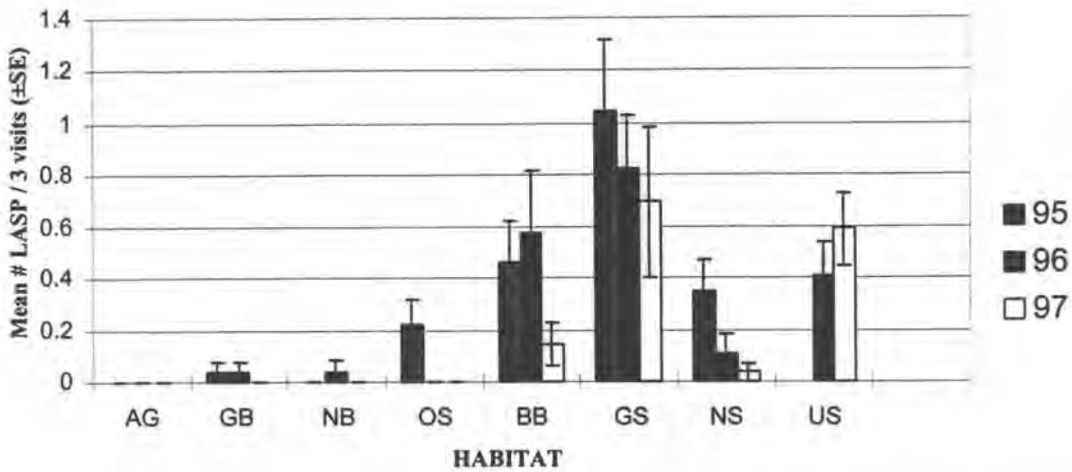



TABLE 30. Means and standard error of vegetation and habitat variables associated with the presence of Lark Sparrows in bitterbrush and sagebrush communities.

| Variable | Shrub points with LASP (*n*=54) | Shrub points without LASP (*n*=49) | *P* |
|---|---|---|---|
| total green (%) | 17.18 ± 1.07 | 21.21 ± 1.64 | .035 |
| total grass (%) | 11.38 ±.93 | 16.44 ± 1.51 | .003 |
| perennial grass (%) | .30 ± .08 | 4.13 ± 1.10 | .000 |
| bare ground (%) | 31.78 ± 3.58 | 22.58 ± 2.92 | .049 |
| sagebrush cover (%) | 18.45 ± 1.97 | 13.21 ± 1.84 | .053 |

Table 31. Logistic regression model for probability that a Lark Sparrow will be present at a sagebrush or bitterbrush point count station with at least 5% shrub cover.

Number of points = 103
LRS = 9.75
P>chi$^2$ = 0.0076
Psuedo R$^2$ = 0.0684

Dependent term: presence of LASP

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| sagebrush cover | 0.015 | 0.037 | 0.016 |
| bare ground | 0.014 | 0.022 | 0.010 |

Table 32. Linear regression model for abundance (log-transformed) of Lark Sparrow at the 66 points where they were detected at least once.

Number of points =66
$F(3, 62) = 7.01$ $R^2 = 0.2533$
$P > F = 0.0004$ $R^2a = 0.2172$

Dependent term: Lark Sparrow abundance (log-transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| perennial grass | -3.197 | 0.002 | -0.313 | 0.010 |
| log (open ground) | 2.756 | 0.008 | 0.219 | 0.080 |
| rabbitbrush stems < 2.5 cm | -2.484 | 0.016 | -0.003 | 0.001 |

**Nest Data:** Proportional nest success for 19 nests over 3 years was 32%. Mayfield estimates of nest survivorship for 18 nests was similar at 30%. The Mayfield estimates for total and daily (SE) nest survivorship, and the number of days under observation is presented in Table 33. Two of the 19 (10%) nests we monitored were parasitized by Brown-headed Cowbirds.

TABLE 33. Number of nests, days under observation, and Mayfield estimates of total and daily (SE) survivorship.

| Species | Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|---|
| **Lark Sparrow** | **Entire** | **18** | **256** | **.300** | **.953 (.013)** |

**Management:** In Arizona, Bock et al. (1984) found that moderate grazing can have a positive effect on Lark Sparrow populations. On the Bombing Range Lark Sparrows were most abundant in shrub habitats which lacked dense cover of perennial grass, even though they are known to use bunchgrass as nest substrate. Further documentation of nest success relative to habitat type and substrate are needed to make management recommendations.

### Sage Sparrow

**Status:** Breeding Bird Survey data show stable population trends for Sage Sparrows in the Columbia River Basin between 1968-1994 (Saab and Rich 1997). They are listed as a USFWS Region 1 species of concern and on the ODF&W sensitive species list. They were also identified as a species of high concern to management under all proposed management themes in a Large-scale conservation assessment for migratory landbirds in the Interior Columbia River Basin (Saab and Rich 1997). Gabrielson and Jewett (1940) begin their account of the Sage Sparrow in Oregon; "To think of the Northern Sage Sparrow brings to mind the sage-covered sand areas of northern Morrow County...". One can infer it was once an abundant denizen of sagebrush habitats in the area. The current distribution of Sage Sparrows in Morrow County is much reduced and may be limited to parts of the Bombing Range and the adjacent state lands being leased to Boeing.

**Distribution / Relative Abundance:** On the Bombing Range, Sage Sparrow distribution is very local and limited. The TASP approach used to survey the upland habitat, documented 52 territories in 1996. In addition, several pairs were found each year in a sandy patch of sagebrush at the northeast of RNA C, and in the second and third years of the study there was at least 1, and possibly 2 pairs in Well Spring Canyon (RNA C). Figure 16 shows the location of all territories located in 1996, and the boundaries of the TASP areas.

Sage Sparrows were detected at least once during the study at 3 of 23 (13%) of the grazed sagebrush point count locations, 2 of 29 (7%) of the ungrazed sagebrush, and 16 of 34 (50%) of the upland sagebrush. At points where they occurred, mean annual detections within 100 meters was .33 (one in 3 years) in the ungrazed sagebrush, .78 in the grazed sagebrush, and 2.35 in the upland sagebrush.

**Habitat Associations:** Vegetation data collected around each point count was used to compare points where Sage Sparrows occurred with those where they were absent. Correlation coefficients of habitat characteristics associated with sage sparrow occurrence are presented in Appendix 6 Table 1. Habitat variables correlated with abundance of sparrows at 21 points where they were detected at least once during the study are presented in Appendix 6, Table 3. There was no significant year effect on the abundance of Sage Sparrows ($P > 0.1$, ANOVA). In summary, the occurrence of Sage Sparrows was positively correlated with a number of shrub characteristics including cover, density, and number of large sagebrush stems. They were negatively correlated with ground cover variables such as total green cover and total grass cover. This data suggests that densely growing annuals such as cheatgrass may have a negative effect on Sage Sparrows. The means of all significant variables related to Sage Sparrow presence and absence are presented in Table 34. In order to investigate the affect of vegetation on Sage Sparrow abundance, we divided points where they occurred into two samples split along the median abundance.

Points with a mean annual abundance greater than 1.5 sparrows had less annual grass, less litter, more open ground, higher sagebrush cover and density, and lower mean sagebrush height, than points where the mean annual abundance was 1.5 or less. Litter cover averaged 10.18 % at points with high abundance, 21.55 % at points with lower abundance, and 32.9 % at points where Sage Sparrows did not occur. Mean annual grass cover was 2.7 % at points with higher sparrow abundance, and 6.84 % where sparrows were less abundant.

We modeled presence and absence of Sage Sparrows in sagebrush habitats using stepwise logistic regression at points with at least 5% shrub cover (Table 35). Of the 10 variables which were significant in univariate regressions, only 2 were retained in the final model. There is a strong positive association with shrub cover, and a negative one with total green ground cover. This model correctly classifies occurrence of Sage Sparrows at 61 of 75 (81.4%) of the sagebrush points.

FIGURE 16. Location of TASP areas and Sage Sparrow territories located in 1996.

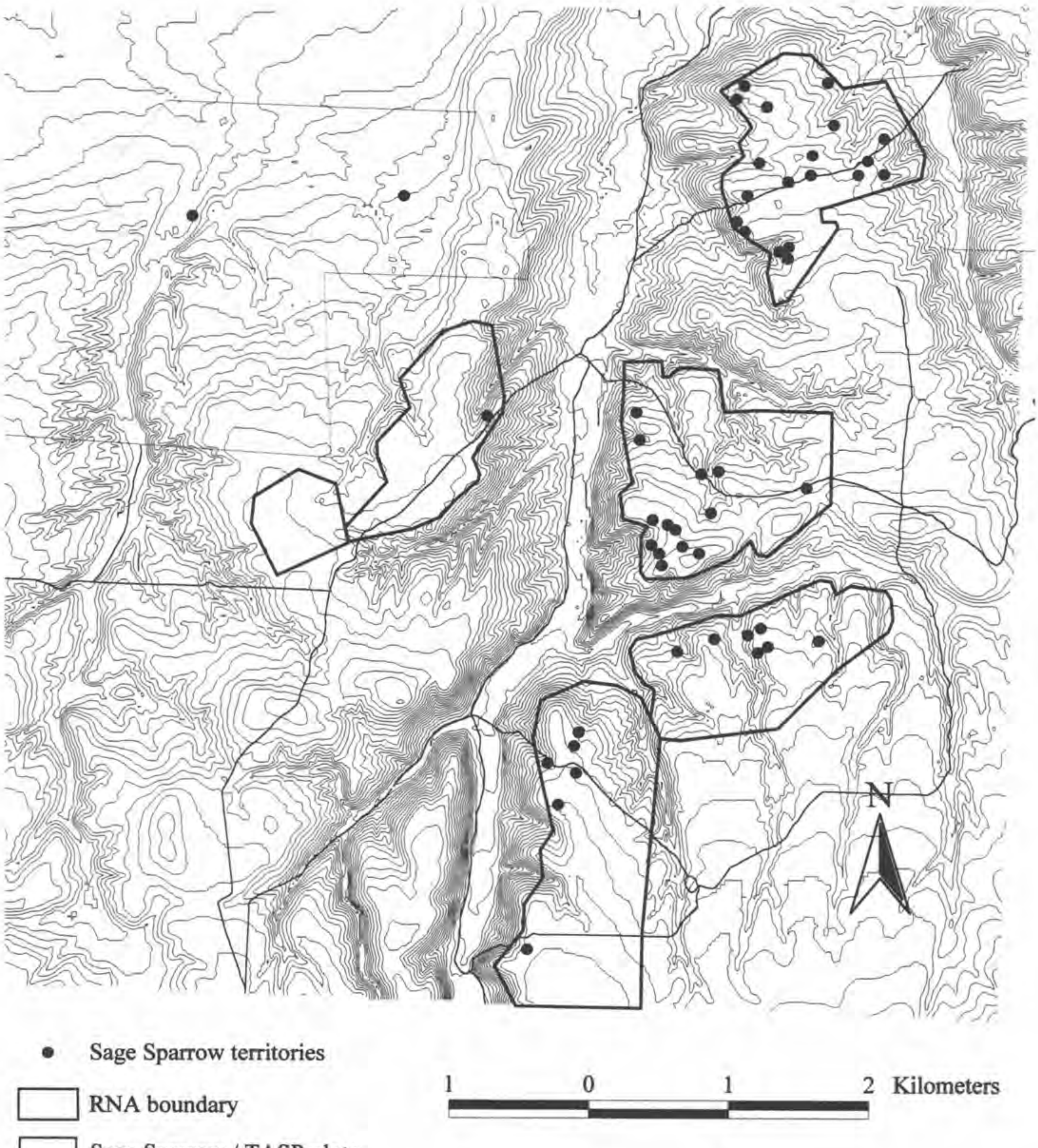


TABLE 34. The means and standard errors of different vegetation and habitat variables related to the presence of Sage Sparrows in sagebrush habitats of the NWSTF in 1995-1997.

| Variable | Sagebrush Points with SAGS (*n*=21) | Sagebrush Points without SAGS (*n*=58) | *P* |
|---|---|---|---|
| total green cover (<40cm, %) | 10.78 ± .83 | 19.58 ± 1.44 | .000 |
| total grass cover (%) | 8.08 ± .77 | 15.40 ± 1.43 | .000 |
| perennial grass cover (%) | .53 ± .21 | 4.13 ± 1.02 | .011 |
| open ground (%) | 82.79 ± 2.55 | 61.07 ± 3.44 | .000 |
| litter (%) | 16.13 ± 2.50 | 32.90 ± 3.40 | .002 |
| shrub cover (%) | 31.21 ± 2.00 | 19.11 ± 1.38 | .000 |
| shrub density (#) | 84.78 ± 6.24 | 47.69 ± 3.24 | .000 |
| sagebrush cover (%) | 30.01 ± 2.27 | 17.71 ± 1.43 | .000 |
| sagebrush density (#) | 81.29 ± 7.14 | 47.69 ± 3.24 | .000 |
| sagebrush stems >2.5cm (#) | 117.10 ± 12.52 | 65.84 ± 5.72 | .000 |

To model the affects of habitat variables on abundance of Sage Sparrows where they occurred, we used stepwise linear regression. The mean annual detections was square-root transformed, and litter cover was log transformed to normalize residuals. Of 6 variables entered into the model only litter (log transformed) was retained ($ß = -0.452$, $P = 0.005$). Litter is strongly correlated with annual grass cover, and negatively correlated with open ground. The model is presented Table 36.

TABLE 35. Logistic regression model for probability that a Sage Sparrow will be present at a sagebrush point count station with at least 5% shrub cover.

Number of points = 75
LRS (2) = 27.68
$P > chi^2 = 0.0000$
Pseudo $R^2 = 0.3112$

Dependent term: presence of SAGS

| Term | *P* | Regression coefficient (β) | SE (β) |
|---|---|---|---|
| Shrub cover | 0.002 | 0.093 | 0.034 |
| Total green cover | 0.000 | -0.200 | 0.076 |

TABLE 36. Linear regression model of Sage Sparrow abundance (square-root transformed) in relation to litter (log-transformed) at 21 points where at least one Sage Sparrow was detected.

Number of points = 21
$F(1, 19) = 10.06$ $R^2 = 0.3462$
$P > F = 0.0050$ $R^2a = 0.3118$

Dependent term: Sage Sparrow abundance (square-root transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| log (litter) | -3.166 | 0.005 | -0.452 | 0.143 |

**Nest Data:** Sage Sparrows were present on the study area when we arrived each year at the end of March. Gabrielson and Jewett (1970) report an early nest, after a particularly mild winter, found just south of Boardman on March 29, 1934 which contained five young. The earliest nest located in this study was found April 1, 1996, with a complete clutch of 3 eggs. We monitored 12 nests during the study, for which the overall proportional success was 33%. Six (50%) of the nests were built on the ground at the base of a sagebrush. Mean nest height was 12.58 cm (range 0-58), and mean nest-shrub height was 88.83 cm (range 62-125). A nest located using the distress calls of an adult Sage Sparrow on May 13, 1996 contained a gopher snake, which was in the process of swallowing 1 of 4 eggs. When the nest was revisited 3 days later, it was empty.

**Management:** The sagebrush east of Juniper Canyon supports perhaps the majority of Sage Sparrows that still breed in Morrow County. Sage Sparrows can be sensitive to fragmentation, favoring larger patches (Knick and Rottenberry 1995), and the presence of Sage Sparrows on the Bombing Range is negatively correlated with grass and litter. Management practices should prevent any further fragmentation of the sagebrush, as well as any further degradation of the cryptobiotic crust. Fire suppression should be considered when a fire threatens any of the larger patches of sagebrush. Use of new water troughs should be avoided in areas that are still dominated by native plants with healthy cryptobiotic crust, such as the upland sagebrush East of Juniper Canyon.

**Black-throated Sparrow**

**Status:** Black-throated Sparrow are listed as a USFWS Region 1 species of concern, and as an ODF&W sensitive species. Because the Interior Columbia Basin is at the periphery of this species range there are insufficient BBS data to calculate a population trend (Saab and Rich 1997).

**Distribution /Relative Abundance:** Rare and local on the NWSTF, we found Black-throated Sparrows to be limited primarily to the bitterbrush habitat. None were observed in 1995, but in the last 2 years of the study, multiple observations were made in the bitterbrush habitat, including 3 males, of which at least 2 were mated, on plot #3. An additional pair was observed courtship feeding just south of the large dune.

**Nest Data:** Although no nests were located, or fledglings observed, we believe pairs in the bitterbrush were breeding as we witnessed alarm calling and courtship feedings. During the last 2 years of the study, solitary males were observed on isolated occasions in sagebrush habitats. In 1994, a singing male was observed about 1 km southwest of the big dune at the North end of the Bombing Range (Livezey, pers. comm.), and a nest was located in Well Spring Canyon, just south of RNA C (Morgan, pers. comm.).

**Management:** We know very little about the ecology of Black-throated Sparrow, especially at the northern edge of their range. Bock et al. (1984) reported a positive response to moderate grazing in a semi-desert habitat in Arizona.

**Brewer's Sparrow**

**Status:** Breeding Bird Survey data shows a 1.3% annual decline in the Columbia basin from 1968 to 1994 ($P < .05$), and a 4.3 % annual decline from 1984 to 1994 ($P < 0.01$) (Saab and Rich 1997).

**Distribution / Relative Abundance:** Brewer's Sparrows were extremely rare and local on the NWSTF. We did not locate any breeding pairs in 1995, possibly due to inadequate sampling of sagebrush habitats. With the addition of the upland sagebrush plots in 1996, we located 3 territories on plot 26. These same 3 territories were occupied in 1997.

**Nest Data:** A recently fledged brood was observed near point number 10 on Plot 26 in 1996, and a nest which had apparently already failed was located on the same territory in 1997.

**Western Meadowlark**

**Status:** Breeding Bird Survey data for the Columbia basin shows a 0.8% annual decline between 1968 and 1994 ($P < 0.1$), and a 3.7% annual decline between 1984 and 1994 ($P < 0.01$, Saab and Rich 1997). They were identified as a species of high concern to management under all proposed management themes for the Interior Columbia Basin (Saab and Rich 1997).

**Distribution and Relative Abundance:** Meadowlarks, detected within 100 m at least once at every sampling point, were the most abundant bird on the Bombing Range. Relative abundance was greatest in the bitterbrush and ungrazed sagebrush habitats. Within the bunchgrass habitat there were significantly more meadowlarks at points free from livestock grazing ($t_{51} = 3.42$, $P < 0.001$). There were also greater mean annual abundance at points in ungrazed sagebrush than in grazed sagebrush ($t_{51} = 2.23$, $P = 0.031$, abundance square-root transformed), or in upland sagebrush ($t_{62} = 2.45$, $P = 0.017$). The relative abundance of meadowlarks for each habitat and year is presented in Figure 16.

**Habitat Associations:** Because of the meadowlark's ubiquitous distribution, we did not model occurrence in relation to vegetation characteristics. Abundance differed significantly between 1995 and the second 2 years, decreasing in the grassland, and increasing slightly in the shrub habitats. Across habitats, we identified 13 habitat variables that were significantly correlated with abundance of meadowlarks. These are presented in Appendix 6, Table 4. We developed a multivariable model using stepwise linear regression, which retained 3 of the 13 variables; percent open ground, shrub height, and bitterbrush density. Mean annual abundance, the dependent term, was square-root transformed to normalize data. The final multivariable model is presented in Table 37.

**Nest Data:** We monitored 80 nests with known outcomes, of which 22 (28%) fledged young. Proportional success was 48% in 1995 ($n = 37$), 18% in 1996 ($n = 17$), and 15% in 1997 ($n = 26$). The Mayfield estimate of nest survivorship using all 3 years was 11% ($n = 78$), and did not differ significantly between incubation and nestling periods. Total and daily Mayfield survivorship estimates with standard error and observation days for each year are presented in Table 38.

FIGURE 17. Relative abundance of Western Meadowlarks among general habitat types of the NWSTF, 1995-1997. AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open-low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush

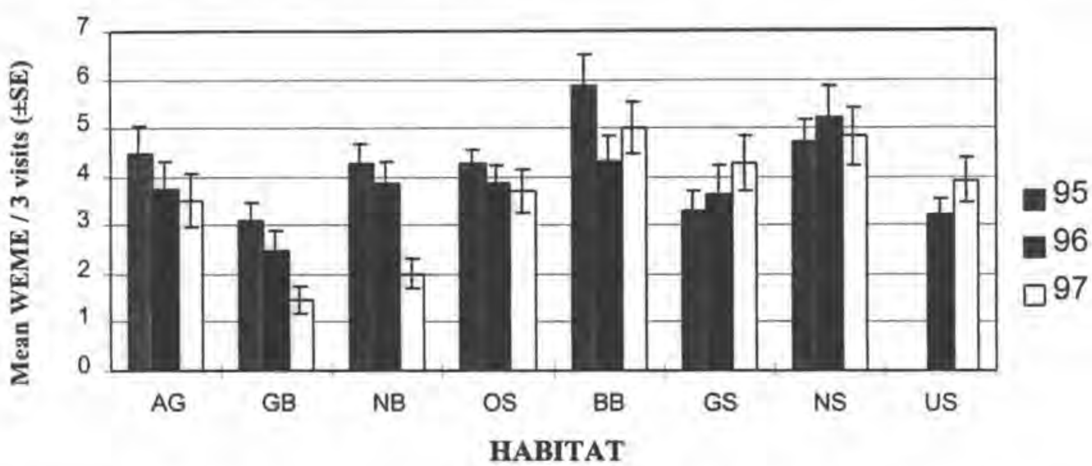



TABLE 37. Linear regression model of Western Meadowlark abundance as related to open ground, shrub height, and number of bitterbrush intercepted in 200 meters of transect

Number of points = 220
$F(3, 216) = 17.60$ — $R^2 = 0.1964$
$P > F = 0.0000$ — $R^2a = 0.1853$

Dependent term: Western Meadowlark abundance (square-root transformed)

| Term | t | $P > \|t\|$ | Regression coefficient (β) | SE (β) |
|---|---|---|---|---|
| open ground | -3.740 | 0.000 | -0.005 | 0.001 |
| shrub height | 4.564 | 0.000 | 0.004 | 0.001 |
| bitterbrush density | 2.611 | 0.010 | 0.010 | 0.004 |

Proportional success was higher in ungrazed treatments, although not significantly so ($P > 0.05$, ANOVA), nor was there a significant difference in Mayfield estimates between treatments ($P > 0.05$). The low nest success reported here is similar to the 10% nest survivorship found in Montana grasslands (PRBO unpublished data).

TABLE 38. Number of nests and days of nest observation used for analysis, total survivorship daily survivorship, and standard error estimates for Western Meadowlark nests in each year, and all years combined. Survivorship during the incubation and nestling stage are presented for all years combined.

| Year | Period | Number of nests | Days of observation | Total S | Daily S (SE) |
|---|---|---|---|---|---|
| 1995 | entire | 36 | 294 | .187 | .945 (.013) |
| 1996 | entire | 16* | 194 | .126 | .933 (.018) |
| 1997 | entire | 26 | 231 | .05 | .905 (.019) |
| '95-'97 | laying | 9* | 18 | .448 | .833 (.088) |
| '95-'97 | incubation | 56 | 384 | .542 | .956 (.011) |
| '95-'97 | nestling | 52 | 317 | .303 | .905 (.016) |
| **'95-'97** | **entire** | **78** | **719** | **.111** | **.929 (.010)** |

## Brewer's Blackbird

**Status:** Brewer's Blackbird have shown a 4.3% annual decline from 1984 through 1994 on Breeding Bird Surveys in the Columbia basin (Saab and Rich 1997).

**Distribution / Relative Abundance:** Blackbirds nested both individually and in small, loose, colonies in the sagebrush habitat. Although they were regularly seen, and detected on point counts in the bitterbrush, we never located a nest in bitterbrush. If birds were not breeding in colonies in that habitat type, we would be less likely to locate them. Small colonies were located in 1995 in sagebrush along the eastern edge of plot 9, (Township 2N, Range 25 E, Section 10, at the mouth of "Rattlesnake Canyon" (Section 21), and along the Oregon Trail (Section 13 and 14). A few birds were at the Oregon Trail and Rattlesnake Canyon sites in 1996, but none on plot 9. In 1997, the only colonial site we located was at the mouth of a draw just northeast of plot 9, but we also found a single pair nesting at the northern edge of the juniper trees at the Oregon Trail.

**Nest Data:** We located 10 nests in 1995, 3 of which fledged young. No young fledged from 6 nests in 1996, and 7 nests in 1997. Overall proportional success (n=23) was 13%. Brown-headed Cowbirds were usually present around the blackbird colonies, and parasitized 14 (78%) of 18 nests that were observed with a complete clutch. Due to low host nest success, only 1 cowbird managed to fledge. Blackbirds may be the primary host for Brown-headed Cowbird eggs at the NWSTF.

**Bullock's Oriole**

**Status:** Breeding Bird Survey data shows no population trend in the interior Columbia Basin from 1968-1994.

**Distribution / Relative Abundance:** Orioles were very limited and locally distributed on the Bombing Range, and confirmed breeders only in the juniper trees. Individuals were observed on several occasions in the bitterbrush habitat, including 1 detection on a point count census in 1996, and 3 on censuses in 1997.

**Nest Data:** Because of difficulties seeing nest contents, precise dates of clutch initiation were never achieved. Orioles began nesting later than any other species we documented to breed on the Bombing Range; a material-carry was witnessed on 20 May, and the earliest complete nest found 24 May, 1996. Overall nest success for 7 nests was 71.4%, with 2 of 4 nests fledging in 1996, and all 3 nests fledging young in 1997.

## Anecdotal Species Accounts

**Mallard:** Mallard were not observed using the Bombing Range with one notable exception. In 1997, there was a nest in the annual grass habitat in northern Juniper Canyon (Township 4 North, Range 25 East, Section 36). This nest was at least 3.2 km from the nearest water, and failed due to mammalian depredation. A Northern Pintail nest was located in the same pasture in 1981 (Greg Green, personal comm.).

**Killdeer:** Killdeer were associated with human activity on the Bombing Range. They nested in an area dominated by bare ground and Sandberg's bluegrass, adjacent to the horse corral known as "Lonesome Dove" in 1995 and 1996. Another pair nested on the roadside just outside the maintenance complex gate in 1995. A pair was observed at the corral (Township 4 North, Range 25 East, Section 28) in 1997, but no nest was located. They were also noted regularly at the sheep camp. All 3 nests we monitored were successful. Sightings were recorded on "wildlife observation" forms.

**American Kestrel:**
Kestrels were observed in every habitat type except ungrazed sagebrush, where their absence is most likely related to its proximity to available nest sites. In 1995 a pair of kestrels nested on a building of the maintenance complex adjacent to plot 1. In 1997 a nest was located in a gravel mine 100 m east of the property boundary of Section 12 (Township 2 North, Range 25 East). In 1996, and 1997, a pair was regularly seen in the relatively vegetation free area 400 m northeast of Tubb Springs, where a nest site may have been available. However, we never observed behavior indicative of breeding.

**Gray Partridge:**
Somewhat limited in distribution on the Bombing Range, Gray Partridge were found primarily in sagebrush habitats. A freshly hatched brood was observed on plot 20, and an empty nest was found 50 m inside the RNA border, due east of the plot. Sightings were mapped, and recorded on wildlife observation forms for future development of a GIS layer.

**Ring-necked Pheasant:**
Pheasant were observed in every habitat type, but were associated with shrubby areas when encountered in grassland. They were only detected twice (within 200 m) on 9 point count surveys over 3 years in the annual grass ($n = 27$) and grazed bunchgrass habitats ($n = 27$). In addition, they were detected between 16 (ungrazed bunchgrass $n = 25$) and 31 times (open low shrub $n = 27$) in the other habitats. We made no effort to monitor nests of this species.

**Barn Owl:**
A pair of Barn Owls nested each year in a vertical wall of an eroded drainage in Juniper Canyon (Township 2 North, Range 25 East, NE edge of Section 3). We did not determine the outcome of this nest in 1995 or 1996, although young close to fledging age were observed in the area during both years. In 1997, the nest fledged 3 young during the second week of July.

**Short-eared Owl:**
A pair was observed every year of the study on plots 19 and 20 (ungrazed bunchgrass), and a successful nest was monitored on plot 19 in 1997. Short-eared owls were also observed at 3 locations in the open-low shrub habitat, in annual grass/intermittent shrub east of the impact area, and at one location in the bitterbrush, at the northwest of plot 2. Sightings were mapped, and recorded on wildlife observation forms.

**Northern Rough-winged Swallow:**
Seldom seen in the first two years, at least two pairs of Northern Rough-winged Swallows attempted a nest in 1997. One nest, located across from the Barn Owl nest, had an undetermined outcome, while the other failed, possibly from abandonment.

**Barn Swallow:**
Barn Swallow nested in a cement bunker at the West edge of plot 4 in 1995. They also nested at the maintenance complex, and were observed occasionally in each general habitat type.

**European Starling:**
Starlings nested in buildings at the maintenance complex, the horse corral known as "Lonesome Dove", and in Navy equipment stored east of tower 2 in 1997. Additionally in 1996, a nest was located in the washed out drainage of Juniper Canyon, within 2 m of an active Barn Owl nest. No efforts were made to monitor starlings.

**Brown-headed Cowbird**
Cowbirds are reported to have stable population trends in the Basin from 1968 to 1994 (Saab and Rich 1997). Brown-headed Cowbirds were known to parasitize nests of Brewer's Blackbirds in all years, and Lark Sparrows in 1996. Of 23 Brewer's Blackbird nests found, 18 were observed with a complete

clutch, and 14 (78%) of these were parasitized by cowbirds. However, due to low nest success, only one fledged a cowbird. Of 11 Lark Sparrow nests located in 1995, none were host to cowbird eggs. Two of the 7 nests located in 1996 (29%) contained cowbird eggs, and both fledged 1 cowbird, while the single nest located in 1997 was not parasitized. In summary, cowbirds appear to have minimal influence on the majority of nesting bird species on the Bombing Range.

**House Sparrow:**

House Sparrows nested in buildings at the sheep camp, and the maintenance complex. Distribution was limited to human structures, and no efforts were made to monitor their nests, although fledglings were noted in 1996.

## Pair-wise Correlations in Species Abundance

Species within a community may or may not respond to the same habitat features. Managing for habitat features that one species is associated with may negatively affect another species. To investigate the extent and patterns of habitat affinities among the species of the Bombing Range, we conducted pair-wise comparisons of variation in abundance of breeding species. We looked at correlations using sampling points pooled across habitat types ($n$ = 220), in grassland types ($n$ = 79), and in shrub habitats ($n$ = 141). Modeling of abundance presented in species accounts used only points where a given species was detected, where here we are including points where birds were absent. Of 21 comparisons of variations in individual species abundance for each set of, there were 5 (23.8%) that were significant across habitats, 4 (19%) in grassland, and only one (4.3%) in shrub habitats. Table 5 shows significant correlations between the abundance of pairs of species breeding on the NWSTF across the habitat types, within shrub habitat types, and within grassland habitats. We believe these correlations suggest similar (positive) or differing (negative) habitat affinities between species. We investigated a few of the negative correlations by examining each species response to habitat variables. For example, in grassland

TABLE 39. Pairwise correlations of breeding species abundance.

| Species Pair<br>across habitats (220 points) | R |
|---|---|
| Grasshopper Sparrow x Horned Lark | .68*** |
| Grasshopper Sparrow x Lark Sparrow | -.37** |
| Horned Lark x Lark Sparrow | -.29** |
| Horned Lark x Long-billed Curlew | .22*** |
| Sage Sparrow x Lark Sparrow | .25*** |
| | |
| Species pair (141 shrub points) | |
| Grasshopper Sparrow x Horned Lark | .71*** |
| | |
| Species pair (79 grassland points) | |
| Grasshopper Sparrow x Horned Lark | .37** |
| Grasshopper Sparrow x Long-billed Curlew | -.45** |
| Horned Lark x Lark Sparrow | .24 * |
| Horned Lark x Western Meadowlark | -.32 ** |

* = P<0.05, ** = P<0.001, *** = P<0.0001

there is a strong negative correlation between Grasshopper Sparrow and Long-billed Curlew. We know that at points where they were detected, each of these species responded differently in regards to bunchgrass cover, and curlews were not very abundant in the native grasslands, especially those that are not grazed. We used unpaired t-tests, not assuming equal variance, to test for differences in cover between vegetation variables which each species responded differently. There is significantly more perennial grass cover at points where Grasshopper Sparrows occurred than at points where curlews occurred ($P < 0.01$). It is not surprising that we had some significant correlations using all habitats combined, as you would expect grassland birds to be positively correlated with other grassland birds, and negatively correlated with birds occurring primarily in shrub habitats.

There are many significant differences in vegetation variables that might explain the negative correlations between Lark Sparrows and two primary grassland species; Grasshopper Sparrow and Horned Lark. The only pairwise correlation that was significant in each of the three samples of points was between Grasshopper Sparrow and Horned Lark. Especially in shrub habitats, these two species appear to responding to similar vegetational conditions in both occurrence and abundance.

## Summary of Management Recommendations

We recommend that the NWSTF be managed for a mosaic of plant communities. Species of concern on the Bombing Range have different habitat requirements within the patchwork of grass and shrubland, and practices that benefit one species may not benefit others. Upland sagebrush supports what is maybe the majority of Sage Sparrows left in Morrow County. Sage Sparrows and Brewer's Sparrows can be sensitive to fragmentation, favoring larger patches (Knick and Rottenberry 1995), and the presence of Sage Sparrows can be negatively correlated with grass cover and litter (Wiens and Rotenberry 1981). Management practices should prevent any further fragmentation of the sagebrush, as well as any further degradation of the cryptobiotic crust. Fire suppression should be considered when a fire threatens any of the larger patches of sagebrush. Use of new water troughs should be avoided in areas that are still dominated by native plants with healthy cryptobiotic crust, such as the upland sagebrush.

Livestock grazing seasons and distribution should be evaluated with the goal of promoting the growth of native grasses. Perennial bunchgrass is extremely important for Grasshopper Sparrow and Horned Lark. While increased rest in a rest-rotation system may benefit the native plants, deferring livestock grazing until the bunchgrass begins to cure should also be considered. Heavy spring grazing can reduce or eliminate native bunchgrass by preventing seed-set, and there is some evidence that shrubsteppe birds prefer native grass seed to that of exotics (Kelrick et al. 1996). Long-billed Curlews utilize areas with short grass, and are virtually restricted to grazed areas within perennial grassland. Winter and early spring grazing should benefit curlews by providing habitat with short grass before the onset of nesting. However, curlews and other ground nesting species would benefit further from reduced nest trampling under a winter only grazing scheme. Our data shows a positive correlation between curlew nest success and grass height surrounding the nest. We recommend that at least parts of the grasslands at the North end of the Bombing Range be incorporated in a rest rotation system where cattle would be removed at the end of the winter, prior to the onset of nesting.

Data from rope-dragging suggest that bunchgrass grazed in the dormant season, and left alone during the growing season supports similar numbers of nesting Grasshopper Sparrows to bunchgrass that has not been grazed in over 20 years. In contrast, we never located a Grasshopper Sparrow nest in the heavily spring-grazed 17.5 ha, to the west of plot number 19. This needs to be replicated at another site but also suggests that Grasshopper Sparrows would benefit from a deferred grazing scheme

Badger holes, essential to Burrowing Owls, may limit owl numbers on parts of the Bombing Range in some years. High densities of burrows not only provide numerous nest sites, but they also allow for escape for young owls. Livestock trampling of badger burrows could greatly reduce the quality of certain areas of the Bombing Range for Burrowing Owls in years of low badger abundance. Deferring grazing until after the native grass cures, and removing livestock before the growing season would also greatly reduce the amount of trampling. No Badgers should be killed as part of a predator control program on the Bombing Range.

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## Appendix 1. Species list and number of individuals by species and habitat

TABLE 1. List of all birds seen or heard between March 20 and August 1, 1995-1997 on the NWSTF. USFWS region 1 species of concern are italicized, and ODF&W sensitive species are marked with an asterisk. Species in bold text are known to breed on the NWSTF. This list includes all species detected from standardized data collection and casual observations. Common names (from A.O.U. checklist 1983, and supplements 1987, 1996), breeding status[3] by habitat type, and migratory behavior are listed for all birds encountered.

| | Habitat[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A.O.U. Common Name | AG | GB | NB | OS | BB | GS | NS | US | ST | JT | migratory behavior[2] |
| American Crow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| American Goldfinch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| **American Kestrel** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | res |
| American Robin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| **Barn Owl** | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | res |
| **Barn Swallow** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | mig |
| **Black-billed Magpie** | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 1 | 0 | 3 | res |
| **Brown-headed Cowbird** | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 3 | 0 | 0 | mig |
| **Brewer's Blackbird** | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | res |
| ***Brewer's Sparrow*** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | mig |
| Black-crowned Night Heron | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| ****Black-throated Sparrow*** | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | mig |
| Blue-winged Teal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| **Bullock's Oriole** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | mig |
| ****Burrowing Owl*** | 3 | 3 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | mig |
| California Gull | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| California Quail | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Caspian Tern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Chipping Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Chukar | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | res |
| Cliff Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Common Nighthawk | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | mig |
| Common Poorwill | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **Common Raven** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | res |
| Cooper's Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **European Starling** | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | res |
| ****Ferruginous Hawk*** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | mig |
| Fox Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Golden-crowned Kinglet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Golden Eagle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Gray Flycatcher | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | mig |
| **Gray Partridge** | 0 | 0 | 0 | 3 | 0 | 3 | 3 | 1 | 0 | 0 | res |
| ****Grasshopper Sparrow*** | 3 | 3 | 3 | 3 | 0 | 0 | 3 | 1 | 0 | 0 | mig |
| **Horned Lark** | 3 | 3 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | res |
| House Finch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| **House Sparrow** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | res |
| House Wren | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| **Killdeer** | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |

[1] AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush, ST = human structure (any habitat type), JT = Juniper Trees (in grazed sagebrush)
[2] res = resident, mig = migrant
[3] 0=no evidence of breeding, 1= possible breeder, 2 = probable breeder, 3 = confirmed breeder

**Appendix 1. Species list and number of individuals by species and habitat (cont').**

| A.O.U. Common Name | Habitat[1] AG | GB | NB | OS | BB | GS | NS | US | ST | JT | migratory behavior[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ****Lark Sparrow*** | 0 | 0 | 0 | 1 | 3 | 3 | 3 | 3 | 0 | 0 | mig |
| Lewis' Woodpecker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| ****Loggerhead Shrike*** | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 1 | 0 | 3 | mig |
| ***Long-billed Curlew*** | 3 | 3 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | mig |
| **Long-eared Owl** | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | res |
| Macgillivray's Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **Mallard** | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Merlin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Mountain Bluebird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **Mourning Dove** | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 1 | 0 | 3 | mig |
| Northern Flicker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Northern Harrier | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | res |
| **Northern Rough-winged Swallow** | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | mig |
| Orange-crowned Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Prairie Falcon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | res |
| Red-tailed Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Red-winged Blackabird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Ring-billed Gull | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **Ring-necked Pheasant** | 1 | 2 | 3 | 1 | 2 | 3 | 3 | 2 | 0 | 0 | res |
| Rock Wren | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | res |
| Rough-legged Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Rufous Hummingbird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| ****Sage Sparrow*** | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 | 0 | 0 | mig |
| **Sage Thrasher** | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 0 | 0 | mig |
| Say's Phoebe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Savannah Sparrow | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | mig |
| Sharp-shinned Hawk | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| ***Short-eared Owl*** | 0 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | res |
| Spotted Sandpiper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| ***Swainson's Hawk** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | mig |
| Townsend's Solitaire | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Res |
| Turkey Vulture | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| *Upland Sandpiper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Vesper Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | mig |
| Violet-green Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| **Western Kingbird** | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 1 | 3 | 3 | mig |
| **Western Meadowlark** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | res? |
| Wilson's Warbler | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| White-crowned Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Western Tanager | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |
| Yellow-headed Blackbird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | mig |

[1] AG = annual grass, GB = grazed bunchgrass, NB = ungrazed bunchgrass, OS = open low shrub, BB = bitterbrush, GS = grazed sagebrush, NS = ungrazed sagebrush, US = upland sagebrush, ST = human structure (any habitat type), JT = Juniper Trees (in grazed sagebrush)
[2] res = resident, mig = migrant
0=no evidence of breeding, 1= possible breeder, 2 = probable breeder, 3 = confirmed breeder

**Appendix 1. Species list and number of individuals by species and habitat (cont').**

TABLE 2. Total number of individuals (within 100 m) of each species censused during 1995 point counts by general habitat type.

| | Habitat[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **AG** | **GB** | **NB** | **OS** | **BB** | **GS** | **NS** | **US*** |
| American Kestrel | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Barn Swallow | 1 | 0 | 2 | 0 | 3 | 1 | 0 | 0 |
| Black-billed Magpie | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| Brewer's Blackbird | 0 | 10 | 0 | 0 | 16 | 8 | 0 | 1 |
| Burrowing Owl | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chipping Sparrow | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Cliff Swallow | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Common Nighthawk | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Common Raven | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Gray Partridge | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Grasshopper Sparrow | 62 | 116 | 105 | 27 | 0 | 0 | 77 | 0 |
| Horned Lark | 40 | 130 | 70 | 53 | 0 | 1 | 38 | 0 |
| Lark Sparrow | 0 | 1 | 0 | 6 | 13 | 25 | 10 | 6 |
| Long-billed Curlew | 72 | 16 | 1 | 31 | 0 | 0 | 0 | 0 |
| Loggerhead Shrike | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 1 |
| Mourning Dove | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Northern Harrier | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 0 |
| Ring-necked Pheasant | 0 | 0 | 3 | 0 | 6 | 2 | 0 | 0 |
| Red-winged Blackbird | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Sage Sparrow | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 5 |
| Say's Phoebe | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Savannah Sparrow | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Western Kingbird | 0 | 2 | 4 | 2 | 2 | 0 | 0 | 0 |
| Western Meadowlark | 121 | 84 | 106 | 115 | 164 | 76 | 137 | 23 |

[1]AG= annual grass (27 points), GB= grazed bunchgrass (27 points), NB= ungrazed bunchgrass (25 points), OS = open low shrub (27 points), GS = grazed sagebrush (23 points), NS = ungrazed sagebrush (29 points), US = grazed upland sagebrush *(The plots in this habitat stratification were not created until 1996. The above numbers come from points 1,5,6, and 7 on plot #08)

**Appendix 1. Species list and number of individuals by species and habitat (cont').**

TABLE 3. Total number of individuals (within 100 m) of each species censused during 1996 point counts by general habitat type.

| | Habitat[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **AG** | **GB** | **NB** | **OS** | **BB** | **GS** | **NS** | **US** |
| Barn Swallow | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Black-billed Magpie | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Brewer's Blackbird | 0 | 0 | 0 | 2 | 20 | 0 | 1 | 0 |
| Brewer's Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Black-throated Sparrow | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Brown-headed Cowbird | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| Bullock's Oriole | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Burrowing Owl | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chipping Sparrow | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Common Raven | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 1 |
| Golden Eagle | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gray Flycatcher | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Grasshopper Sparrow | 63 | 138 | 105 | 60 | 1 | 2 | 81 | 13 |
| Horned Lark | 49 | 169 | 79 | 36 | 1 | 5 | 45 | 2 |
| Lark Sparrow | 0 | 1 | 1 | 0 | 16 | 20 | 3 | 14 |
| Long-billed Curlew | 60 | 36 | 3 | 21 | 9 | 6 | 2 | 0 |
| Loggerhead Shrike | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 |
| Mourning Dove | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| Red-winged Blackbird | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Ring-necked Pheasant | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 4 |
| Sage Sparrow | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 27 |
| Sage Thrasher | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 2 |
| Savannah Sparrow | 0 | 2 | 0 | 0 | 3 | 0 | 1 | 0 |
| Vesper Sparrow | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Western Kingbird | 2 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| Western Meadowlark | 101 | 67 | 97 | 104 | 121 | 83 | 151 | 108 |
| White-crowned Sparrow | 2 | 0 | 0 | 8 | 7 | 7 | 0 | 0 |

[1] AG= annual grass (27 points), GB= grazed bunchgrass (27 points), NB= ungrazed bunchgrass (25 points), OS = open low shrub (27 points), GS = grazed sagebrush (23 points), NS = ungrazed sagebrush (29 points), US = grazed upland sagebrush (34 points)

**Appendix 1. Species list and number of individuals by species and habitat (cont').**

TABLE 4. Total number of individuals (within 100 m) of each species censused during 1997 point counts by general habitat type.

| | Habitat[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **AG** | **GB** | **NB** | **OS** | **BB** | **GS** | **NS** | **US** |
| Barn Swallow | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Black-billed Magpie | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Brewer's Blackbird | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| Brewer's Sparrow | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 6 |
| Black-throated Sparrow | 0 | 0 | 0 | 0 | 5 | 0 | 1 | 0 |
| Brown-headed Cowbird | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Bullock's Oriole | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Burrowing Owl | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chipping Sparrow | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Chukar | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Common Raven | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| European Starling | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Grasshopper Sparrow | 78 | 153 | 147 | 69 | 12 | 0 | 100 | 13 |
| Gray Partridge | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Horned Lark | 60 | 161 | 31 | 45 | 0 | 2 | 66 | 2 |
| Lark Sparrow | 0 | 0 | 0 | 0 | 4 | 16 | 1 | 20 |
| Long-billed Curlew | 51 | 28 | 0 | 28 | 0 | 3 | 0 | 11 |
| Loggerhead Shrike | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 6 |
| Mourning Dove | 0 | 0 | 1 | 0 | 0 | 4 | 5 | 1 |
| Northern Rough-winged Swallow | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Red-winged Blackbird | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 |
| Ring-necked Pheasant | 0 | 0 | 1 | 0 | 1 | 1 | 5 | 2 |
| Sage Sparrow | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 50 |
| Sage Thrasher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Savannah Sparrow | 1 | 0 | 3 | 2 | 0 | 4 | 1 | 0 |
| Western Kingbird | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Western Meadowlark | 95 | 40 | 50 | 100 | 140 | 98 | 140 | 133 |
| White-crowned Sparrow | 1 | 0 | 0 | 0 | 6 | 7 | 0 | 14 |

[1] AG= annual grass (27 points), GB= grazed bunchgrass (27 points), NB= ungrazed bunchgrass (25 points), OS = open low shrub (27 points), GS = grazed sagebrush (23 points), NS = ungrazed sagebrush (29 points), US = grazed upland sagebrush (34 points)

**Appendix 2. Indices of abundance, species richness, and species diversity.**

TABLE 1aCumulative and mean (se) species diversity, richness, number of detections, and number of point count stations, by general habitat type for all detections within 100 m in 1995.

| Habitat | Diversity($N_1$) cumulative | Diversity($N_1$) mean(se) | Species richness cumulative | Species richness mean (se) | Total det (100m) | Mean det./ pt.(se) |
|---|---|---|---|---|---|---|
| Annual grass | 3.82 | 2.85(.14) | 5 | 3.37(.15) | 297 | 11(.82) |
| Grazed bunchgrass | 3.99 | 3.01(.15) | 8 | 3.41 | 361 | 13.37(.96) |
| Ungrazed bunchgrass | 3.51 | 2.58(.09) | 8 | 2.8(.16) | 294 | 11.76(.76) |
| Open low shrub | 3.81 | 2.32(.16) | 6 | 2.63(.19) | 234 | 8.67(.79) |
| Bitterbrush | 2.16 | 1.45(.11) | 7 | 1.75(.17) | 204 | 7.28(.86) |
| Grazed sagebrush | 3.77 | 1.87(.18) | 11 | 2.09(.21) | 127 | 5.52(.65) |
| Ungrazed sagebrush | 3.27 | 2.47(.17) | 6 | 2.90(.16) | 267 | 9.21(.71) |

TABLE 1b. Cumulative and mean (se) species diversity, richness, number of detections, and number of point count stations, by general habitat type for all detections within 100 meters in 1996.

| Habitat | Diversity($N_1$) cumulative | Diversity($N_1$) mean(se) | Species richness cumulative | Species richness mean (se) | Total det (100m) | Mean det./ pt.(se) |
|---|---|---|---|---|---|---|
| Annual grass | 4.11 | 2.57(.18) | 6 | 2.96(.21) | 277 | 10.26(.93) |
| Grazed bunchgrass | 3.51 | 2.80(.10) | 5 | 3.41(.13) | 411 | 15.22(.79) |
| Ungrazed bunchgrass | 3.25 | 2.57(.11) | 6 | 2.8(.12) | 286 | 11.44(.85) |
| Open low shrub | 3.64 | 2.36(.16) | 6 | 2.63(.19) | 224 | 8.30(.83) |
| Bitterbrush | 3.13 | 1.38(.17) | 10 | 1.54(.22) | 177 | 6.32(1.01) |
| Grazed sagebrush | 3.41 | 1.86(.15) | 10 | 2.17(.21) | 125 | 5.34(.78) |
| Ungrazed sagebrush | 3.43 | 2.45(.13) | 11 | 2.90(.17) | 292 | 10.07(.66) |
| Upland sagebrush | 4.01 | 1.86(.12) | 10 | 2.12(.14) | 180 | 5.29(.46) |

TABLE 1c . Cumulative and mean (se) species diversity, richness, number of detections, and number of point count stations, by general habitat type for all detections within 100 meters in 1997.

| Habitat | Diversity($N_1$) cumulative | Diversity($N_1$) mean(se) | Species richness cumulative | Species richness mean (se) | Total det (100m) | Mean det./ pt.(se) |
|---|---|---|---|---|---|---|
| Annual grass | 3.96 | 3.17(.13) | 5 | 3.59(.13) | 285 | 10.56(.76) |
| Grazed bunchgrass | 3.23 | 2.64(.10) | 5 | 3.04(.14) | 383 | 14.19(.86) |
| Ungrazed bunchgrass | 3.21 | 2.39(.15) | 9 | 2.88(.17) | 245 | 9.8(.74) |
| Open low shrub | 3.69 | 2.60(.13) | 5 | 2.93(.17) | 243 | 9 (.79) |
| Bitterbrush | 2.23 | 1.45(.16) | 8 | 1.68(.15) | 172 | 6.14(.60) |
| Grazed sagebrush | 2.77 | 1.67(.12) | 10 | 1.87(.16) | 132 | 5.74(.69) |
| Ungrazed sagebrush | 3.73 | 2.67(.14) | 10 | 3.10(.17) | 325 | 11.21(.85) |
| Upland sagebrush | 4.70 | 2.13(.14) | 12 | 2.47(.16) | 251 | 7.35(.54) |

**Appendix 2. Indices of abundance, species richness, and species diversity.**

Table 2. Cumulative species diversity, richness, number of individuals and number of stations at each unit for point count detections within 100 m in 1995.

| Habitat | Site | Diversity $N_1$ | Species Richness | Total ind. (<100) | Number of Stations |
|---|---|---|---|---|---|
| Bitterbrush | 01 | 2.61 | 6 | 116 | 10 |
| | 02 | 1.27 | 2 | 46 | 9 |
| | 03 | 1.46 | 3 | 42 | 9 |
| Annual grass | 04 | 3.60 | 5 | 72 | 9 |
| | 05 | 3.25 | 4 | 131 | 9 |
| | 06 | 3.99 | 5 | 94 | 9 |
| Grazed Sagebrush | 07 | 2.50 | 5 | 47 | 9 |
| | 08 | 3.20 | 7 | 66 | 9 |
| | 09 | 3.83 | 6 | 50 | 9 |
| Open low shrub | 10 | 3.08 | 81 | 5 | 9 |
| | 11 | 2.70 | 6 | 44 | 9 |
| | 12 | 3.11 | 4 | 109 | 9 |
| Grazed Bunchgrass | 16 | 3.70 | 4 | 78 | 9 |
| | 17 | 3.31 | 4 | 147 | 9 |
| | 18 | 4.23 | 8 | 136 | 9 |
| Ungrazed Bunchgrass | 19 | 3.04 | 4 | 132 | 9 |
| | 20 | 3.14 | 5 | 109 | 9 |
| | 21 | 3.21 | 6 | 73 | 9 |
| Ungrazed Sagebrush | 22 | 3.04 | 5 | 79 | 9 |
| | 23 | 2.96 | 4 | 88 | 9 |
| | 24 | 3.28 | 5 | 80 | 9 |

**Appendix 2. Indices of abundance, species richness, and species diversity.**

TABLE 3. Cumulative species diversity, richness, number of individuals and number of stations at each unit for point count detections within 100 m in 1996.

| Habitat | Site | Diversity $N_1$ | Species Richness | Total ind. (<100) | Number of Stations |
|---|---|---|---|---|---|
| Bitterbrush | 01 | 2.99 | 7 | 73 | 10 |
| | 02 | 1.56 | 2 | 31 | 9 |
| | 03 | 2.57 | 6 | 73 | 9 |
| Annual grass | 04 | 3.47 | 5 | 62 | 9 |
| | 05 | 3.81 | 4 | 127 | 9 |
| | 06 | 2.82 | 5 | 88 | 9 |
| Grazed Sagebrush | 07 | 2.75 | 5 | 61 | 9 |
| | 08 | 3.25 | 5 | 41 | 9 |
| | 09 | 3.01 | 6 | 39 | 9 |
| Open low shrub | 10 | 2.65 | 5 | 60 | 9 |
| | 11 | 2.82 | 5 | 56 | 9 |
| | 12 | 3.60 | 4 | 108 | 9 |
| Grazed Bunchgrass | 16 | 3.09 | 4 | 129 | 9 |
| | 17 | 3.59 | 4 | 124 | 9 |
| | 18 | 3.33 | 5 | 158 | 9 |
| Ungrazed Bunchgrass | 19 | 3.00 | 3 | 119 | 9 |
| | 20 | 3.41 | 7 | 128 | 9 |
| | 21 | 2.21 | 3 | 60 | 9 |
| Ungrazed Sagebrush | 22 | 3.66 | 6 | 82 | 9 |
| | 23 | 3.07 | 5 | 80 | 9 |
| | 24 | 2.99 | 5 | 109 | 9 |
| Upland Sagebrush | 25 | 2.02 | 6 | 70 | 15 |
| (grazed) | 26 | 4.76 | 8 | 95 | 15 |

**Appendix 2. Indices of abundance, species richness, and species diversity.**

TABLE 4. Cumulative species diversity, richness, number of individuals and number of stations at each unit for point count detections within 100 m in 1997.

| Habitat | Site | Diversity $N_1$ | Species Richness | Total ind. (<100) | Number of Stations |
|---|---|---|---|---|---|
| Bitterbrush | 01 | 1.88 | 7 | 88 | 10 |
| | 02 | 1.32 | 3 | 32 | 9 |
| | 03 | 2.57 | 4 | 52 | 9 |
| Annual grass | 04 | 3.82 | 4 | 92 | 9 |
| | 05 | 4.02 | 5 | 97 | 9 |
| | 06 | 3.22 | 4 | 96 | 9 |
| Grazed Sagebrush | 07 | 2.47 | 5 | 40 | 9 |
| | 08 | 3.88 | 7 | 67 | 9 |
| | 09 | 2.31 | 5 | 53 | 9 |
| Open low shrub | 10 | 3.82 | 4 | 76 | 9 |
| | 11 | 2.84 | 4 | 57 | 9 |
| | 12 | 3.25 | 5 | 110 | 9 |
| Grazed Bunchgrass | 16 | 2.80 | 4 | 108 | 9 |
| | 17 | 3.16 | 4 | 151 | 9 |
| | 18 | 3.26 | 5 | 124 | 9 |
| Ungrazed Bunchgrass | 19 | 3.47 | 6 | 90 | 9 |
| | 20 | 2.75 | 5 | 107 | 9 |
| | 21 | 2.75 | 5 | 65 | 9 |
| Ungrazed Sagebrush | 22 | 3.75 | 8 | 66 | 9 |
| | 23 | 3.26 | 5 | 117 | 9 |
| | 24 | 3.47 | 6 | 125 | 9 |
| Upland Sagebrush | 25 | 3.12 | 7 | 124 | 15 |
| (grazed) | 26 | 4.29 | 7 | 98 | 15 |

**Appendix 3. Percent of points detected at and numbers of detections for dominant grassland birds.**

TABLE 1. Number of Grasshopper Sparrows, Horned Larks, and Western Meadowlarks detected within 100 meters, by plot, for 1995, 1996, 1997.

| | | Grasshopper Sparrow | | | Horned Lark | | | Western Meadowlark | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Hab[a] | Site (#pts.) | 1995 | 1996 | 1997 | 1995 | 1996 | 1997 | 1995 | 1996 | 1997 |
| AG | 04 (9) | 10 | 7 | 29 | 10 | 5 | 12 | 36 | 22 | 27 |
| | 05 (9) | 33 | 45 | 24 | 10 | 42 | 35 | 67 | 23 | 18 |
| | 06 (9) | 19 | 18 | 25 | 20 | 2 | 13 | 18 | 56 | 50 |
| GB | 16 (9) | 30 | 72 | 58 | 18 | 40 | 32 | 21 | 30 | 17 |
| | 17 (9) | 51 | 49 | 59 | 58 | 44 | 66 | 32 | 19 | 15 |
| | 18 (9) | 35 | 35 | 36 | 54 | 85 | 63 | 31 | 18 | 8 |
| NB | 19 (9) | 40 | 51 | 48 | 57 | 40 | 20 | 34 | 40 | 15 |
| | 20 (9) | 42 | 35 | 67 | 13 | 40 | 13 | 49 | 52 | 25 |
| | 21 (9) | 28 | 53 | 40 | 0 | 0 | 0 | 35 | 18 | 16 |
| OS | 10 (9) | 3 | 22 | 18 | 6 | 1 | 20 | 45 | 34 | 27 |
| | 11 (9) | 1 | 5 | 7 | 2 | 2 | 2 | 31 | 37 | 33 |
| | 12 (9) | 23 | 41 | 44 | 45 | 33 | 23 | 39 | 33 | 40 |
| BB | 01 (10) | 0 | 1 | 0 | 0 | 0 | 0 | 83 | 44 | 76 |
| | 02 (9) | 0 | 1 | 0 | 0 | 0 | 0 | 43 | 26 | 30 |
| | 03 (9) | 0 | 0 | 12 | 0 | 1 | 0 | 38 | 51 | 34 |
| GS | 07 (9) | 0 | 0 | 0 | 1 | 5 | 2 | 33 | 43 | 30 |
| | 08 (9) | 0 | 0 | 0 | 0 | 0 | 2 | 42 | 24 | 37 |
| | 09 (9) | 0 | 2 | 0 | 0 | 0 | 0 | 24 | 25 | 38 |
| NS | 22 (9) | 19 | 21 | 19 | 9 | 13 | 6 | 46 | 41 | 34 |
| | 23 (9) | 28 | 36 | 47 | 17 | 10 | 27 | 42 | 40 | 40 |
| | 24 (9) | 26 | 37 | 27 | 12 | 21 | 31 | 38 | 57 | 60 |
| US | 25 (15) | - | 18 | 11 | - | 2 | 0 | - | 58 | 85 |
| | 26 (15) | - | 8 | 2 | - | 0 | 0 | - | 40 | 41 |

[a] habitat: AG=annual grass, BB= bitterbrush, NB= ungrazed bunchgrass, OS= open low shrub, GS= grazed sagebrush, NS= ungrazed sagebrush, US= upland sagebrush (grazed)
[b] not censused in 1995

[b] not censused in 1995

**Appendix 3. Percent of points detected at and numbers of detections for dominant grassland birds.**

TABLE 2. Percent of points in each habitat where Grasshopper Sparrow, Horned Lark, and Western Meadowlark were detected within 100 meters, for each year.

| | | Grasshopper Sparrow | | | Horned Lark | | | Western Meadowlark | | |
|---|---|---|---|---|---|---|---|---|---|---|
| hab[a] | #pts. | 1995 | 1996 | 1997 | 1995 | 1996 | 1997 | 1995 | 1996 | 1997 |
| AG | 27 | 88.9 | 87.5 | 100 | 74.1 | 51.9 | 77.8 | 85.2 | 85.2 | 96.3 |
| GB | 27 | 96.3 | 100 | 100 | 88.9 | 96.3 | 100 | 88.9 | 88.9 | 66.7 |
| NB | 25 | 100 | 100 | 100 | 56 | 64 | 52 | 96.0 | 100 | 88 |
| OS | 27 | 40.7 | 77.8 | .78 | 59.3 | 44.4 | 59.3 | 96.3 | 96.3 | 96.3 |
| BB | 28 | 0 | 3.6 | 21.4 | 0 | 3.6 | 0 | 96.4 | 85.7 | 92.9 |
| GS | 23 | 0 | 8.7 | 0 | 4 | 8.7 | 4.3 | 95.7 | 91.3 | 100 |
| NS | 29 | 93.1 | 82.8 | 89.7 | 62.1 | 75.9 | 69.0 | 96.6 | 96.6 | 96.6 |
| US | 34 | - | 23.5 | 26.5 | - | 6.5 | 2.9 | - | 91.2 | 91.2 |

Table 10 Total detections within 100m for each habitat and year, and the percent of those detections made by each of 3 dominant species. The last column (tot%) is the sum of the previous 3.

| hab[a] | YEAR | TOT DET | %GRSP | %HOLA | %WEME | TOT% |
|---|---|---|---|---|---|---|
| AG | 1995 | 297 | 20.87 | 13.47 | 40.74 | 75.08 |
| | 1996 | 277 | 22.74 | 17.69 | 36.46 | 76.90 |
| | 1997 | 285 | 27.37 | 21.05 | 33.33 | 81.75 |
| GB | 1995 | 361 | 32.13 | 36.01 | 23.27 | 91.41 |
| | 1996 | 411 | 33.58 | 41.12 | 16.30 | 91.01 |
| | 1997 | 383 | 39.95 | 42.04 | 10.44 | 92.43 |
| NB | 1995 | 298 | 36.05 | 23.81 | 36.39 | 96.26 |
| | 1996 | 286 | 36.71 | 27.62 | 33.92 | 98.25 |
| | 1997 | 245 | 60.00 | 12.65 | 20.41 | 93.06 |
| OS | 1995 | 234 | 11.54 | 22.65 | 49.14 | 83.33 |
| | 1996 | 224 | 26.79 | 16.07 | 46.43 | 89.29 |
| | 1997 | 243 | 28.40 | 18.52 | 41.15 | 88.07 |
| BB | 1995 | 204 | 0 | 0 | 80.34 | 80.34 |
| | 1996 | 177 | 0.56 | 0.56 | 68.36 | 69.49 |
| | 1997 | 172 | 6.98 | 0 | 81.40 | 88.37 |
| GS | 1995 | 127 | 0 | 0.79 | 59.84 | 61.42 |
| | 1996 | 125 | 1.6 | 4.0 | 66.4 | 72 |
| | 1997 | 132 | 0 | 1.52 | 74.24 | 75.76 |
| NS | 1995 | 267 | 28.84 | 14.23 | 51.31 | 94.38 |
| | 1996 | 292 | 27.74 | 15.41 | 51.71 | 94.86 |
| | 1997 | 325 | 30.77 | 20.31 | 43.08 | 94.15 |
| US | 1996 | 180 | 7.22 | 1.11 | 59.44 | 67.78 |
| | 1997 | 251 | 5.18 | 0.81 | 52.99 | 58.96 |

## Appendix 4. Burrowing Owl use, availability, and reoccupancy of badger burrows.

TABLE 1a. Availability status of 1995 owl burrows in April 1996 at Juniper Canyon sectors.

| | *n* | open 96 | | silted 96 | | trampled 96 | | other 96 * | |
|---|---|---|---|---|---|---|---|---|---|
| | (1995) | # | % | # | % | # | % | # | % |
| North Juniper | 21 | 8 | 38.10 | 5 | 23.81 | 6 | 28.57 | 2 | 9.52 |
| Middle Juniper | 10 | 7 | 70.00 | 0 | 0.00 | 3 | 30.00 | 0 | 0.00 |
| South Juniper | 9 | 8 | 88.88 | 1 | 1.11 | 0 | 0.00 | 0 | 0.00 |
| NJ, MJ, SJ | 40 | 23 | 57.50 | 6 | 15.00 | 9 | 22.50 | 2 | 5.00 |

TABLE 1b. Availability status of 1995 owl burrows in April 1997 at Juniper Canyon sectors.

| | *n* | open 97 | | silted 97 | | trampled 97 | | other 97 * | |
|---|---|---|---|---|---|---|---|---|---|
| | (1995) | # | % | # | % | # | % | # | % |
| North Juniper | 21 | 3 | 14.28 | 6 | 28.57 | 10 | 47.62 | 2 | 9.52 |
| Middle Juniper | 10 | 5 | 50.00 | 2 | 20.00 | 3 | 30.00 | 0 | 0.00 |
| South Juniper | 9 | 4 | 44.44 | 5 | 55.55 | 0 | 0.00 | 0 | 0.00 |
| NJ, MJ, SJ | 40 | 12 | 30.00 | 13 | 32.50 | 13 | 32.50 | 2 | 5.00 |

* One burrow was destroyed by human activity; the other was blocked by Russian Thistle.

TABLE 1c. Availability status of 1996 owl burrows in April 1997.

| | *N* | open 97 | | silted 97 | | trampled 97 | |
|---|---|---|---|---|---|---|---|
| | (1996) | # | % | # | % | # | % |
| North Juniper | 11 | 6 | 54.50 | 4 | 36.40 | 1 | 9.10 |
| Middle Juniper | 16 | 9 | 56.33 | 5 | 31.25 | 2 | 12.50 |
| South Juniper | 30 | 25 | 83.33 | 5 | 16.67 | 0 | 0.00 |
| Valley sector | 6 | 2 | 33.33 | 2 | 33.33 | 2 | 2.00 |
| Well Spring | 8 | 8 | 100.0 | 0 | 0.00 | 0 | 0.00 |
| Total | 71 | 50 | 70.40 | 16 | 24.60 | 5 | 7.00 |
| NJ, MJ, SJ | 57 | 40 | 70.20 | 14 | 22.50 | 3 | 5.26 |

TABLE 2a. Reuse of 1995 Burrowing Owl holes in 1996.

| **Sector** | **Number open** | **number used** | **percent used** |
|---|---|---|---|
| North Juniper | 8 | 8 | 100 |
| Middle Juniper | 7 | 7 | 100 |
| South Juniper | 8 | 6 | 75 |
| Valley Sector | 1 | 1 | 100 |
| **Total** | **24** | **22** | **91.67** |

**Appendix 4. Burrowing Owl use, availability, and reoccupancy of badger burrows (cont').**

TABLE 2b. Reuse of 1996 Burrowing Owl holes in 1997.

| Sector | Number open | number used | percent used |
|---|---|---|---|
| North Juniper | 6 | 3 | 50 |
| Middle Juniper | 9 | 9 | 100 |
| South Juniper | 25 | 12 | 48 |
| Valley Sector | 2 | 1 | 50 |
| Well Spring | 8 | 6 | 75 |
| **Total** | **50** | **31** | **62** |

TABLE 3. Badger burrow use of and availability for Burrowing Owl in North and middle Juniper Canyon, and the Valley Sector in 1996 and 1997.

| | 1996 (960 ha) | 1997 (800 ha) |
|---|---|---|
| Total burrows | 738 | 2072 |
| Total burrows / 100 ha | 76.87 | 259 |
| Number open burrows / 100 ha | 34.2 | 108.2 |
| Percent open burrows | 44.04% | 41.8% |
| Number partially closed / 100 ha | 10.7 | 16.6 |
| Percent partially closed burrows | 13.96% | 6.42% |
| Number closed burrows / 100 ha | 9.2 | 56.9 |
| Percent closed burrows | 11.92% | 21.96% |
| Number fully closed burrows / 100 ha | 23.1 | 77.5 |
| Percent fully closed burrows | 30.08% | 29.92% |
| Number of burrows in use by Burrowing Owl / 100 ha | 3.3 | 2.6 |
| Percent open burrows used by Burrowing Owl | 9.84% | 2.42% |
| Number open burrows with badger sign | 4.9 | 56.6 |
| Percent open burrows with badger sign | 14.46% | 52.3% |
| Number available burrows / 100 ha | 28.6 | 50.75 |
| Percent available burrows used by BUOW | 11.63% | 5.17% |
| Number partially to fully closed burrows that were trampled by cattle / 100 ha | 10.4 | 47.3 |
| Percent of all partially to fully closed burrows damaged by cattle | 57.39% | 60.97% |
| Percent of all burrows damaged by cattle | 31.13% | 18.24% |

**Appendix 5. Vegetation and habitat variables used in modeling habitat associations.**

TABLE 1. List of vegetation and habitat variables used in modeling habitat associations for occurrence and abundance of Grasshopper Sparrow, Horned Lark, Sage Sparrow, Lark Sparrow, Long-billed Curlew, and Western Meadowlark (abundance only).

Ground Cover variables:

total green cover (below 50 cm) (%)
total grass cover (excluding Sandberg's bluegrass, %)
annual grass cover (%)
perennial grass cover (%)
Sandberg's bluegrass cover (%)
forb cover (%)
snakeweed cover (%)
litter (%)
cryptobiotic crust (%)
bare ground (%)
open ground (cryptobiotic crust + bare ground, %)

Shrub variables:

shrub cover, all species(%)
shrub density (# of shrubs intersected in 200 meters)
shrub stems <2.5 cm @ 10 cm (# counted in the three 5 meter diameter plots)
shrub stems >2.5 cm @ 10 cm (#)
shrub height (mean shrub height from 200 meters of intercept)

sagebrush cover (%)
sagebrush density (# of sagebrush intersected in 200 meters)
sagebrush stems <2.5 cm @ 10 cm (#)
sagebrush stems >2.5 cm @ 10 cm (#)
sagebrush height (mean shrub height from 200 meters of intercept)

bitterbrush cover (%)
bitterbrush density (# of shrubs intersected in 200 meters)
bitterbrush stems <2.5 cm @ 10 cm (#)
bitterbrush stems >2.5 cm @ 10 cm (#)
bitterbrush height (mean shrub height from 200 meters of intercept)

rabbitbrush cover (%)
rabbitbrush density (# of rabbitbrush intersected in 200 meters)
rabbitbrush stems <2.5 cm @ 10 cm (#)
rabbitbrush stems >2.5 cm @ 10 cm (#)
rabbitbrush height (mean shrub height from 200 meters of intercept)

**Appendix 6. Significance levels of univariate regressions used in building habitat association models.**

TABLE 1. Significance levels for univariate logistic regression (occurrence) using 75 points in sagebrush habitat with at least 5% shrub cover.

| Variable | GRSP, *P* > LRS | HOLA, *P* > LRS | LASP, *P* > LRS | SAGS, *P* > LRS |
|---|---|---|---|---|
| total green | .0012 | .0004 | -- | .0000 |
| total grass | .0010 | .0080 | -- | .0007 |
| Perennial grass | .0000 | .0000 | -- | .0116 |
| Sandberg's bluegrass | -- | .0006 | -- | -- |
| open Ground | .0099 | -- | -- | .0001 |
| Litter | -- | -- | -- | .0025 |
| shrub "snags" | -- | -- | .0246 | -- |
| shrub cover | .0017 | -- | .0092 | .0001 |
| shrub density | .0003 | .0289 | -- | .0000 |
| shrub height | .0116 | .0019 | -- | -- |
| sagebrush cover | .0000 | .0235 | .0039 | .0001 |
| sagebrush density | .0000 | .0018 | -- | .0000 |
| sagebrush height (cm) | -- | .0204 | -- | -- |
| Sagebrush stems >2.5 cm @ 10cm | .0022 | -- | -- | .0002 |

TABLE 2. Matrix of *P* values for univariate logistic regression using all 220 points. GRSP detected at 151, and HOLA at 123 points.

| Variable | GRSP, *P* > LRS | HOLA, *P* > LRS |
|---|---|---|
| total green cover | .0000 | .0000 |
| total grass cover | .0000 | .0000 |
| perennial grass cover | .0000 | .0000 |
| forb cover | .0019 | .0002 |
| Cryptobiotic crust | -- | .0375 |
| Litter | -- | .0221 |
| shrub "snags" | .0000 | .0002 |
| shrub cover | .0000 | .0000 |
| shrub density | .0000 | .0000 |
| shrub height | .0000 | .0000 |
| shrub stems <2.5cm @ 10cm | .0048 | .0311 |
| shrub stems >2.5cm @ 10cm | .0000 | .0000 |
| Sagebrush cover | .0000 | .0000 |
| Sagebrush density | .0000 | .0000 |
| Sagebrush height | .0000 | .0002 |
| sagebrush stems <2.5cm @ 10cm | .0000 | .0003 |
| sagebrush stems >2.5cm @ 10cm | .0000 | .0000 |
| rabbitbrush height | .0208 | -- |
| bitterbrush cover | .0000 | .0000 |
| bitterbrush density | .0000 | .0000 |
| bitterbrush height | .0000 | .0000 |
| bitterbrush stems <2.5cm @ 10cm | .0000 | .0000 |
| bitterbrush stems >2.5cm @ 10cm | .0000 | .0000 |

**Appendix 6. Significance levels of univariate regressions used in building habitat association models.**

TABLE 3. Correlation coefficients and significance of 19 habitat variables at points where a given species was detected at least once during the study within 100 m.

| | GRSP (n=151) | | HOLA (n=123) | | LBCU (n=90) | | LASP n=(66) | | SAGS (n=21) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Habitat variables | r | $P > F$ | r | $P > F$ | r | $P > F$ | r | $P > F$ | r | $P > F$ |
| total green cover | .1952 | * | -- | --- | .2088 | * | -.3653 | * | -.4951 | ** |
| total grass cover | .3968 | *** | -- | -- | -- | -- | -.3576 | * | -- | -- |
| annual grass cover | -- | -- | -- | -- | -- | -- | -- | -- | -.4675 | * |
| perennial grass cover | .5822 | *** | .4737 | *** | -.2401 | * | -.2933 | * | -- | -- |
| forb cover | .2454 | .** | -.2992 | *** | .2103 | * | -- | -- | -- | -- |
| cryptobiotic crust | .2439 | ** | -- | -- | -.2247 | * | -- | -- | -- | -- |
| open ground | .2146 | * | .1780 | * | -- | -- | .2702 | * | .4584 | * |
| Litter | -- | -- | -.3119 | *** | -- | -- | -- | -- | -- | -- |
| shrub "snags" | -.4012 | *** | -.2806 | ** | -.2224 | * | -- | -- | -- | -- |
| shrub cover | -.4502 | *** | -.4055 | *** | -.3222 | ** | -- | -- | -- | -- |
| shrub density | -.3825 | *** | -.3631 | *** | -.3019 | * | .2842 | * | -- | -- |
| shrub height | -.3544 | .*** | -.4055 | *** | -.2359 | * | -- | -- | -- | -- |
| shrub stems <2.5cm | -2174 | * | -.1978 | * | -- | -- | -- | -- | -- | -- |
| shrub stems >2.5cm | -.3858 | *** | -.3867 | *** | -.2277 | * | -- | -- | -- | -- |
| sagebrush cover | -.2865 | *** | -.3607 | *** | -.3137 | ** | .2836 | * | -- | -- |
| sagebrush density | -.2634 | ** | -.3564 | *** | -.2840 | * | -.3005 | * | .5193 | * |
| sagebrush height | -- | -- | -.2717 | ** | -.3021 | * | -- | -- | .5181 | * |
| rabbitbrush cover | -.1819 | * | -- | -- | -- | -- | -- | -- | -- | -- |
| rRabbitbrush height | -.3752 | *** | -- | -- | -- | -- | -- | - | -- | -- |
| sagebrush stems <2.5cm | -.2089 | * | -.2546 | * | -- | -- | -- | -- | .4652 | * |
| sagebrush stems >2.5cm | -.2547 | ** | -.3197 | *** | -.2129 | * | -- | -- | -- | -- |

* = $P < .05$, ** = $P < .003$ level, *** = $P < .001$

**Appendix 6. Significance levels of univariate regressions used in building habitat association models.**

TABLE 4. Correlation coefficients and *P* values for univariate linear regression of Western Meadowlark abundance and habitat variables. Only significant variables are shown.

| Variable | r | *P* > F |
|---|---|---|
| annual grass cover | .2140 | .0014 |
| perennial grass cover | -.1372 | .0421 |
| bare ground | -.1792 | .0077 |
| open ground | -.2353 | .0004 |
| Litter | .2418 | .0003 |
| shrub "snags" | .1419 | .0354 |
| shrub cover | .1330 | .0488 |
| shrub height | .3093 | .0000 |
| bitterbrush cover | .2271 | .0007 |
| bitterbrush density | .2484 | .0002 |
| bitterbrush height | .2177 | .0012 |
| bitterbrush stems <2.5cm @ 10cm | .1785 | .0080 |
| bitterbrush stems >2.5cm @ 10cm | .2159 | .0013 |

TABLE 5. Correlation coefficients and *P* values for univariate linear regression of Long-billed Curlew abundance and habitat variables at the 79 grassland points. Only significant variables are shown.

| Variable | *P* > LRS |
|---|---|
| annual grass cover | .0000 |
| perennial grass cover | .0000 |
| Sandberg's blugrass cover | .0438 |
| forb cover | .0000 |
| bare ground | .0249 |
| cryptobiotic crust | .0001 |
| Litter | .0000 |
| rabbitbrush cover | .0003 |
| rabbitbrush density | .0002 |
| rabbitbrush height | .0001 |

**Appendix 7. Select vegetation variables by habitat.**

TABLE 1. Select vegetation variable means with standard deviation, and range for 28 bitterbrush points. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$), plots with a + or - symbol have means greater or less than the others.

| Variable | mean (SD) $n = 28$ | Range | plot 1 | plot 2 | plot 3 |
|---|---|---|---|---|---|
| total grass cover | 16.22 (7.96) | 5.4 - 35.8 | a | a | - |
| annual grass cover | 14.92 (8.27) | 1.5 - 35.8 | + | a | a |
| perennial grass cover | 0.05 (0.13) | 0 - 0.6 | a | + | a |
| Sandberg's bluegrass cover | 4.54 (3.49) | 0 - 12.7 | | | |
| forb cover | 8.30 (4.67) | 2.7 - 21.7 | | | |
| cyptobiotic crust | 10.81 (6.01) | 3.9 - 25.8 | a | a | a |
| bare ground | 41.22 (11.43) | 20.4 - 61.3 | - | a | a |
| open ground | 52.03 (12.06) | 26.3 - 72.6 | - | a | a |
| litter | 38.18 (9.88) | 20.3 - 58.8 | + | a | a |
| shrub "snag" density | 12.39 (10.64) | 0 – 40 | - | a | a |
| shrub cover | 20.77 (8.27) | 6.1 - 36.1 | a | + | a |
| shrub density | 39.64 (14.79) | 13 - 71 | a | + | a |
| shrub height | 82.27 (14.55) | 53.6 - 108.1 | + | a | a |
| sagebrush cover | - | - | | | |
| sagebrush density | - | - | | | |
| sagebrush height | - | - | | | |
| rabbitbrush cover | 8.87 (8.63) | 0 - 27.1 | a | + | a |
| rabbitbrush height | 54.32 (20.11) | 0 - 80.4 | a | a | a |
| bitterbrush | 11.89 (7.77) | 1 - 30.4 | a | a | a |
| bitterbrush density | 19.00 (12.42) | 2 - 44 | + | a | a |
| bitterbrush height | 105.74 (19.64) | 82 – 176 | a | a | - |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 2. Select vegetation variable means with standard deviation, and range for 27 annual grass point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others.

| Variable | mean (SD) $n = 27$ | range | plot 4 | plot 5 | plot 6 |
|---|---|---|---|---|---|
| total grass cover | 26.98 (13.71) | 11.7 - 57.9 | a | + | a |
| annual grass cover | 21.86 (13.71) | 2.8 - 53.6 | a | + | a |
| perennial grass cover | 0.59 (1.68) | 0 - 8.5 | a | a | a |
| Sandberg's bluegrass cover | 4.54 (3.49) | 0 - 12.7 | | | |
| forb cover | 15.13 (7.03) | 4.7 - 27.7 | | | |
| cyptobiotic crust | 13.33 (8.75) | 1.5 - 38 | a | a | a |
| bare ground | 26.36 (17.6) | 7.3 - 77.1 | a | - | a |
| open ground | 39.69 (17.39) | 13.4 - 78.6 | a | - | a |
| litter | 47.35 (17.08) | 11.6 - 74.2 | a | a | a |
| shrub "snag" density | 0.81 (1.55) | 0 - 6 | a | + | a |
| shrub cover | 1.04 (2.07) | 0 - 10.24 | a | a | a |
| shrub density | 3.18 (6.31) | 0 - 32 | a | a | a |
| shrub height | 32.47 (25.09) | 0 - 64 | a | a | a |
| sagebrush cover | 0.08 (0.41) | 0 - 2.13 | a | a | a |
| sagebrush density | 0.30 (1.54) | 0 - 8 | a | a | a |
| sagebrush height | 2.26 (11.74) | 0 - 61 | a | a | a |
| rabbitbrush cover | 0.96 (1.71) | 0 - 8.11 | a | a | a |
| rabbitbrush height | 32.46 (25.08) | 0 - 64 | a | a | a |
| bitterbrush | - | - | | | |
| bitterbrush density | - | - | | | |
| bitterbrush height | - | - | | | |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 3. Select vegetation variable means with standard deviation, and range for grazed bunchgrass. Plots which share the same letter do not differ significantly (ANOVA, $P > 0.05$). Plots with a + or - symbol have means greater or less than the others.

| Variable | mean (SD), *n* = 27 | range | plot 16 | plot 17 | plot 18 |
|---|---|---|---|---|---|
| total grass cover | 16.28 (5.57) | 6.7 - 28.8 | a | a | a |
| annual grass cover | 2.16 (1.33) | 0 - 5.2 | a | a | a |
| perennial grass cover | 13.10 (5.59) | 1.5 - 24.3 | a | a | b |
| Sandberg's bluegrass cover | 0.98 (1.39) | 0 - 5.5 | a | ab | a |
| forb cover | 7.52 (4.47) | 2.3 - 20 | a | a | a |
| cyptobiotic crust | 8.23 (6.96) | 0 - 35 | a | a | a |
| bare ground | 57.97 (10.71) | 40.9 - 75.3 | a | a | a |
| open ground | 66.26 (8.72) | 46.8 - 77.8 | - | a | a |
| litter | 13.90 (6.42) | 4.6 - 22.8 | a | + | a |
| shrub "snag" density | 0.26 (0.94) | 0 - 4 | a | a | a |
| shrub cover | 0.59 (1.09) | 0 - 3.9 | a | + | a |
| shrub density | 3.11 (6.10) | 0 - 21 | a | + | a |
| shrub height | 17.26 (21.94) | 0 - 56 | b | a | ab |
| sagebrush cover | - | - | | | |
| sagebrush density | - | - | | | |
| sagebrush height | - | - | | | |
| rabbitbrush cover | 0.59 (1.09) | 0 - 3.9 | a | + | a |
| rabbitbrush height | 17.26 (21.94) | 0 - 56 | a | a | a |
| bitterbrush | - | - | | | |
| bitterbrush density | - | - | | | |
| bitterbrush height | - | - | | | |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 4. Select vegetation variable means with standard deviation, and range for grazed sagebrush point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others.

| Variable | mean (SD) $n = 23$ | range | plot 7 | plot 8 | plot 9 |
|---|---|---|---|---|---|
| total grass cover | 13.87 (11.37) | 0.7 - 50.2 | a | a | a |
| annual grass cover | 11.12 (11.08) | 0.7 - 50.2 | a | a | a |
| perennial grass cover | 0.20 (0.37) | 0 - 1.4 | | | |
| Sandberg's bluegrass cover | 2.30 (4.07) | 0 - 17.2 | - | a | a |
| forb cover | 6.92 (5.90) | 0.8 - 21.6 | | | |
| cyptobiotic crust | 31.02 (26.15) | 0 - 78.1 | - | a | a |
| bare ground | 25.12 (25.32) | 0.9 - 93.2 | a | a | a |
| open ground | 56.14 (32.59) | 2.9 - 122.8 | a | a | a |
| litter | 37.19 (25.05) | 1.5 - 85.8 | a | a | a |
| shrub "snag" density | 16.65 (14.93) | 0 - 50 | a | a | a |
| shrub cover | 19.90 (12.08) | 0 - 40.02 | a | a | a |
| shrub density | 42.30 (26.06) | 0 - 107 | a | a | a |
| shrub height | 84.40 (33.27) | 0 - 135.6 | a | a | a |
| sagebrush cover | 19.86 (12.08) | 0 - 40 | a | a | a |
| sagebrush density | 42 (25.95) | 0 - 107 | a | a | a |
| sagebrush height | 84.68 (33.27) | 0 - 135.6 | a | a | a |
| rabbitbrush cover | 0.04 (0.09) | 0 - 0.37 | a | a | a |
| rabbitbrush height | 7.86 (18.41) | 0 - 65 | a | a | a |
| bitterbrush | - | - | | | |
| bitterbrush density | - | - | | | |
| bitterbrush height | - | - | | | |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 5. Select vegetation variable means with standard deviation, and range for ungrazed bunchgrass point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others.

| Variable | mean (SD) $n = 25$ | range | plot 19 | plot 20 | plot 21 |
|---|---|---|---|---|---|
| total grass cover | 31.22 (7.60) | 15.8 - 46.8 | + | a | a |
| annual grass cover | 1.98 (2.66) | 0 - 9 | a | a | a |
| perennial grass cover | 26.82 (5.81) | 14.6 - 39.4 | a | a | a |
| Sandberg's bluegrass cover | 2.47 (2.00) | 0.5 - 8.5 | + | a | a |
| forb cover | 2.56 (1.09) | 0.7 - 5 | a | a | a |
| cyptobiotic crust | 65.87 (15.34) | 26.3 - 85.7 | a | ab | b |
| bare ground | 3.57 (3.12) | 0.3 -13.4 | a | a | a |
| open ground | 69.45 (13.50) | 36.2 - 91.3 | a | b | ab |
| litter | 7.92 (8.97) | 0.7 - 42.7 | b | ab | a |
| shrub "snag" density | .48 (1.29) | 0 - 5 | a | a | a |
| shrub cover | 1.46 (2.11) | 0 - 8.3 | a | a | a |
| shrub density | 4.8 (6.57) | 0 - 22 | a | a | a |
| shrub height | 51.08 (39.25) | 0 - 159.5 | a | b | ab |
| sagebrush cover | 0.93 (1.96) | 0 - 8.3 | a | a | a |
| sagebrush density | 2.56 (5.40) | 0 - 22 | a | a | a |
| sagebrush height | 34.81 (47.06) | 0 - 159.5 | a | a | a |
| rabbitbrush cover | .53 (0.90) | 0 - 2.7 | a | a | a |
| rabbitbrush height | 21.38 (25.90) | 0 - 77 | a | a | a |
| bitterbrush | - | - | | | |
| bitterbrush density | - | - | | | |
| bitterbrush height | - | - | | | |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 6. Select vegetation variable means with standard deviation, and range for ungrazed sagebrush point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others. (2 points included from plot 20)

| Variable | mean (SD) $n = 29$ | range | plot 22 | plot 23 | plot 24 |
|---|---|---|---|---|---|
| total grass cover | 22.80 (14.55) | 3.8 - 58.8 | - | a | a |
| annual grass cover | 10.3 (15.56) | 0.1 - 57.5 | a | a | a |
| perennial grass cover | 10.63 (10.58) | 0 - 34.0 | a | ab | b |
| Sandberg's bluegrass cover | 1.62 (2.11) | 0 - 8.9 | a | a | + |
| forb cover | 3.74 (2.53) | 0.9 - 11.1 | a | a | a |
| cyptobiotic crust | 46.19 (25.97) | 5 - 82.3 | a | a | a |
| bare ground | 20.51 (22.99) | 0.5 - 76.4 | + | a | a |
| open ground | 66.71 (19.27) | 12.6 - 86.1 | a | a | a |
| litter | 20.53 (17.45) | 2.5 - 66.7 | a | a | a |
| shrub "snag" density | 17.86 (25.97) | 0 - 140 | a | a | a |
| shrub cover | 17.00 (13.02) | 0 - 46.5 | a | b | ab |
| shrub density | 39.52 (25.97) | 0 - 97 | a | b | ab |
| shrub height | 67.81 (19.93) | 0 - 98.1 | a | a | a |
| sagebrush cover | 13.85 (12.51) | 0 - 42.5 | a | a | a |
| sagebrush density | 29.90 (24.17) | 0 - 97 | a | a | a |
| sagebrush height | 69.41 (27.90) | 0 - 109.9 | a | a | a |
| rabbitbrush cover | 3.16 (6.87) | 0 - 29.7 | + | a | a |
| rabbitbrush height | 22.73 (23.31) | 0 - 60 | a | a | a |
| bitterbrush | - | - | | | |
| bitterbrush density | - | - | | | |
| bitterbrush height | - | - | | | |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 7. Select vegetation variable means with standard deviation, and range for open low shrub point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others.

| Variable | Mean (SD) $n = 27$ | Range | plot 10 | plot 11 | plot 12 |
|---|---|---|---|---|---|
| total grass cover | 16.15 (5.50) | 6.1 – 26.3 | a | a | a |
| annual grass cover | 9.78 (5.67) | 1.3 – 22.8 | a | a | a |
| perennial grass cover | 4.19 (3.63) | 0 – 14.9 | a | - | a |
| Sandberg's bluegrass cover | 1.33 (1.49) | 0 - 6.2 | a | a | a |
| forb cover | 11.51 (4.51) | 4.9 – 24 | a | a | a |
| cyptobiotic crust | 6.53 (4.64) | 1.3 – 15.8 | a | a | a |
| bare ground | 51.29 (14.09) | 19 – 69.6 | a | a | a |
| open ground | 57.82 (12.40) | 29.8 –73.2 | a | a | a |
| Litter | 29.66 (11.79) | 11.4 –62.83 | a | a | a |
| shrub "snag" density | 12.78 (6.88) | 0 – 25 | a | a | a |
| shrub cover | 11.85 (6.54) | 2.8 – 26 | a | a | a |
| shrub density | 35.33 (19.31) | 7 – 73 | ab | a | b |
| shrub height | 54.83 (6.82) | 44.8 – 71.9 | a | a | a |
| sagebrush cover | 0.53 (2.70) | 0 – 14 | a | a | a |
| sagebrush density | 0.67 (3.27) | 0 - 17 | a | a | a |
| sagebrush height | 5.90 (22.58) | 0 - 107.2 | a | a | a |
| rabbitbrush cover | 10.03 (5.71) | 2.8 - 26 | ab | a | b |
| rabbitbrush height | 51.60 (4.42) | 44.82 - 63.57 | a | a | a |
| bitterbrush | 1.29 (2.73) | 0 - 12.9 | a | a | a |
| bitterbrush density | 2.33 (4.59) | 0 - 17 | a | a | a |
| bitterbrush height | 34.79 (47.19) | 0 - 129 | a | ab | b |

**Appendix 7. Select vegetation variables by habitat (cont').**

TABLE 8. Select vegetation variable means with standard deviation, and range for upland sagebrush point counts. Plots which share the same letter do not differ significantly (ANOVA, $P > .05$). Plots with a + or - symbol have means greater or less than the others (4 of the points are from plot 8).

| Variable | Mean (SD) $n = 27$ | Range | Plot 25(15) | Plot 26(15) |
|---|---|---|---|---|
| total grass cover | 9.40 (3.95) | 1.6 - 20.8 | a | a |
| annual grass cover | 4.50 (3.40) | 0.5 - 14.6 | a | a |
| perennial grass cover | 0.47 (0.76) | 0 - 4.2 | a | a |
| Sandberg's bluegrass cover | 4.59 (3.14) | 0 - 12.75 | a | a |
| forb cover | 1.79 (2.0) | 0.8 - 12.1 | a | a |
| cyptobiotic crust | 52.16 (30.17) | 3.6 - 93.2 | a | a |
| bare ground | 16.76 (25.44) | 0 - 90.9 | - | + |
| open ground | 68.92 (27.59) | 8.4 - 96.3 | - | + |
| litter | 32.08 (28.30) | 3.4 - 91.7 | + | - |
| shrub "snag" density | 16.97 (10.55) | 3 - 42 | a | a |
| shrub cover | 24.16 (11.50) | 5.8 - 49 | - | + |
| shrub density | 72.18 (32.95) | 11 - 162 | - | + |
| shrub height | 79.60 (11.24) | 56.9 - 103.5 | + | - |
| sagebrush cover | 23.75 (11.92) | 2.6 - 49 | - | + |
| sagebrush density | 70.76 (34.03) | 4 - 162 | - | + |
| sagebrush height | 81.11 (12.45) | 56.9 - 107.5 | + | - |
| rabbitbrush cover | 0.41 (.98) | 0 - 4.6 | - | + |
| rabbitbrush height | 17.33 (26.16) | 0 - 75.5 | - | + |
| bitterbrush | - | - | | |
| bitterbrush density | - | - | | |
| bitterbrush height | - | - | | |

**Appendix 8. Species for which sightings are recorded on "wildlife observation" forms.**

Mammals

Long-tailed Weasel
Mule Deer
Nuttall's Cottontail
Porcupine
Washington Ground Squirrel

Birds

Bald Eagle
Black-throated Sparrow
California Quail
Empidonax spp.
Golden Eagle
Gray Partridge
Killdeer
Merlin
Prairie Falcon
Red-tailed Hawk
Sage Thrasher
Say's Phoebe
Short-eared Owl
Turkey Vulture

Reptiles

Garter Snake
Rubber Boa
Short-horned Lizard
Side-blotched Lizard
Western Fence Lizard
Western Rattlesnake
Yellow-bellied Racer

Amphibians

Spade-foot toad

*Any observations of rare or unusual species are also recorded.

**Appendix 9. Standard names.**

TABLE 1. Common and standard names for mammal species mentioned in this report.

| | |
|---|---|
| Coyote | *Canis latrans* |
| Great Basin pocket mouse | *Perognathus parvus* |
| Bushy-tailed wood-rat | *Neotoma fuscipes* |
| Nuttal's cottontail | *Sylvilagus nuttalli* |
| Badger | *Taxidea taxus* |
| Washington Ground Squirrel | *Spermophilus washingtoni* |

TABLE 2. Common and standard names for reptile and amphibian species mentioned in this report.

| | |
|---|---|
| Garter snake | *Thamnophis elegans* |
| Yellow-bellied racer | *Coluber constrictor* |
| Gopher snake | *Pituophis melanoleucus* |
| Western rattlesnake | *Crotalus viridis* |
| Sagebrush lizard | *Sceloperus graciosus* |
| Western fence lizard | *Sceloperus occidentalis* |
| Side-blotched lizard | *Uta stansburiana* |
| Short-horned lizard | *Phrynosoma douglassi* |
| Great Basin spadefoot toad | *Scaphiopus intermontanus* |

TABLE 3. List of plant species common names, standard names, and four letter codes used for data entry and notes.

| | | | |
|---|---|---|---|
| Family Boaraginacieae | | | |
| | Tarweed fiddleneck | *Amsinckia lycopsoides* | AMLY |
| | Cryptantha | *Cryptantha intermedia* | CRIN |
| Family Caparidacieae | | | |
| | Yellow bea-plant | *Cleome lutea* | CLLU |
| Family Cactaceae | | | |
| | Prickly pear cactus | *Opuntia polycantha* | OPPO |
| Family Chenopodiacieae | | | |
| | Russian thistle | *Sasola Kali* | SAKA |
| | Greasewood | *Sarcobatus vermiculatus* | SAVE |
| Camily Compositae | | | |
| | Yarrow | *Achillea millefolium* | ACME |
| | Big sagebrush | *Artemesia tridentata* | ARTR |
| | Carey's balsamroot | *Balsamorhiza careyana* | BACA |
| | Knapweed spp. | *Centaura spp.* | CENT |
| | Hoary chaenactis | *Chaenactis douglasii* | CHDO |
| | Hairy goldaster | *Chrysopsis villosa* | CHRV |
| | Gray Rabbitbrush | *Chrysothamnus naseosus* | CHNA |
| | Green Rabbitbrush | *Chrysothamnus viscidiflorus* | CHVI |
| | Horseweed (marestail) | *Conyza canadensis* | COCA |
| | Long-leaf Hawksbeard | *Crepis acuminatus* | CRAC |
| | Thread-leaf dais | *Erigeron filifolius* | ERFI |
| | Shaggy daisy | *Erigeron pumilus* | ERPU |
| | Snakeweed | *Gutierrezia sarothrae* | GUSA |
| | Common spikeweed | *Hemizonia pungens* | HEPU |
| | Prickly lettuce | *Lactuca serriola* | LASE |
| | Yellow salsify | *Tragopogon dubius* | TRDU |

**Appendix 9. Standard names (cont').**

TABLE 3. continued

| | | |
|---|---|---|
| Cluster tarweed | *Madia glomerata* | MAGL |
| Skeleton weed | *Stephanomeria paniculata* | STPA |
| Family Cruciferae | | |
| Draba | *Draba verna* | DRVE |
| Prarie rocket | *Erysimum asperum* | ERAS |
| Clasping peppergrass | *Lepidium perfoliatum* | LEPE |
| Jim-hill Mustard | *Sysimbrium altissimum* | SYAL |
| Family Cupressaceae | | |
| Western juniper | *Juniperus occidentalis* | JUOC |
| Family Geraniaceae | | |
| Filaree | *Erodium cicutarium* | ERCI |
| Family Gramineae | | |
| Dune wildrye | *Elymus mollis* | ELMO |
| Crested whetgrass | *Agropyron cristatam* | AGCR |
| Thickspike wheatgrass | *Agropyron dasytachyum* | AGDA |
| Bluebunch wheatgrass | *Agropyron spicatum* | AGSP |
| Cheatgrass | *Bromus tectorum* | BRTE |
| Saltgrass | *Distichlis stricta* | DIST |
| Foxtail barley | *Hordeum sp.* | HORD |
| Koelaria | *Koelaria cristata* | KOCR |
| Indian ricegrass | *Oryzopsis hymenoides* | ORHY |
| Bulbous bluegrass | *Poa bulbosa* | POBU |
| Sandberg's bluegrass | *Poa sandbergii* | POSA |
| Squirreltail | *Sitanion hystrix* | SIHY |
| Needle-and-thread grass | *Stipa comata* | STCO |
| Wheat | *Triticum aestivum* | TRAE |
| Threadleaf phacelia | *Phacelia linearis* | PHLI |
| Family Leguminosae | | |
| Pursh's milk-vetch | *Astragalus purshii* | ASPU |
| Astragalus spp. | *Astragalus spp.* | ASTR |
| Scurf pea | *Psolarea lanceolata* | PSLA |
| Family Liliaceae | | |
| Douglas' brodiaea | *Brodiaea douglasii* | BRDO |
| Sagebrush mariposa | *Calochartus macrocarpus* | CAMA |
| Yellow bell | *Fritillaria pudica* | FRPU |
| Family Linaceae | | |
| Wild Flax | *Linium perenne* | LIPE |
| Family Onagraceae | | |
| Parched fireweed | *Epilobium paniculatum* | EPPA |
| Pale evening primrose | *Oenthera pallida* | OEPA |
| Family Polemoniaceae | | |
| Microsteris | *Microsteris gracilis* | MIGR |
| Phlox spp. | *Phlox spp.* | PHLO |
| Family Plantaginaceae | | |
| Indian Wheat | *Plantago patagonia* | PLPA |
| Family Polygoniaceae | | |

**Appendix 9. Standard names (cont').**

TABLE 3. continued

| | | | |
|---|---|---|---|
| | Snow buckwheat | *Eriogonum niveum* | ERNI |
| Family Ranunculaceae | | | |
| | Upland larkspur | *Delphinium nuttallianum* | DENU |
| | Hornseed buttercup | *Ranunculus testiculatus* | RATE |
| Family Rosaceae | | | |
| | Bitterbrush | *Purshia tridentata* | PUTR |
| Family Solanaceae | | | |
| | Solanum triflorum | *Cut-leaf Nightshade* | SOTR |
| Family Umbellifereae | | | |
| | Cous biscuit-root | *Lomatium cous* | LOCO |
| | Large-fruited desert parsley | *Lomatium macrocarpum* | LOMA |
| | Nine-leaved desert-parsley | *Lomatium triternatum* | LOTR |
| OTHER | | | |
| | unidentified annual grass | | AGRA |
| | unidentified perennial grass | | PGRA |
| | unidentified annual forb | | AFOR |
| | unidentified perennial forb | | PFOR |
| | ornamental (non-native) shrub | | ORSH |

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# BURROWING OWL NEST SUCCESS AND BURROW LONGEVITY IN NORTH CENTRAL OREGON

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ABSTRACT.—We studied nest success, burrow longevity, and rates of burrow reuse for a migratory population of Burrowing Owl (*Athene cunicularia*) in north central Oregon from 1995 to 1997. Nest success varied annually from 50% to 67%. Principal causes of nest failure were desertion (26%) and depredation by badgers (*Taxidea taxus;* 13%). Reuse of available nest and satellite burrows in subsequent years was 87% in 1996 and 57% in 1997. Reuse was highest at burrows in sandy soils, which may indicate that nest-site availability is a limiting factor in sandier soil types. Trampling by livestock resulted in the loss of 24% of all burrows between one season and the next, and natural erosion resulted in closure of 17%. Both causes of burrow failure occurred more frequently in soils with a sand component due to their friable nature. We recommend that habitat used by livestock be evaluated for use by Burrowing Owls, that occupied areas be managed to minimize destruction of burrows by livestock, and that predator-control efforts be revised to exclude mortality of badgers.

*Key words: Burrowing Owl,* Athene cunicularia, *nesting success, shrubsteppe, livestock, Oregon, trampling.*

The Burrowing Owl is a species of conservation concern throughout much of its range in western North America (James and Epsie 1997, Sheffield 1997, Holroyd et al. 2001). It has been extirpated as a breeding species from British Columbia since 1980 (Haug et al. 1993) and has declined recently at a rate of approximately 20% a year in the prairie region of southern Alberta and Saskatchewan (Holroyd et al. 2001, Skeel et al. 2001). Currently there is no federal regulatory designation in the U.S., although the U.S. Fish and Wildlife Service included the Burrowing Owl on a list of regional priority conservation species in the midwestern and western U.S. (U.S. Fish and Wildlife Service 2002). In contrast to monitoring programs in Canada and the Midwest, Breeding Bird Survey data for the Columbia Plateau indicate a significantly increasing population, although the estimate is considered imprecise (Sauer et al. 2001). Due in part to this increasing trend and their widespread breeding distribution, Burrowing Owls in the Columbia Plateau were given a relatively low score in a species assessment and prioritization process recently completed by Partners in Flight (total score of 16; Panjabi et al. 2001).

Impacts of human activity and land use on reproductive success and habitat use of this species vary. In Florida, mowing, livestock grazing (Ligon 1963), and wetland drainage (Millsap 1996) helped expand the species' range by increasing the availability of suitable habitat. Intensive agriculture can reduce available nesting habitat and result in increased depredation of nests (Haug 1985), but it has also been shown to provide foraging habitat (Rich 1986). Control of burrowing mammals including badgers (*Taxidea taxus*), which provide Burrowing Owl nest sites (Butts 1973), and agricultural pesticides, which kill Burrowing Owl prey (James and Fox 1987), also have been implicated in Burrowing Owl population declines.

In general, these owls prefer open, sparsely vegetated, relatively flat grasslands rather than shrubby habitats or those with dense or tall grass (MacKracken et al. 1985, Rich 1986, Green and Anthony 1989, Plumpton and Lutz 1993). Because of this habitat preference, one could assume that some grazing by livestock would increase habitat suitability in areas of taller vegetation. Studies evaluating the effects of livestock grazing on habitat use, however, particularly in shrubsteppe habitats, suggest a

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mixed response by Burrowing Owls (Saab et al. 1995). Green and Anthony (1989) reported reduced vulnerability to badger depredation at nests lined with cattle dung (because dung covered the owl scent) and suggested provisioning nesting areas with fresh cattle dung where it is not already available (Green and Anthony 1997). While it is known that migratory Burrowing Owls reuse nest sites from one year to the next (Rich 1984, Lutz and Plumpton 1999), there is no information on the impacts of livestock trampling on burrow longevity or nesting success. Our objectives were to determine nest success, survival of burrows between years, badger burrow availability, and rates of burrow reuse for a population of migratory Burrowing Owls nesting in shrubsteppe habitat in north central Oregon. Specifically, we tested whether there were differences in nest success between soil types or years and whether there were soil-type differences in burrow reuse, destruction of burrows by natural erosion, and destruction of burrows by livestock.

## STUDY SITE

The study was conducted in Morrow County, north central Oregon, on the 19,000-ha Naval Weapons Systems Training Facility (NWSTF), Boardman. Topography ranges from flat to undulating with elevations from 120 m to 275 m. Terraces with gentle slopes of 2% to 10% typify most of the study area, although these terraces graduate into rounded hillsides and valleys with slopes of 5% to 20% at the southern end of the study area. Soils grade from a Quincy-Koehler association at the northern end, to predominantly Sagehill-Taunton, and then to deep Warden soils at the southern end of the facility (McClelland and Bedell 1987). Average annual precipitation in the area is approximately 22 cm (Ruffner 1978), mostly occurring from November through May. Summers are hot and dry with maximum temperatures exceeding 40°C.

Climax vegetation at the site during our study was within the *Artemisia/Agropyron* (now *Pseudoroegnaria*), *Artemesia/Stipa* (now *Hesperostipa*), or *Purshia/Stipa* associations (Franklin and Dyrness 1988). However, climax communities were rare and patchily distributed due to a history of livestock grazing, frequent fires from military activities and lightning strikes, and invasive plants, especially the exotic cheatgrass (*Bromus tectorum*). Shrubs included big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), gray rabbitbrush (*Chrysothamnus nauseosus*), and green rabbitbrush (*C. vicidiflorus*). Important grasses included cheatgrass, Sandberg's bluegrass (*Poa sandbergii*), needle-and-thread (*Hesperostipa comata*), and bluebunch wheatgrass (*Pseudoroegnaria spicata*). Bitterbrush was sparse and restricted to sandy soils at the northern end of the study area, and sagebrush communities were restricted to the southern half. The central area was a mosaic of needle-and-thread, rabbitbrush shrublands, and extensive open areas dominated by cheatgrass. Widespread and locally abundant forbs included scurf pea (*Psolarea lanceolata*), hairy plantain (*Plantago patogonica*), hairy goldenaster (*Chrysopsis villosa*), and tumble mustard (*Sysimbrium altissimum*).

Livestock used the study area from January or early February to late May or early June at an annual stocking rate of approximately 0.20 AUM (animal unit month—1 adult cow and 1 calf or 5 sheep per month) per ha. Approximately 720 of the total 3470 AUMs were allocated on the southern half of the study area to sheep. Pastures were of varying size and valley bottoms were used more than uplands and slopes, resulting in a mosaic of grazing intensities.

## METHODS

We thoroughly searched approximately 2000 ha of the study area early (April) and late (June) in the season to locate a representative sample of nesting Burrowing Owls. In addition, we located nests when carrying out other field surveys. When a nest was located, we searched the immediate area for neighboring pairs (Green and Anthony 1989). Because previous work in north central Oregon showed that Burrowing Owls avoid dense rabbitbrush shrublands for nesting (Green and Anthony 1989), we did not search extensively in larger patches of that habitat.

We checked nests from a distance of 20 m to 200 m once every 3–10 days. We identified nest sites and determined outcomes following methods outlined in Green and Anthony (1989). In summary, we used the length of known occupancy and behaviors that coincided with egg laying, incubation, and brooding (Coulombe 1971, Martin 1973) to determine if nesting occurred. We considered a nesting attempt successful when young reached flight stage (6 weeks of age). Unsuccessful nests were those destroyed or deserted after eggs had been laid. Desertion, defined as abandonment of a nest occupied by eggs or nestlings, was indicated by a lack of fresh owl tracks, prey, and sign of disturbance. Tracks and evidence of fresh digging from badgers or coyotes (*Canis latrans*) indicated when nests had been preyed upon by those species. We intensively searched the area within 300 m of deserted nest burrows to determine if the owls had shifted sites as described by Henny and Blus (1981).

We uniquely numbered all burrows used by owls, marking each with a small metal tag anchored to the ground approximately 4 m from the entrance. We classified soil type around each burrow into 1 of 3 classifications that generally followed the north-to-south gradient: loamy sand, sandy loam, and silty loam. Individual burrows were tracked from one season to the next and their status (open, closed naturally, closed due to trampling) was assessed each spring during late April to early May. Two burrows located on roadcuts that were destroyed by grading equipment were excluded from analyses of burrow availability and reuse. In total, 44 burrows (both nest and satellite) used in 1995 were tracked for the duration of the study. Fifty-six additional burrows used in 1996 were tracked through summer 1997.

In April 1996 and 1997 we surveyed 915 ha of the study area to record burrow use and density. This area was composed almost entirely of grassland dominated by cheatgrass and Sandberg's bluegrass, with intermittent areas of rabbitbrush. The area also included approximately 80 ha of bitterbrush and 35 ha of sagebrush. We divided the area into plots of various sizes and systematically searched each with 2 to 6 observers spaced 20–60 m apart, depending on vegetation density. Observers doubled back upon reaching the predetermined boundary and searched a parallel swath of habitat. Wire flags were used to mark the edge of each pass to ensure complete coverage. Burrows were marked with a shoe print just outside the entrance to prevent double counting. Each burrow detected was classified as open or closed based on visual inspection of the entrance and tunnel. Open burrows were those with an opening of at least 5 cm and presumably could be re-excavated by owls. We further classified closed burrows as naturally closed when the entrance was completely silted in, or trampled when the tunnel had been collapsed as a result of trampling by cattle. Badger activity was noted if burrows were freshly dug or contained tracks.

We tested for differences in nest success, burrow survival, natural closure rates, and trampling rates among soil types using a Pearson chi-square test. Fisher's exact test was used to examine differences in reoccupancy of nests based on success the previous year. We used ANOVA to examine significance and interaction of factors potentially influencing reuse, including success the previous year, soil type, and calendar year. We set statistical significance at the conventional $P < 0.05$ level.

## RESULTS

We monitored 99 nesting attempts between 1995 and 1997. Although not all pairs used satellite burrows, some nests were associated with as many as 6 additional burrows within 50 m of the nest. It was not uncommon for a nest burrow one year to be used as a satellite burrow the following year or vice versa. A total of 148 unique burrows, used either as satellites or nests, were monitored for at least 1 nesting season.

NEST SUCCESS.—The proportion of nests fledging young ranged from 50% to 67% during the study but did not differ significantly among years (Table 1; Pearson $\chi^2_{(2)} = 2.37$, $P = 0.31$). Desertion was the principal cause of nest failure, and depredation was important only in 1997 (Table 1). Badgers were responsible for 12 of 13 depredated nests and coyote for 1. Trampling of burrows by livestock resulted in failure of 4 active nests over the course of the study. Nest success across years was 43% ($n = 35$) in loamy sand, 71% ($n = 28$) in sandy loam, and 58% ($n = 36$) in silty loam. Differences were not significant (Pearson $\chi^2_{(2)} = 5.24$, $P = 0.073$).

BURROW SURVIVAL AND REUSE.—Combining data from 1996 and 1997, we found that the proportion of burrows surviving from one season to the next varied significantly among soil types (Table 2A; Pearson $\chi^2_{(2)} = 33.986$, $P < 0.001$). Burrows in sandy loam were twice as likely as those in the sandiest soils (loamy sand) to survive from one season to the next, and burrows in silty loam were 3 times as

TABLE 1. Nest success and causes of nest failure for Burrowing Owls in north central Oregon (1995–1997).

| Year | *n* | Successful nests *n* (%) | Deserted nests *n* (%) | Depredated nests *n* (%) | Trampled nests *n* (%) |
|---|---|---|---|---|---|
| 1995 | 29 | 15 (52) | 12 (41) | 1 (3) | 1 (3) |
| 1996 | 36 | 24 (67) | 8 (22) | 1 (3) | 3 (8) |
| 1997 | 34 | 17 (50) | 6 (18) | 11 (32) | 0 (0) |
| 1995–1997 | 99 | 56 (57) | 26 (26) | 13 (13) | 4 (4) |

TABLE 2. Number of burrows used by Burrowing Owls in the previous year that were (A) open, (B) naturally closed, and (C) closed as a result of trampling by livestock at the beginning of the 1996 and 1997 breeding season in each soil type. Percentages are expressed as the percent of all burrows within each soil type and year.

| | Soil type *n* (% within soil type and year) | | | |
|---|---|---|---|---|
| | Loamy sand | Sandy loam | Silty loam | Total |
| (A) Open burrows | | | | |
| 1996 | 10 (37) | 6 (67) | 8 (100) | 24 (54) |
| 1997 | 5 (23) | 10 (59) | 32 (86) | 47 (61) |
| 1996–1997 | 15 (30) | 16 (61) | 40 (89) | 71 (59) |
| (B) Naturally closed burrows | | | | |
| 1996 | 9 (33) | 0 (0) | 0 (0) | 9 (20) |
| 1997 | 6 (26) | 4 (23) | 2 (5) | 12 (16) |
| 1996–1997 | 15 (30) | 4 (26) | 2 (4) | 21 (17) |
| (C) Trampled burrows | | | | |
| 1996 | 8 (30) | 3 (33) | 0 (0) | 11 (25) |
| 1997 | 12 (52) | 3 (18) | 3 (8) | 18 (23) |
| 1996–1997 | 20 (40) | 6 (22) | 3 (3) | 29 (24) |

likely. The proportion of burrows that failed due to natural closure (Table 2B; Pearson $\chi^2_{(2)} = 10.874$, $P = 0.004$) and through trampling by livestock (Table 2C; Pearson $\chi^2_{(2)} = 15.909$, $P < 0.001$) also followed this soil type gradient, with burrows in sandier soils most likely to fail due to either cause.

Overall, burrows in sandy loam soils were reused most frequently, burrows in loamy sand less, and burrows in silty loam the least (Table 3). A 3-way ANOVA of burrow reuse with soil type, year, and success of burrow in previous year was highly significant ($F = 5.67$, $P = 0.0016$), but it had a relatively low coefficient of determination (adjusted $r^2 = 0.22$), indicating much unexplained variation. Rates of reuse for available burrows differed significantly among soil types ($P = 0.0102$) but not between years ($P = 0.0649$) nor based on success in previous years ($P = 0.0798$). No interaction terms were significant ($P > 0.6$). Successful nest burrows that remained available were used again as nests (as opposed to not used or used as satellites) more frequently (78%, $n = 23$) than those that had failed (44%, $n = 9$; Fisher's exact test, $P = 0.011$).

BURROW ABUNDANCE.—Burrow abundance varied several-fold between the 2 years that we conducted widespread surveys. We documented 44.9 and 124.8 open burrows per 100 ha in 1996 and 1997, respectively. Of these, relatively few showed signs of recent badger activity in 1996 (14.5%), but badger activity increased dramatically in 1997 when fresh burrows accounted for 52.3% of all open burrows. Numbers of recently closed burrows, as indicated by a lack of cheatgrass and other vegetation on the disturbed soil, were also variable between years, increasing from 32.1 per 100 ha in 1996 to 134.2 per 100 ha in 1997. The percentage of closed burrows attributed to trampling by livestock was similar between 1996 (57%) and 1997 (61%).

## DISCUSSION

NESTING SUCCESS.—Nest success during this study (57%, $n = 99$) was similar to the 53%

TABLE 3. Rates of reuse by Burrowing Owls for available burrows within each soil type (1996–1997).

| | Soil type *n* (%) | | | |
|---|---|---|---|---|
| | Loamy sand | Sandy loam | Silty loam | Total |
| Reused in 1996 | 10 (100) | 6 (100) | 8 (62) | 24 (87) |
| Reused in 1997 | 5 (60) | 10 (90) | 32 (47) | 47 (57) |
| Total 1996–1997 | 15 (87) | 16 (94) | 40 (50) | 71 (67) |

($n$ = 139) reported from the same area by Green and Anthony (1989). Depredation of nests, minimal in 1995 and 1996, increased dramatically in 1997. This corresponds with an increase in badger activity on the study area in 1997, as evidenced by a greater than threefold increase in the number of freshly dug burrows documented on extensive surveys. Badgers are the principal predator of Burrowing Owl nests in the Columbia Basin (Green and Anthony 1989), and so this relationship was not unexpected. As badger populations fluctuate, Burrowing Owls may experience years of reduced productivity during periods of high badger abundance, but they also may benefit from the residual effect of increased burrow availability when badger populations again decline. Annual rates of nest desertion in this study were variable (18–41%), but not dissimilar to the 30–35% reported from the same general area in 1980 (Green and Anthony 1989).

BURROW SURVIVAL AND REUSE.—The friable nature of sandy soils resulted in relatively high rates of burrow failure due both to natural erosion and trampling of the burrow entrance or tunnel by cattle (Table 2). Lower trampling rates at burrows in silty loam may be attributable to several factors. Structural stability of burrows in this soil type was greater, and burrows were therefore less likely to fail when stepped on by cattle. Burrows in this soil have the potential to remain open for many years as evidenced by several we observed in areas protected from livestock whose antiquity was confirmed by the presence of well-developed cryptobiotic soil crusts at the entrance (Belnap 1993). An additional consideration is that sheep comprised approximately 40% of the AUMs allocated to areas with loamy and sandy loam soils. Because of their lighter weight, sheep would be less likely to collapse a burrow. The absence of sheep in the parts of our study area classified as loamy sand introduces an unfortunate bias when examining the influence of soil type on trampling rates. However, relative rates of trampling among soil types mirror those of natural closures. We believe this lends support to our conclusion that observed differences in burrow failure are related to soil texture as opposed to variations in livestock management.

In this study reuse of nest and satellite burrows was greater at sites with sandy than loamy soils. We suggest that high rates of nest site reuse and decreased longevity of burrows could indicate that suitable nest locations are a limiting factor in areas of sandy soils. Although we do not know if the same individuals occupied the sites we monitored from one year to the next, nests in our study were more likely to be used again if they had been successful the previous year. Lutz and Plumpton (1999) found owls that switched burrows produced fewer young the preceding season than those that reused a nest site, indicating a similar relationship between reuse and productivity. Destruction of nest burrows forces owls to relocate, which may also impact productivity. Botelho and Arrowood (1998) reported that owls in a partially migratory population that had switched burrow type between years (cliff versus ground) produced fewer nestlings in their new location than their former and suggested there is some advantage to experience with a nest site.

BURROW AVAILABILITY.—Trampling by livestock resulted in a substantial reduction in the number of open badger burrows, especially in areas of sandy soils. This widespread reduction in badger burrows across the landscape may have several effects on populations of Burrowing Owls. First, evidence suggests that breeding density is related to density of available nest sites. Plumpton and Lutz (1993) found that in 1 of 2 years studied, owls selected nest burrows in areas that contained greater burrow density than what was available in the surrounding landscape. Desmond et al. (2000)

demonstrated a decline in Burrowing Owl densities with declining densities of prairie dog burrows, speculating that there may be a time lag in the response of owls to changes in burrow density. Second, additional burrows near the nest allow owls to distribute young among several locations and may reduce the likelihood of losing an entire brood to a predator. As brood protectors, extra escape burrows may be important to young foraging in the vicinity of the natal burrow prior to dispersal (Haug et al. 1993). Burrows are also important to juveniles during post-fledging dispersal. Juvenile owls were observed in Idaho using an average of 5.1 burrows in approximately 40 days after first leaving their natal burrow (King and Belthoff 2001).

MANAGEMENT CONSIDERATIONS.—Burrowing Owl nest sites tended to be reused if they remained available from one year to the next. In friable soils livestock trampling was a primary cause of burrow failure and resulted in reduced availability of burrows overall. We suggest rangelands with sandy soils be monitored for Burrowing Owl use and destruction of burrows by livestock. Where damage to burrows is occurring, changes should be made in stocking rates, duration, and/or season of grazing. Where owls are deemed a high priority for management, the cessation of livestock grazing may be warranted for a period of time sufficient to increase burrow densities.

United States Department of Agriculture (USDA) Animal Damage Control (now Wildlife Services) trapped and killed badgers along with coyotes (the primary target species) at our study area throughout the 1980s. Approximately 6 badgers were removed annually from the NWSTF until this practice was discontinued in 1992 due to concerns over impacts to local badger and Burrowing Owl populations (KBL personal observation). Information obtained from the USDA suggests this practice is still widespread on other rangelands. Wildlife Services removed an average of 148 badgers per year in the state of Oregon between 1996 and 2000 (U.S. Department of Agriculture 2002). The majority of these animals were killed after being caught in leg-hold traps, perhaps incidentally to coyote-control efforts. However, an average of 13 were shot each year during the same period, indicating a targeted effort. The link between fossorial mammals and Burrowing Owls has been widely recognized. Conservation of badgers and other burrow-providers is therefore of utmost importance (Wellicome and Holroyd 2001). We recommend revision of predator-control efforts to prevent incidental or targeted badger mortality.

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## Migratory linkages of Burrowing Owls on DoD installations and adjacent lands
## Final report

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## INTRODUCTION

Burrowing Owls (*Athene cunicularia*) were once a common breeder in grasslands and deserts throughout the western U.S. and Canada. Some populations have declined and Burrowing Owls have been extirpated from areas on the western, northern, and eastern periphery of their breeding range. Because of these declines, Burrowing Owls are listed as a *Species of National Conservation Concern* in the United States (U.S. Fish and Wildlife Service 2008) and federally endangered in Canada. Burrowing Owls are also state endangered in Minnesota and Iowa, and are being considered or have been petitioned for state listing in California and Washington. Moreover, Burrowing Owls are listed as a high priority species in state Partners-in-Flight conservation plans. For example, the Partners-in-Flight plan for Arizona ranks Burrowing Owls 19th in conservation priority out of 177 terrestrial bird species wintering in the state. Similarly, Burrowing Owls are listed as a high responsibility species in the New Mexico Partners-in-Flight plan. Finally, Burrowing Owls are listed as a Bird of Conservation Concern by DoD Partners-in-Flight in 7 of the BCR regions where they occur (BCRs 9, 11, 16, 17, 32, 33, and 35) and by 83 of the 85 DoD installations in those BCRs.

However, population declines in Burrowing Owls do not appear to be ubiquitous; owls appear to be declining in some locations (and on some DoD installations) but not in other locations. Indeed, recent studies suggest that owls are decreasing in the northern periphery of their breeding range in North America, but appear to be stable or increasing in the desert regions of the southwestern U.S. and northwestern Mexico. Owls appear to be year-round residents in the southwestern U.S. and northwestern Mexico and population densities on many DoD installations in the region are much higher compared to the surrounding landscape (Ellis et al. 2004).

One possible explanation for the regional variation in population trends of Burrowing Owls is that they are becoming less migratory; owls which once migrated to northern breeding locations during the summer may have recently become year-round residents in the southwestern U.S. and northern Mexico. In other words, owl populations might be redistributing rather than declining. If this hypothesis is correct, it has implications for the validity of current or future Burrowing Owl listing petitions and the likely effectiveness of different management actions designed to increase local populations. Burrowing Owls breed and/or overwinter on dozens of DoD installations throughout the western U.S. and, hence, any changes in their status may affect the military mission.

Understanding why owls have declined in some locations but not in others requires a broad-scale comparative approach across their breeding range. Burrowing Owls are present on many DoD installations throughout the western U.S. and especially in the southwest; most (if not all) DoD installations located within suitable habitat in this region have (or once had) populations of breeding owls. Hence, DoD is vested in the persistence of this species and maintaining the DoD mission requires a better understanding as to why these birds are declining in some locations but not others.

Over the past 10 years, numerous DoD installations have requested and/or obtained funds to monitor and conduct studies of Burrowing Owls on their installation. Methods and protocols have varied greatly and there has been no coordination or synthesis among these independent efforts. This project conducted studies in a standardized way on bases throughout the western U.S. using a collaborative approach – not only among DoD installations, but also including partnerships with other agencies and organizations. In addition to identifying migratory linkages of Burrowing Owls throughout North America, we produced a series of documents describing standardized protocols so that DoD installations throughout the country can use identical methods (and hence produce comparable results) on any future Burrowing Owl monitoring or research efforts that occur on DoD lands.

The objectives of this project were:

1) Determine the linkages and connectivity of Burrowing Owl populations throughout North America.
2) Estimate the extent of changes in the breeding distribution of Burrowing Owls
3) Estimate the extent to which individual owls move among populations, both among DoD installations and between DoD installations and other lands.
4) Test the hypothesis that Burrowing Owls are redistributing their numbers by becoming less migratory.
5) Develop standardized protocols for coordinated efforts to monitor and study burrowing owls on DoD installations

We used stable isotope ratios from owl feathers, molecular genetics, and radio telemetry to identify linkages among DoD installations and lands managed by other state and federal partners and quantify land-use of migrating and wintering owls in the region. Because Burrowing Owls often nest in close proximity to airfields on DoD installations throughout the southwestern U.S., the telemetry component of this project also provides valuable information to the Bird Air Strike Hazard (BASH) program regarding the foraging areas used by burrowing owls, their migratory trajectories off the installation, and the frequency of owl-aircraft strikes.

**METHODS**

We located, trapped, and individually color-marked adult and juvenile Burrowing Owls at most of the DoD installations in the western U.S. that proved to have substantial aggregations of Burrowing Owls. We collected a feather from each of 3 feather tracts and we collected a blood sample from each bird (see Appendix 1 for details). We analyzed this enormous set of feather and blood samples to identify the latitude at which each feather was grown and to document the extent of connectivity among Burrowing Owls on DoD installations throughout the western U.S.

The project team was led by the 2 principal investigators: Dr. Courtney Conway from the U.S. Geological Survey and the University of Arizona (Tucson, Arizona), and Carol Finley from Kirtland Air Force Base (Kirtland AFB, New Mexico). Other key members of the team included Vicki Garcia from the University of Arizona in Tucson, AZ, Marianne Mershon from Envirological Services Inc. in Albuquerque, NM, 2 graduate students at the University of Arizona (Mark Ogonowski and Alberto Macias-Duarte), 2 senior biologists with Envirological Services (Kirsten McDonnell and Octavio Cruz), and 2 research biologists from the Canadian Wildlife Service (Dr. Geoffrey Holroyd and Dr. Troy Wellicome). All of these key team members had worked on Burrowing Owls for many years and provided team representation from a state university (Garcia, Ogonowski), U.S. government agency (Conway), Canadian government agency (Holroyd, Wellicome), Mexico (Macias-Duarte), the private sector (Mershon, McDonnell, Cruz), and DoD (Finley). The team also included natural resource managers and biologists from many DoD installations who actively participated in the project (e.g., Trish Griffin at White Sands Missile Range, Mead Klavetter at Pinon Canyon Maneuver Site, Robbie Knight at Dugway Proving Ground, and Carl Rudeen at Mountain Home Air Force Base).

**Range-wide patterns in body size of burrowing owls**

We weighed each owl, and measured the wing chord and metatarsal length of each adult in order to determine how Burrowing Owl morphological traits vary with latitude. We used Analysis of Covariance (ANCOVA) to analyze morphological traits of adult Burrowing Owls. The response variables were weight (g), left wing chord length (mm), and right metatarsal length (mm). Explanatory variables for each of the three analyses were latitude, date captured, and sex. We conducted similar analyses to examine body weight (response variable) of juvenile Burrowing Owls and examined latitude, age of juvenile when it was captured (days), and date captured as possible explanatory variables.

**Estimating changes in burrowing owl distribution based on BBS data**

We analyzed data from the North American Breeding Bird Survey (BBS) to quantify changes in the breeding distribution of burrowing owls over the past 40 years. Species distributions are notoriously difficult to define (Gaston 2003), but several analytical approaches have been suggested for delineating species' distributions based on presence-absence data (Fortin et al. 2005). We used an approach intended to model the breeding distribution of burrowing owls as a dynamic process that involved time without partitioning the dataset into discrete subsets of space and time. We used BBS data (USGS Patuxent Wildlife Research Center 2009) from 1967 to 2008 to fit a logistic regression model to predict the probability of burrowing owl presence as a function of longitude, latitude, and year. We modeled logit($p$) to be a linear function of year and we modeled the spatial variation of the linear temporal trend in logit($p$) by making the intercept ($\beta_0$) and the slope ($\beta_1$) a function of longitude and latitude. By following this procedure, we avoided partitioning the dataset into discrete subsets for each BBS route to obtain local estimates of temporal trends. Partitioning the data into subsets creates as many models as the number of BBS routes with burrowing owls (i.e., 588 BBS routes), each with 2 parameters ($\beta_0$ and $\beta_1$, and hence 1176 regression parameters total). Hence, our approach is a more parsimonious way to examine temporal changes in the breeding distribution of the burrowing owl. We also avoided the problem of complete or quasi-complete separation by BBS route (when a year $t$ exists such us that only absences are recorded before $t$ and only presences are recorded after $t$, or vice versa) in the maximum likelihood estimation procedure (Hosmer and Lemeshow 1999) which can lead to numerical errors. We used a double Fourier series to model for the spatially explicit intercept and slope of the equation and assumed that both parameters can be modeled as a sum of two-dimensional wavelets of different frequencies. Sampling effort has increased since the initial implementation of the BBS in the 1960s and may hinder our ability to accurately model the probability of burrowing owl's presence in space and time. The number of BBS routes surveyed (and hence the number of routes with ≥1 burrowing owl detection) has steadily increased since the initial implementation of the BBS in 1967, which creates an unbalanced sampling design in the year variable. Balanced designs reduce bias (i.e. regression coefficients shifting away from zero, Firth 1993) in maximum likelihood estimates for logistic regression in discrete variables (Dietrich 2005). Hence, we used simulations to determine if the increase in sampling effort inherent in BBS data biased our results and was exclusively responsible for the inferred spatio-temporal patterns in the probability of presence by the original dataset. We ran 10 simulations by randomly assigning a presence or absence value to each BBS route sampled through 1967-2008 using a Bernoulli distribution. We used the average yearly proportion of BBS routes with presence of burrowing owls estimated from our logistic regression analysis as the Bernoulli parameter.

**Connectivity among populations based on genetic markers**

We extracted genomic DNA from blood samples using a Qiagen© DNeasy® Blood & Tissue Kit. We initially used microsatellite DNA primers previously developed (Korfanta et al. 2002), but we could consistently obtain PCR products for only two of these markers (BUOW7 and BUOW11). Moreover, all of the microsatellites developed by Korfanta et al. (2002) had low variability (and hence limited ability to distinguish among populations). Hence, we chose to develop a set of novel microsatellite markers for Burrowing Owls that were more variable. Therefore, we extracted further genomic DNA from blood samples using a Qiagen© DNeasy® Blood & Tissue Kit. The DNA was partially restricted with the enzyme RSAI (NEB) and fragments were ligated (using T4 DNA ligase) to double-stranded SNX-24 linkers (Glenn and Schable 2005). To create a whole genome PCR library, linker-ligated fragments were amplified by polymerase chain reaction (PCR) using an SNX-24 forward primer and high-fidelity DNA polymerase (Invitrogen). This library was hybridized to biotinylated microsatellite oligonucleotide probes $(GT)_{15}$, $(CT)_{15}$, and $(GATA)_8$. Hybridized fragments were captured on streptavidin-coated paramagnetic beads (Dynal). Microsatellite-enriched fragments were recovered by PCR and products were ligated and transformed using a TOPO TA cloning kit (Invitrogen). Approximately 276 colonies were amplified using M13 forward and reverse primers, with clones ranging from 500 to 1200 bp, as visualized on 1.5% agarose gels. Clones were sequenced using M13 primers on an ABI 3730xl genetic analyzer (PE Applied Biosystems) using BigDye Terminator. From clones with recognizable microsatellite sequences, we designed 45 primer pairs using Primer 3 software (Rozen and Skaletsky 2000). The designed primer pairs were double-checked for homodimers, hairpins, and heterodimers using Oligo Analyser software (Integrated DNA Technologies; http:// www.idtdna.com/analyser/Applications/OligoAnalyser). Of the initial 45 primer pairs designed, 13 loci amplified and had substantial variation among individuals (Macias-Duarte et al. 2010). We then assessed the variability of these loci in burrowing owls from DoD installations throughout the western U.S. and from Canadian and Mexican populations.

To test our predictions, we grouped the 36 study locations (Table 3) into 3 categories: agricultural areas in the southern portion of the species' range, areas in the northern portion of the species' range where migratory populations are declining, and all other study locations. Seven of our study locations were located in irrigated agricultural areas of northwestern Mexico and southern Arizona ('southern agricultural study locations' hereafter). These study locations were Casa Grande (CAG), Mexicali Valley (MEX), Caborca (CAB), Hermosillo (HER), Yaqui-Mayo Valley (YAQ), Rio Fuerte Valley (FUE), and Culiacan (CUL). Some population declines have been documented throughout the breeding range of the burrowing owl, but systematic regional declines have been most evident in Alberta, Saskatchewan, North Dakota, and South Dakota, where the species is close to extirpation (owls have been extirpated from Manitoba and British Columbia). Therefore, we only defined Alberta (ALB), Saskatchewan (SAK) and Grand River-Little Missouri National Grasslands (GRL) as northern study locations with declining migratory breeding populations ('northern study locations' hereafter).

We used MS Excel© macro GENALEX 3.6 (Peakall and Smouse 2006) to calculate standard descriptive statistics of genetic diversity of burrowing owls in our study locations, including observed heterozygosity, expected heterozygosity, and fixation index F. We also used program ARLEQUIN 3.1.1 (Excoffier 2006) to estimate the Weir and Cockerham's $F_{ST}$ ($\theta$, Weir and Cockerham 1984) for all populations.

We computed actual differentiation *D* (Jost 2008) to test our prediction that gene flow between declining migratory populations in the north and populations in southern agricultural areas would disrupt an otherwise apparent isolation-by-distance relationship. We used the web-based platform GMSOD 1.2.5 (http://www.ngcrawford.com/django/jost/) to compute actual differentiation *D*. We used *D* as our measure of population-pairwise genetic differentiation because $F_{ST}$ does not adequately measure genetic differentiation when within-population allelic diversity is high (Jost 2008). *D* ranges from 0 to 1, corresponding to complete similarity to complete differentiation. We performed a Mantel test (Mantel 1967) to test our assumption of the existence of an isolation-by-distance pattern (i.e., that the genetic differentiation between 2 populations is positively correlated to the geographic distance that separates those populations). If our hypothesis is true, we expected that pairwise comparisons between northern locations and southern agricultural locations would fall below the predicted Mantel regression line in the scatterplot of genetic *vs.* geographic distances.

We performed an Analysis of Molecular Variance *AMOVA* (Weir and Cockerham 1984) using *ARLEQUIN* 3.1.1 to test our prediction that all declining migratory populations in the north and all populations in agricultural areas in the south, pooled together, would be genetically differentiated from the remainder of the breeding populations within the species' range (pooled together). The *AMOVA* is analogous to a nested Analysis of Variance and uses a permutational approach to test the statistical significance of any given classification of study locations in explaining the overall genotypic variation. We performed 2 *AMOVA*s, one based on allele sizes ($R_{ST}$) and the other based on the number of different alleles ($F_{ST}$) (Michalakis and Excoffier 1996). The former measure assumes the stepwise mutation model (Ohta and Kimura 1973), which is appropriate for microsatellite loci. We used the *AMOVAs* to test for evidence of 2 distinct genetic groups: Group 1 with southern agricultural locations (CAG, CAB, CUL, FUE, HER, and YAQ) together with northern locations (ALB, SAK, and GRL), and Group 2 including all other locations. Our large sample size (1,560 individuals) may confer enough statistical power to reject the null hypothesis for any grouping of study locations. To explore this possibility, we conducted 7 additional AMOVAs using 2-group classifications by replacing northern study locations (ALB, SAK, and GRL) from Group 1 with other study locations and moving them to Group 2 (Table 4).

We conducted an assignment test as implemented by program *STRUCTURE* (Hubisz et al. 2009; Pritchard et al. 2000) to test our prediction that southern agricultural study locations will have more individual owls with probabilities of membership similar to those found in individuals from declining populations in the north compared to the non-agricultural study locations in the southern part of the species range. *STRUCTURE* 2.3.3 implements an algorithm suited to infer weak population structure (Hubisz et al. 2009). *STRUCTURE* estimates the posterior probability of the data (L(*K*)=Prob[*Data* |*K*]) given existence of *K* burrowing owl populations under Hardy-Weinberg equilibrium and estimates the posterior probability of membership of each individual owl to each of *K* populations. We used study locations as prior information to assist the inference of population structure (Hubisz et al. 2009) by setting LOCPRIOR=1 in *STRUCTURE*. We performed 10 runs for each *K* = 1, 2, … 10. Each run consisted of a burn-in period of 50,000 Markov Chain Monte Carlo repetitions followed by 50,000 repetitions to sample from the posterior distribution of *K*. We estimated L(*K*) for each *K* from correlated allele frequencies and an admixture model. This approach is superior when population differentiation is low at detecting subtle genetic structure compared to the use of uncorrelated allele frequencies and a non-admixture model (Falush et al. 2003). We used the outputs of the web-based platform STRUCTURE HARVESTER 0.56.3 (http://taylor0.biology.ucla.edu/struct_harvest/) to assess the number of inferred populations. *STRUCTURE HARVESTER* estimates the statistic $\Delta K$ at each value of *K*. $\Delta K$ performs better in detecting population genetic structure than L(*K*) (Evanno et al. 2005). Therefore actual number of populations is revealed by the value of *K* with the highest value of $\Delta K$. We used program *CLUMPP* (Jakobsson and Rosenberg 2007) to calculate the posterior probabilities of membership of each individual owl to each of the *K* populations from our multiple runs in *STRUCTURE*.

**Connectivity and linkages based on stable isotope ratios of feathers**

We obtained the isotope ratios of hydrogen ($\delta$D), carbon ($\delta^{13}$C), and nitrogen ($\delta^{15}$N) from nestling feathers to determine the multi-isotope signature at each sampling location (i.e., each DoD installation or non-DoD sampling location). This information was supplemented with multi-isotope signatures from owls at locations across North America that have already been sampled by our many project partners. With these data, we mapped the local multi-isotope signature throughout the Burrowing Owl breeding range in North America. This map allowed us to estimate the previous breeding location of each adult owl (or the hatching location of first-year breeders) and the extent of population connectivity of Burrowing Owls throughout their breeding range due to regional variation in isotope ratios. For example, $\delta$D varies in a very predictable latitudinal pattern and also correlates with amount of precipitation in the local area; $\delta^{13}$C varies among plant communities based on the composition of $C_2$, $C_3$ and CAM plant species; and $\delta^{15}$N allows discrimination between artificial and natural sources of nitrogen, such as agricultural areas and natural plant communities (Hobson 1999). These isotope signatures are incorporated into a bird's feathers when the bird undergoes a feather molt. Birds typically molt their flight feathers (wing and tail) once per year immediately after breeding (on the breeding grounds). Stable isotope ratios in a feather are fixed once the feather is fully grown, so we can examine a flight feather of a breeding owl to determine where it spent the previous summer.

To obtain the isotope signatures, we washed all feathers in a 2:1 chloroform/methanol solution to remove surface oils (Wassenaar 2008). We rinsed and submerged all feathers for an hour in the chloroform/methanol solution. We then removed the feathers from the solution and let them dry for one hour at room temperature in a fume hood. We cut the distal end of a rectrix for after-hatching-year (AHY) burrowing owls, and the distal end of a breast and/or a back feather for nestlings (HY). We sent our feather samples for analyses by continuous-flow isotope-ratio mass-spectrometry to the Environmental Isotope Laboratory at the University of Arizona.

We collected feathers from young and adult burrowing owls during the breeding seasons of 2004-2009 at 36 study locations throughout the species' breeding range. We defined populations in Alberta (ALB) and Saskatchewan (SAK) as declining migratory populations on the northern edge of the species' breeding distribution based on survey data in those locations (Sauer et al. 2008). We defined populations in Casa Grande (CAG), Salton Sea National Wildlife Refuge (SSW), Mexicali Valley (MEX), Caborca Valley (CAB), Hermosillo (HER), Yaqui-

Mayo Valley (YAQ), Rio Fuerte Valley (FUE), and Culiacan Valley (CUL) as southern resident populations within irrigated agricultural areas. We pulled breast, back, and head feathers from nestlings that were >10 days-old, and we pulled the third right rectrix from adult burrowing owls. We did not use natal down feathers from nestlings in our study, which may have the isotope signature of the mother's diet during spring migration (Duxbury et al. 2003). We performed bird handling, feather collection, and the import and export of feathers through international boundaries under the compliance of Canadian, Mexican, and U.S. regulations.

We initially used a chloroform:methanol solution for cleaning feathers in 45.6% of our samples to remove oils from feathers. We subsequently changed our cleaning protocol to a two-step cleaning procedure that included both a detergent solution and chloroform:methanol solution after a paper was published by Paritte and Kelly (2009). We processed all our samples in the Environmental Stable Isotope Laboratory at the University of Arizona. We used a Finnegan MAT TC/EA connected to Finnegan Delta Plus mass spectrometer through a Finnegan MAT CONFOLO III Interface to measure $\delta^2$H in feather samples. Our analytical precision for $\delta^2$H based on the repeated analysis of a benzoic acid lab standard was better than 1.8‰. We used sheep wool and swan feather trace standards to calculate non-exchangeable $\delta^2$H in owl feather samples. We equilibrated samples and tracer standards with ambient water vapor in the laboratory for at least 4 days. After equilibration, we dried samples to eliminate the effects of adsorbed water. We included tracer standards with each batch of owl feather samples analyzed to monitor the effects of lab water vapor on measured $\delta^2$H values. We used the $\delta^2$H value of the tracer standards to calculate the $\delta^2$H value of the exchangeable hydrogen in owl feather samples. We then calculated the value of non-exchangeable hydrogen in owl feather samples using a mass balance equation based on the proportion of exchangeable hydrogen and their total $\delta^2$H value. We used a percentage of exchangeable hydrogen of 9.0% (based on estimates from swan feather tracer standards) and an arbitrary fractionation factor of $\alpha$ =1.12. We measured $\delta^{13}$C and $\delta^{15}$N on a continuous-flow gas-ratio mass spectrometer (Finnigan Delta PlusXL). We combusted samples in an elemental analyzer (Costech) coupled to the mass spectrometer. Standardization was based on acetanalide for elemental concentration, NBS-22 and USGS-24 for $\delta^{13}$C, and IAEA-N-1 and IAEA-N-2 for $\delta^{15}$N. Precision based on repeated internal standards was better than 0.08‰ for $\delta^{13}$C and better than 0.2‰ for $\delta^{15}$N. Values of $\delta^2$H, $\delta^{13}$C, and $\delta^{15}$N (in parts per mil, ‰) are computed for the Vienna Standard Mean Ocean Water standard, PeeDee Belemite standard, and atmospheric $N_2$, respectively. Precision for $\delta^2$H, $\delta^{13}$C, and $\delta^{15}$N based on replicate subsamples from the same feather were ±4.78‰ (1,263 feathers), ±2.89‰ (222 feathers), and ±0.32‰ (222 feathers), respectively, measured as the square root of the mean square error from an analysis of variance with feather sample (for $\delta^2$H ,$\delta^{13}$C, and $\delta^{15}$N) and date of measurement (for $\delta^2$H) as fixed effects. We included date of measurement in our estimates of precision for $\delta^2$H (and not for $\delta^{13}$C and $\delta^{15}$N) to account for variability in $\delta^2$H measurements caused by the uncontrolled exchange of $^2$H atoms between ambient water (vapor) and the keratin in our feather samples (Wassenaar and Hobson 2003). The magnitude of this interchange can vary from date to date with temporal changes of $\delta^2$H in ambient water and humidity, and can considerably affect measurements of $\delta^2$H in feather samples.

Variability of $\delta^2$H measurements on the same feather among laboratories (Smith et al. 2009) and across time within the same laboratory (Lott and Smith 2006) create challenges for using deuterium to track animal movements. We attempted to address these sources of measurement error by measuring $\delta^2$H twice in almost all feather samples in the same laboratory (within 2 different batches analyzed $\bar{x} = 30$ days apart, range = 0–479 days). We replicated samples within and among dates of analysis. We used a generalized linear mixed model (Bolker et al. 2008) in the *R* package *NLME* to generate $\delta^2$H for individual owls (fixed effect) accounting for date of measurement (random effect).

First, we assumed that adult burrowing owls with stable isotope signatures outside of the 95$^{th}$-percentile ellipses defined by nestling signatures were not in the location the previous breeding season. The purpose of this approach was not to predict the origin of owls classified as migrant, but rather to estimate the proportion of adults in each population that was immigrant. We used package *ellipse* in program *R* (R Development Core Team 2009) to generate and plot the 95$^{th}$-percentile ellipses from a bivariate normal distribution for $\delta^{13}$C or $\delta^{15}$N. Second, we used a local regression analysis (LOESS, Cleveland et al. 1992) for spatial interpolation to build base maps of $\delta^2$H, $\delta^{13}$C, and $\delta^{15}$N across North America based on the stable isotope signatures of nestling feathers. $^2$H base maps for feathers are available for other bird species for portions of our study area (Lott and Smith 2006, Hobson et al. 2009). The use of $\delta^{13}$C and $\delta^{15}$N base maps to track animal movements remains largely unexplored (Bowen and West 2008). Therefore, feather base maps for $\delta^{13}$C and $\delta^{15}$N are not currently available, although surrogate base maps exists for $^{15}$C in terrestrial vegetation (Suits et al. 2005) and $^{15}$N for soil-plant interface (Amundson et al. 2003). We decided to build our own base maps specific to burrowing owl feathers given: 1) the lack of information regarding interspecific variation in fractionation processes, and 2) our exhaustive sampling of nestling feathers throughout the species' breeding range (we typically caught juveniles while attempting to catch adults). We wrote our own script in program *R* to conduct geographic assignment of individuals with known isotopic signature and unknown origin. We created a 100×100 grid of points for the region encompassed by our study populations, with 0.23°×0.31° grid cells. We trimmed this grid by a maximum convex polygon with vertices defined by our study populations to avoid assignment of adult owls to locations out of our range of inference. We then used the command *predict.loess* to predict $\delta^2$H, $\delta^{13}$C, and $\delta^{15}$N values for each location in the final grid based on the *R* object generated with command *loess* on nestling data. We computed the standardized Euclid distance from the isotopic signature of the *i*-th adult burrowing owl (i = 1, 2, … , 894) to the isotopic signature predicted by the three base maps at each point on the geographic grid (j = 1, 2, … , 5129).

We assigned each adult burrowing owl to the location on our grid that had the most similar stable isotope signature to that of the adult owl (i.e., the location that resulted in the lowest Euclidian distance; *d*). In situations where >1 location had similar *d* values, we assumed that the location closest to the collection site was more likely to represent the true origin of an owl. Therefore, we assigned each adult burrowing owl's origin to the closest geographic location on the grid among competing locations with the same *d*. We used this as a conservative approach intended to prevent the detection of spurious long-distance dispersal events. A basic assumption in this analysis is that stable isotope signatures of juvenile body feathers are comparable to those of rectrices in adult feathers grown in the same location (Langin et al. 2007, Smith et al. 2008). Meehan et al. (2003) showed a large, unexplained difference in $\delta^2$H values between juvenile and adult Cooper's hawks. Burrowing owls molt their rectricies simultaneously or nearly so, towards the end of the nestling stage. Thus, we do not expect substantive differences such as those found in Cooper's hawk primaries that are molted over a longer time period during the post-breeding season. We decided to use juvenile body feathers (rather than rectrices of fledglings) because nestlings are considerably easier to trap and estimate age than fledglings (which can be mistaken as after-hatching-year birds) and we could obtain a large sample allowing for more precise estimates. Moreover, we did collect developing rectrices from juveniles to avoid any harm to the growing birds. We used program *R* v. 2.9.2 for Mac to perform all statistical analyses.

**Linkages and migratory movements based on radio telemetry**

We also placed radio transmitters on a subset of owls on Kirtland AFB and followed these birds as they began their fall migration. The information related to the telemetry portion of the project is presented as a stand-alone document in Part II (page 77 of this report).

## RESULTS AND DISCUSSION

**Training workshops and partnerships**

We held 4 training workshops for DoD personnel and we sponsored DoD personnel who participated in our training workshops to obtain their banding sub-permits from the USGS National Bird Banding Laboratory. During the workshops, each participant received one-on-one instruction and ample first-hand practice on how to handle, band, and collect feathers from at least 3-4 owls. Additionally, we trained participants to accurately record data from Burrowing Owl captures, to store feathers, and to construct Burrowing Owl traps. We provided Burrowing Owl traps and banding supplies to those participants who needed them. We also provided participants with a booklet containing protocols for Burrowing Owl banding and data collection, datasheets for recording data from captured owls, and checklists of items to take in the field when trapping owls. At the end of the workshops, each participant was competent to trap owls on their own. We sponsored the applications of 7 DoD personnel from 5 installations who are now sub-permittees under the Master Banding Permit of C. Conway. These individuals were then able to trap and band Burrowing Owls at their respective installations and were active team members in the project.

We also worked with a large number of partners from other agencies and organizations to accomplish the project's goals. This project is a good example of a true multi-agency partnership which used Legacy funds to encourage participation and leverage funds from other national and international partners. In addition to the many DoD installations in the region that have nesting Burrowing Owls, many other agencies manage lands that have breeding owls on lands adjacent to DoD installations. We partnered with these agencies and organizations since owl populations on these lands are likely not distinct from those on DoD installations. The project included 16 partner organizations in the U.S. and Canada, and 17 partner organizations in Mexico, in addition to the 38 individual DoD installations that helped with the project. Together, these partners provided matching funds and in-kind support for the project of >$550,000.$^{00}$. The project partners included: U.S. Fish and Wildlife Service, Canadian Wildlife Service, U.S. Geological Survey, National Park Service, U.S. Environmental Protection Agency, U.S. Department of Energy, Sonoran Joint Venture, World Wildlife Fund, University of Arizona, National Fish and Wildlife Foundation, T&E Inc., Envirological Services Inc., University of Alberta, and National Council of Science and Technology (Mexico). DoD can take credit for leading this large-scale partnership throughout the western U.S. The project also generated many products: 10 papers published in peer-reviewed scientific journals, 4 graduate theses, 16 technical reports, 8 articles/programs in the popular press, 40 presentations at regional, national, and international meetings, and 17 awards given to the graduate students working on the project.

**Standardized field protocols**

We developed standardized protocols (Appendix 1) for each of the following activities: 1) surveying owls on DoD bases, 2) trapping adult and juvenile owls on bases, 3) banding owls, 4) collecting feather samples from adult and juvenile owls, 5) estimating Burrowing Owl demographic traits, and 6) collecting blood samples from owls (to infer population connectivity via genetic analyses).

**Trapping and nest monitoring**

We trapped a total of 3131 Burrowing Owls at 56 different locations (38 DoD installations and 18 areas managed by other project partners; Tables 1- 2) in 2005-09 and collected feathers and blood samples from each owl following standardized protocols (Appendix 1). The number of owls and nests provided in Table 2 represent the number captured on DoD and surrounding lands, and thus should be considered the minimum at each of those sites. Additionally, different levels of effort each year at each site affected the number caught. The location of nests and active satellite burrows are reported in Appendix 2. Along with our cooperators in Mexico, we visited 21 Mexican states (also see Part II). We collected blood and feather samples from 7152 Burrowing Owls throughout the species' breeding range, from Alberta and Saskatchewan in Canada, throughout the western United States and northern Mexico and as far south as Mexico City.

**Range-wide patterns in body size of burrowing owls**

Burrowing Owls captured on DoD and surrounding areas in the U.S. and Mexico were heavier ($F_{1,774}$ = 38.3, $P$ <0.001) and their wing chords were longer ($F_{1,585}$ = 17.8, $P$ <0.001) as latitude increased (after accounting for sex and capture date; Figs. 1 and 2). In contrast, we did not find a significant pattern in metatarsal length of Burrowing Owls with changing latitude after accounting for sex and capture date (Fig. 3) ($F_{1,756}$ = 0.9, $P$ = 0.356). Juvenile Burrowing Owls were also heavier with increasing latitude after accounting for the age of the juvenile and capture date (Fig. 4) ($F_{1,1389}$ = 27.3, $P$ <0.001). The pattern that owls are heavier and larger as latitude increases is a common pattern in endotherms (Mayr 1963).

**Estimating changes in burrowing owl distribution based on BBS data**

Our model of burrowing owl breeding distribution based on BBS survey data suggests temporal and spatial changes in the likelihood of detecting burrowing owls on BBS routes throughout North America. The overall proportion of BBS routes at which surveyors detected burrowing owls has decreased in several areas near the northern and eastern edge of the burrowing owl distribution, especially in southern Canada, in eastern North and South Dakota, in eastern Nebraska, and in southern Texas since the first half of the 1970s. In this regard, our logistic regression model suggests a contraction of the burrowing owl's breeding distribution, primarily at the edges of its range (Fig. 5). Overall, the burrowing owl's breeding range evidently retreated from 1967 to 2008 in southern and northern California, Washington, southern Canada, eastern North and South Dakota, eastern Nebraska, eastern Kansas, and southern Texas. All 10 simulations (not shown) failed to reproduce the range contraction observed when we modeled the original dataset. Our simulations produced inconsistent, random contractions and expansions throughout the eastern and northern edges of the burrowing owl's breeding distribution. The results of these simulations suggest that our inferred contraction in the species' distribution is real and is not an artifact of the sampling scheme in the BBS.

**Connectivity among populations based on genetic markers**

We developed 10 new microsatellite markers for burrowing owls (Macias-Duarte et al. 2010). Burrowing owls exhibited high levels of genetic diversity (Table 5) with relatively low variation among study locations. Per-locus average of number of effective alleles (range 5.70–7.82), expected heterozygosity (range 0.78–0.84), observed heterozygosity (range 0.78–0.87), and fixation index (range -0.06–0.04) were similar among the 36 study locations (Table 5) in spite of the relatively large differences in sample size (range 21-73; Table 3), per-locus average number of alleles (range 9.40–15.70), and number of private alleles (alleles present at only 1 population, range 0.00–0.50; Table 5). We detected the possible occurrence of null alleles for locus ATCU13 in BUC and CUL study locations, for locus ATCU20 in LAG and SAK study locations, for locus ATCU39 in NTS study location, and for locus ATCU45 in MEX study location.

Burrowing owls had low levels of genetic differentiation among study locations as shown by relatively low overall $F_{ST}$ ($\theta = 0.008$) and low pairwise $F_{ST}$ statistics ($\overline{F}_{ST} = 0.0113 \pm 0.0002$, n=630). Low levels of genetic differentiation were also evident in our estimates of actual differentiation *D*, ranging from 0.00 to 0.11. In this regard, we found only a very weak relationship between genetic distance and geographic distance among our study locations (Fig. 6) with a non-significant Mantel's test ($r = 0.015$, $P = 0.43$ based on 1000 permutations). Nevertheless, pairwise comparisons of genetic and geographic distances among northern study locations and southern agricultural locations fall below the Mantel regression line (Fig. 6) in agreement with the prediction of the migration-mediated range-shift hypothesis.

Low levels of genetic differentiation among populations were also highlighted by our *AMOVA*s based on the $R_{ST}$ and $F_{ST}$ statistics. Genetic variation within study locations explained 99% of the total genetic variation, whereas between-study locations and between two-group classifications of study locations explained the remaining 1%. Despite the low levels of genetic differentiation described above, our *AMOVA* based on the $F_{ST}$ statistic provided support the range-shift hypothesis. Both a standard *AMOVA* and a weighted-averaged *AMOVA* over all loci provided suggestive evidence that northern study locations (ALB, SAK, and GRL) and southern agricultural study locations (CAG, CAB, CUL, FUE, HER, MEX, YAQ) together are genetically differentiated from the rest of the study locations ($P = 0.03$ and $P = 0.01$, respectively) although this result did not hold true for the 2 *AMOVA*s based on $R_{ST}$ ($P$=0.38 and $P$=0.34, respectively). In addition, only 1 of the 7 additional *AMOVA*s based on $F_{ST}$ was significant for both the standard *AMOVA* and the weighted-averaged *AMOVA* over all loci (Table 4), which is precisely the *AMOVA* that included the nearest 3 study locations (CHI, JAN, and TUC) within Group 1.

*STRUCTURE* revealed a genetic structure consisting of 3 populations in the western burrowing owl in spite of the low levels of genetic differentiation among study locations shown by $F_{ST}$ and *D* statistics. Mean log-likelihood of the observed genotypic data and $\Delta K$ was highest at $K$=3 (indicating 3 distinct populations). The posterior probabilities of membership of each of our 1,560 individual owls assigned to these putative populations had a noticeable geographic pattern (Fig. 7). Almost all burrowing owls in southern agricultural study locations in southern Sonora (YAQ) and Sinaloa (FUE and CUL) had a higher probability of membership to one inferred population (Sinaloan population). This genetic structure was corroborated by a standard *AMOVA* (based on the $F_{ST}$ ) which differentiates this Sinaloan population (CUL, FUE, and YAQ) from the rest of the study locations ($P = 0.005$). This Sinaloan fingerprint is relatively common within nearby populations in Sonora, southern Arizona, and as far as Chihuahua (CHI), northern Texas (TXP) and the Central Valley of California (DIX) (green color in pie charts in Fig. 7).

Similarly, burrowing owls from Nellis Air Force Base in southern Nevada (NEL) define a distinctive population (Mohave population), whose fingerprint also appears in burrowing owl populations in the western portion of the breeding range in Washington, California, and Utah (blue color in pie charts in Fig. 7). Finally, the great majority of the individuals in the remainder of the study locations, including northern study locations, had the fingerprint of a third inferred population (North American population) where northern study locations and the northern half of the southern agricultural study locations (HER, CAB, MEX, and CAG) are included. Under this scenario, our hypothesis is not supported. Individual owls from 4 southern agricultural study locations (CAG, MEX, CAB, HER) had similar probabilities of membership to those found in owls from northern locations but also similar to those found in owls from non-agricultural study locations in the southern part of the range (e.g., JAN, GAL). In addition, probabilities of membership were remarkably different in owls from the 3 southernmost agricultural locations (CUL, FUE, and YAQ), compared to those found in owls from northern locations (ALB, SAK, and GRL).

Our genetic analyses suggest differentiation among Burrowing Owl populations for the 2 island populations off the coast of Mexico (on Guadalupe Island and Clarion Island). Our genetic data suggest that Burrowing Owls on these 2 populations are genetically distinct and may warrant subspecies status. Our results suggest high levels of connectivity among Burrowing Owl populations throughout mainland North America with subtle structure indicating more than expected linkages between the northern-most populations and populations in southern agricultural areas. This pattern lends some support for the hypothesis that irrigated agriculture in northwestern Mexico and southwestern United States may have caused a change in migratory behavior of northern Burrowing Owl populations.

**Connectivity and linkages based on stable isotope ratios of feathers**

The distribution of isotopic signatures of nestling feathers varied among study populations (Fig. 8). We found a general pattern of increased enrichment in both $\delta^{13}C$ and $\delta^{15}N$ with decreasing latitude, but we also found some examples of similar $^{13}C$–$^{15}N$ signatures in nestling feathers from distant locations. For example, the northwestern Sonora ellipse (CAB) overlaps with that of distant populations in central Colorado (BRM; Fig. 8). In addition, the ellipse from northern Baja California (MEX) overlaps with those for Alberta and Saskatchewan. The use of 95$^{th}$-percentile ellipses allows us to minimize the error of classifying a local burrowing owl as an immigrant, although this procedure may classify some immigrants as locals. The area of the 95$^{th}$-percentile ellipses was not correlated ($r = 0.25$) with the number of data points used to generate them, suggesting that the sample sizes we used to generate the ellipses did not bias our results.

In most locations, the signatures of feathers collected from adults (open circles and triangles in Fig. 8) had higher intra-population variation than those of the nestlings in that same location (filled circles in Fig. 8), which is expected given the likely existence of immigrants within the adult population. We found a remarkable geographic pattern of philopatry-immigration among burrowing owl populations. Northern populations in Alberta (ALB), Saskatchewan (SAK), and southwestern Idaho (MNH) had the highest proportion of immigrants among all burrowing owl populations, with 95%, 92%, and 67% of their breeding populations originating elsewhere, respectively (Fig. 9). We also observed a high proportion of immigrants in the peripheral populations in central and southern Baja California (MUL and SDO), as well as in southwestern Utah (SGE), although our sample sizes in those locations were low. We observed the highest proportion of philopatic birds in an isolated population in central Mexico (TEX) where 100% of the adult owls shared the stable isotope signature of the local nestlings. The proportion of return birds in the remaining populations, including agricultural populations in northwestern Mexico, averaged 70.0±2.7% (range 41.7-89.5%). The highest proportion of philopatric birds among these populations (89.5%) was within an agricultural area in central Sonora (Hermosillo, HER; Fig. 9), providing some support to the first prediction of our hypothesis: that irrigated agricultural areas in the southern portion of the species' range have higher site fidelity than southern populations in non-agricultural areas. However, agricultural areas in Imperial Valley (SSW) had a relatively low proportion of philopatric owls (41.7%) compared to the rest of the interior populations. Populations in eastern Washington (TCY) at the northwestern edge of the species' breeding distribution also had relatively high levels of philopatry compared to that of populations in Canada.

LOESS regression allowed us to find geographic gradients in $\delta^2H$, $\delta^{13}C$, and $\delta^{15}N$ values in nestling feathers across North America (Fig. 10), and use these isoscapes to document general patterns of burrowing owl breeding dispersal throughout the North American continent. Deuterium showed a latitudinal gradient consistent with the well-known geographical pattern documented for precipitation, with more enriched deuterium in southern latitudes. However, we found a noticeable disruption in the general latitudinal pattern in $\delta^2H$ in southwestern United States and northwestern Mexico. This disruption originated from extraordinarily low $\delta^2H$ values in burrowing owl nestling feathers at Salton Sea National Wildlife Refuge (SSW) and the Mexicali valley (MEX) along the lower Colorado River (Fig. 11). We also observed a latitudinal pattern in $\delta^{15}N$ without major disruptions, with more $^{15}N$ -enriched nestling feathers in southern latitudes (Fig. 10). $\delta^{13}C$ showed a longitudinal pattern with the less $^{13}C$-enriched values towards the Rocky Mountains (Fig. 10). Despite these latitudinal and longitudinal patterns in our 3 isotopes, we found large variation within study populations that limited our precision in predicting the origin of adult burrowing owls based solely on their isotopic signatures. The difference between the maximum and minimum predicted values (range) of $\delta^2H$, $\delta^{13}C$, and $\delta^{15}N$ in basemaps was 76.5, 9.7, and 5.6‰, respectively (Fig. 10). This overall geographic variation approaches the within-population variation in $\delta^2H$, $\delta^{13}C$, and $\delta^{15}N$, with 95%-interpercentile range for residuals of 45.2, 9.2, and 5.3‰, respectively. Therefore, our results should be interpreted with caution.

Breeding dispersal in burrowing owls seemed unconstrained throughout the North American continent, although some latitudinal patterns in dispersion distances were evident. Northern populations (e.g., ALB, SAK, MOS, TCY and WYO) received immigrants from more southern populations. Populations in Canada received immigrants from locations as far south as central California, southern Nevada, and western Arizona. However, adult burrowing owls captured in Canada that were assigned to southern locations irrigated with water from the Colorado River may be an artifact of similar isotopic signatures in these 2 regions (Fig. 11). Burrowing owl breeding populations at intermediate latitudes, such as eastern Colorado (BRM) received immigrant owls from an extensive region spanning from Canada to northwestern Mexico, as well as central Mexico (Fig. 12). Southern populations relied more on local recruitment and immigration from neighbouring populations than northern populations. Populations in the California Central Valley (DIX) seemed to recruit breeding burrowing owls exclusively within the valley. Populations in the Mohave Desert (EDW) apparently received immigrants from populations in agricultural areas in southern California and northwestern Mexico, as well as from populations in Canada and central Mexico.

Burrowing owl populations breeding in agricultural areas in southwestern United States and northwestern Mexico differed in the geographic origin of their immigrants. Our study populations at Casa Grande (CAG) and Mexicali Valley (MEX) showed high levels of local recruitment and immigration from neighboring populations. However, the burrowing owl population in southern California (SSW), adjacent to the Mexicali Valley (MEX), received immigrants from a much larger segment of the species' breeding range, including central Sinaloa, eastern Washington, and Canada. Both Sinaloa populations (FUE and CUL) had high local recruitment in addition to immigrants from areas east of the Sierra Madre Occidental, but received no migrants from Canada. FUE and CUL appeared to receive fewer long-distance immigrants compared to other populations. Owl populations breeding in agricultural areas of southern Sonora (YAQ) relied exclusively on local recruitment and immigration from the Sonoran desert populations, including those in southern California. Our results suggest a relatively high proportion of local recruits in agricultural populations in central Sonora (HER), with some immigrants for central Mexico. Isotopic signatures of adults breeding in agricultural areas in northwestern Sonora (CAB) suggest immigration from neighbouring populations and from as far north as Canada and as far south as central Mexico. Therefore, we found evidence of burrowing owls from northern latitudes (where only migratory populations breed) becoming resident breeders in agricultural areas in both southern California and northwestern Sonora. This pattern is what was predicted by the migratory-mediated range-shift hypothesis.

Populations in the Mexican Highlands in Chihuahua (JAN, CHI, and DEL), Coahuila (LAG), and Nuevo Leon (GAL) suggest primarily breeding dispersal at a regional level (within the Mexican Highlands and the Great Plains) plus immigrants from elsewhere: eastern Washington for JAN and CHI, Sonora and Sinaloa for LAG and GAL, and central Mexico for all 5 populations.

## CONCLUSIONS

The Burrowing Owl is a bird high on priority lists of regional and national Partners in Flight conservation plans. Numerous regional, national, and international efforts are underway to develop management or conservation plans for Burrowing Owls. Our modeling effort confirms that the breeding range of the burrowing owl has contracted over the past 40 years; local populations have been extirpated in the northern, eastern, and western periphery of the breeding range. Our results suggest that most Burrowing Owl populations throughout western North America have high connectivity with little or no genetic differentiation. However, we did find some evidence that northern-most populations (that are 100% migratory) are more closely linked to populations in southern agricultural areas (in the southwestern U.S. and northern Mexico) than would be expected by chance. Although this pattern, on the surface, supports the hypothesis that owls in the northern portion of their range are becoming less migratory, our stable isotope analysis suggests that dispersal is occurring in the opposite direction (owls originating from southern latitudes are dispersing to northern latitudes). In fact, our results suggest that owls at the northern extent of their range are being "rescued" by immigrants from the southern extent of the range. Moreover, we found evidence that suggests 3 genetically distinct populations of burrowing owls in Mexico. Levels of differentiation among these populations appear sufficient to warrant status as separate subspecies. Aside from these distinct populations in Mexico, the fate of burrowing owls at locations throughout the U.S. is dependent on healthy rates of dispersal from other locations within the species' range. Efforts to boost burrowing owl populations in one portion of their range may best be served by documenting the locations from where the target area typically receives dispersing immigrants.

Table 1. All DoD installations and other sites that participated in the DoD Legacy Program Burrowing Owl project, 2005-2009.

| State | Site | DoD installation |
|---|---|---|
| AZ | Avra Valley | |
| AZ | Barry M. Goldwater Range | ✓ |
| AZ | Casa Grande National Monument | |
| AZ | Davis-Monthan AFB | ✓ |
| AZ | Salton Sea NWR | |
| AZ | Tucson | |
| AZ | Yuma | |
| AZ | Yuma Marine Corps Air Station | ✓ |
| AZ | Yuma Proving Ground | ✓ |
| AZ | Camp Pendleton | ✓ |
| CA | Dixon Navy Radio Transmitter Facility | ✓ |
| CA | Edwards AFB | ✓ |
| CA | El Centro, NAF | ✓ |
| CA | Fort Irwin | ✓ |
| CA | George Air Force Base/Adelanto | ✓ |
| CA | Hemet | |
| CA | March JARB | ✓ |
| CA | MCLB Barstow | ✓ |
| CA | NAS Lemoore | ✓ |
| CA | Naval Base Coronado | ✓ |
| CA | Seal Beach Naval Weapons Station | ✓ |
| CA | Sharpe Depot | ✓ |
| CA | Travis AFB | ✓ |
| CO | Buckley AFB | ✓ |
| CO | Fort Carson | ✓ |
| CO | Pinon Canyon Maneuver Site | ✓ |
| CO | Pueblo Chemical Depot | ✓ |
| CO | Rocky Flats | |
| CO | Rocky Mountain Arsenal NWR | |
| CO | Schriever AFB | ✓ |
| ID | Crooked Creek Ranch | |
| ID | Elmore | |
| ID | Hwy 26/Blackfoot | |
| ID | Mountain Home AFB | ✓ |
| ID | Orchard Training Range | ✓ |
| ID | Power | |

| State | Site | DoD installation |
|---|---|---|
| NM | Cannon AFB | ✓ |
| NM | Fort Bliss AFB | ✓ |
| NM | Holloman AFB | ✓ |
| NM | Kirtland AFB | ✓ |
| NM | White Sands Missile Range | ✓ |
| NV | Nellis AFB | ✓ |
| NV | Nevada Test Site | |
| OR | Boardman Bombing Range | ✓ |
| UT | Antelope Island | |
| UT | Deseret Chemical Depot | ✓ |
| UT | Dugway Proving Ground | ✓ |
| UT | Hill AFB | ✓ |
| UT | Kennecott Mining Co., Saltair | |
| UT | St. George | |
| UT | Stark Road | |
| UT | Vernon | |
| WY | Camp Guernsey | ✓ |
| WY | FE Warren AFB | ✓ |
| WY | Lovell Training Area | ✓ |
| WY | Sheridan Training Area | ✓ |

Table 2. Number of females, males, adults of unknown sex, and juveniles captured at each participating site from 2005-2009. The number of nests is based on the number of owls captured, not a total count of nests in the area, and thus should only be considered a minimum. Additionally, the level of effort at each site varied across years.

| State | Site | Year | Females | Males | Adults (sex unknown) | Juveniles | # of nests |
|---|---|---|---|---|---|---|---|
| AZ | Avra Valley | 2006 | 1 | | | | 1 |
| AZ | Avra Valley | 2007 | 3 | 1 | | 6 | 3 |
| AZ | Barry M. Goldwater Air Force Range | 2006 | | | | | 0 |
| AZ | Casa Grande | 2005 | 84 | 53 | | 253 | 109 |
| AZ | Casa Grande | 2006 | 51 | 43 | 10 | 7 | 78 |
| AZ | Davis Monthan Air Force Base | 2005 | 55 | 43 | 4 | 208 | 74 |
| AZ | Davis Monthan Air Force Base | 2006 | 26 | 24 | 6 | 18 | 38 |
| AZ | Tucson | 2005 | 16 | 7 | 2 | 49 | 26 |
| AZ | Tucson | 2006 | 6 | 3 | 1 | | 8 |
| AZ | Tucson | 2007 | 18 | 10 | | 33 | 22 |
| AZ | Tucson | 2008 | 5 | 2 | | | 6 |
| AZ | Yuma | 2006 | 3 | 3 | | 3 | 5 |
| AZ | Yuma Marine Corps Air Station | 2006 | 2 | 5 | | | 5 |
| AZ | Yuma Proving Ground | 2006 | | | | | 0 |
| CA | Camp Pendleton | 2006 | | | | | 0[a] |
| CA | Dixon Navy Radio Transmitter Facility | 2006 | 7 | 13 | | 4 | 17 |
| CA | Dixon Navy Radio Transmitter Facility | 2007 | 9 | 4 | | 34 | 12 |
| CA | Edwards Air Force Base | 2006 | 16 | 18 | | 46 | 32 |
| CA | Edwards Air Force Base | 2007 | 13 | 16 | | 7 | 19 |
| CA | Fort Irwin | 2006 | | | | | 0 |
| CA | George Air Force Base/Adelanto | 2005 | | | | 3 | 1 |
| CA | Hemet and surrounding areas | 2005 | 11 | 6 | | 19 | 16 |
| CA | March Air Force Base | 2006 | 3 | 2 | | 10 | 5 |
| CA | MCLB Barstow surrounding area | 2007 | | | | | 0[b] |
| CA | Naval Air Facility El Centro | 2006 | 22 | 20 | | 8 | 24 |
| CA | Naval Air Facility El Centro | 2007 | 22 | 18 | | 23 | 29 |
| CA | Naval Air Station Lemoore | 2006 | 18 | 14 | | 70 | 31 |
| CA | Naval Air Station Lemoore | 2007 | 9 | 9 | | 8 | 13 |
| CA | Naval Air Station North Island | 2005 | 1 | | | 7 | 3 |
| CA | Naval Air Station North Island | 2006 | 5 | 4 | | 14 | 7 |
| CA | Naval Air Station North Island | 2007 | 3 | 2 | | 4 | 3 |
| CA | Naval Air Station North Island | 2008 | 1 | 1 | | 4 | 1 |
| CA | Seal Beach Naval Weapons Station | 2005 | 1 | 2 | | 2 | 2 |
| CA | Sharpe Depot | 2007 | 11 | 7 | | 35 | 17 |
| CA | Travis Air Force Base | 2007 | 8 | 5 | | 15 | 8 |
| CO | Buckley Air Force Base | 2006 | 11 | 14 | | 44 | 15 |
| CO | Buckley Air Force Base | 2007 | 3 | 5 | | 10 | 6 |
| CO | Fort Carson | 2006 | 7 | 3 | | 25 | 9 |
| CO | Fort Carson | 2007 | 1 | | | 18 | 5 |
| CO | Pinon Canyon Maneuver Site | 2006 | | | | 19 | 9 |
| CO | Pinon Canyon Maneuver Site | 2007 | 7 | 2 | | 32 | 20 |
| CO | Pueblo Chemical Depot | 2006 | 14 | 5 | | 44 | 21 |
| CO | Pueblo Chemical Depot | 2007 | 1 | 2 | | 27 | 10 |
| CO | Rocky Mountain Arsenal | 2007 | 10 | 6 | | 14 | 12 |
| CO | Rocky Flats | 2006 | | | | | 0 |

| State | Site | Year | Females | Males | Adults (sex unknown) | Juveniles | # of nests |
|---|---|---|---|---|---|---|---|
| CO | Schriever Air Force Base | 2006 | 6 | 2 | | 8 | 6 |
| ID | Blackfoot | 2007 | 3 | 1 | | 28 | 9 |
| ID | Blackfoot | 2008 | 2 | | | 5 | 4 |
| ID | Crooked Creek Ranch | 2007 | 2 | 1 | | 1 | 2 |
| ID | Elmore | 2008 | 3 | 1 | | 9 | 3 |
| ID | Mt. Home Air Force Base | 2007 | 26 | 25 | | 48 | 42 |
| ID | Mt. Home Air Force Base | 2008 | 12 | 4 | | 28 | 14 |
| ID | Orchard Training Range | 2007 | | | | | 0[c] |
| ID | Power | 2008 | 2 | | | 19 | 5 |
| NM | Cannon | 2008 | 2 | 1 | | 3 | 5 |
| NM | Fort Bliss | 2006 | | | | 2 | 1 |
| NM | Fort Bliss | 2007 | 1 | 1 | | 10 | 4 |
| NM | Fort Bliss | 2008 | 2 | 0 | | 0 | 2 |
| NM | Holloman Air Force Base | 2005 | | | | 2 | 1 |
| NM | Holloman Air Force Base | 2006 | | | | 8 | 4 |
| NM | Holloman Air Force Base | 2007 | 0 | 2 | | 14 | 6 |
| NM | Holloman Air Force Base | 2008 | 4 | 2 | | 13 | 9 |
| NM | Kirtland Air Force Base | 2005 | 9 | 10 | | 41 | 22 |
| NM | Kirtland Air Force Base | 2006 | 7 | 5 | | 67 | 23 |
| NM | Kirtland Air Force Base | 2007 | 6 | 8 | | 61 | 25 |
| NM | Kirtland Air Force Base | 2008 | 6 | 12 | | 60 | 30 |
| NM | White Sands Missle Range | 2005 | | | | 4 | 1 |
| NM | White Sands Missle Range | 2006 | 3 | 1 | | 16 | 5 |
| NM | White Sands Missle Range | 2007 | 7 | 2 | | 22 | 7 |
| NM | White Sands Missle Range | 2008 | 4 | 2 | | 4 | 4 |
| NV | Nellis Air Force Base | 2006 | 20 | 20 | | 19 | 23 |
| NV | Nellis Air Force Base | 2007 | 11 | 11 | | | 19 |
| NV | Nevada Test Site | 2005 | 1 | | | 21 | 6 |
| NV | Nevada Test Site | 2006 | 12 | 4 | | 18 | 12 |
| NV | Nevada Test Site | 2007 | 4 | 1 | | 2 | 4 |
| NV | Nevada Test Site | 2008 | 6 | 1 | | 2 | 7 |
| OR | Boardman Bombing Range | 2006 | 1 | | | 1 | 2 |
| UT | Antelope Island | 2008 | | 2 | | 4 | 3 |
| UT | Deseret Chemical Depot | 2008 | 1 | 2 | | 8 | 2 |
| UT | Dugway Proving Ground | 2007 | | 2 | | | 1 |
| UT | Dugway Proving Ground | 2008 | 9 | 2 | | 30 | 11 |
| UT | Hill Air Force Base | 2007 | 1 | | | | 1 |
| UT | Kennecott Mining Co. | 2007 | 1 | | | 3 | 1 |
| UT | Stark Road | 2008 | 1 | | | 5 | 1 |
| UT | St. George | 2007 | 5 | 1 | | 14 | 9 |
| UT | Vernon | 2008 | 5 | 1 | | 24 | 7 |
| WY | Camp Guernsey | 2007 | | | | | 0 |
| WY | FE Warren AFB | 2007 | | | | | 0 |
| WY | Lovell Training Area | 2007 | | | | | 0 |
| WY | Sheridan | 2007 | 1 | 1 | | | 1 |

[a] Camp Pendleton is no longer thought to have breeding owls but does support migrant (and perhaps wintering) owls.

[b] Only the area surrounding the base was surveyed.

[c] No owls were banded at Orchard but >0 owls were present.

Table 3. Numbers of individuals sampled within each of 36 burrowing owl study locations in Canada, United States, and Mexico. Study location acronyms with (*) and (†) denote southern agricultural populations and northern declining migratory populations, respectively

| Study location | Acronym | Individuals genotyped |
|---|---|---|
| Southern Alberta, Alberta, Canada | ALB† | 37 |
| Baja California Sur, Mexico | BCS | 23 |
| Buckley Air Force Base, Colorado, U.S.A. | BUC | 33 |
| Buffalo Gap National Grassland, South Dakota, U.S.A. | BUF | 54 |
| Caborca Valley, Sonora, Mexico | CAB* | 25 |
| Casa Grande, Arizona, U.S.A. | CAG* | 59 |
| Fort Carson Army Base, Colorado, U.S.A. | CAR | 23 |
| Coyame and Ahumada, Chihuahua, Mexico | CHI | 34 |
| Comanche National Grassland, Colorado, U.S.A | COM | 40 |
| Culiacan Valley, Sinaloa, Mexico | CUL* | 63 |
| Delicias, Chihuahua, Mexico | DEL | 25 |
| Dixon Naval Radio Transmitter Facility, California, U.S.A. | DIX | 29 |
| Dugway Air Force Base, Utah, U.S.A. | DUG | 30 |
| Edwards Air Force Base, California, U.S.A. | EDW | 44 |
| Rio Fuerte Valley, Sinaloa, Mexico | FUE* | 67 |
| Galeana, Nuevo Leon, Mexico | GAL | 47 |
| Grand River-Little Missouri Natl. Grasslands, North Dakota | GRL† | 21 |
| Hermosillo, Sonora, Mexico | HER* | 60 |
| Holloman Air Force Base, New Mexico, U.S.A. | HOL | 22 |
| Janos, Chihuahua, Mexico | JAN | 62 |
| Kiowa - Rita Blanca National Grasslands, NM, TX, U.S.A. | KIB | 29 |
| Kirtland Air Force Base, New Mexico, U.S.A. | KIR | 73 |
| La Laguna, Coahuila, Mexico | LAG | 54 |
| Naval Air Station Lemoore, California, U.S.A. | LEM | 47 |
| Mexicali Valley, Baja California, Mexico | MEX* | 59 |
| Mountain Home Air Force Base, Idaho, U.S.A. | MNH | 62 |
| Moses Lake, Washington, U.S.A. | MOS | 55 |
| Nellis Air Force Base, Nevada, U.S.A. | NEL | 55 |
| Nevada Test Site, Nevada, U.S.A. | NTS | 25 |
| Pawnee National Grassland, Colorado, U.S.A. | PAW | 54 |
| Grasslands National Park and Regina Plains, Saskatchewan | SAK† | 61 |
| Tri-Cities, Washington, U.S.A. | TCY | 54 |
| Tucson, Arizona, U.S.A. | TUC | 25 |
| Texas Panhandle, Texas, U.S.A. | TXP | 15 |
| White Sands Missile Range, New Mexico, U.S.A. | WSM | 24 |
| Yaqui-Mayo Valley, Sonora, Mexico | YAQ* | 70 |

Table 4. Statistical significance (*P*-values) of Analyses of Molecular Variance (*AMOVA*) based on the $F_{ST}$ statistics for each of 8 two-group classifications of 36 burrowing owl study sites. Group 1 includes the southern agricultural study sites (CAB, CAG, CUL, FUE, HER, MEX, and YAQ) and the study sites listed in the table below. Group 2 includes the remainder of the study sites. Acronyms are listed in Table 3. Bold-face values denote significant comparisons for $\alpha$ = 0.05

| Study sites in Group 1 | *P*-value | |
|---|---|---|
| | Standard | Weighted averaged over all loci |
| **ALB, GRL, SAK** | **0.028** | **0.012** |
| MNH, MOS, TCY | 0.240 | 0.218 |
| BUF, CAR, PAW | 0.131 | 0.117 |
| EDW, NEL, NTS | 0.220 | 0.238 |
| COM, KIB, KIR | 0.184 | 0.174 |
| DEL, GAL, LAG | 0.060 | **0.046** |
| DIX, LEM | 0.329 | 0.328 |
| **CHI, JAN, TUC** | **0.027** | **0.008** |

Table 5. Mean number of alleles ($N_a$), number of effective alleles ($N_e$), number of private alleles ($N_p$), observed heterozygosity ($H_O$), expected heterozygosity ($H_E$), and fixation index ($F$) averaged across all 11 loci for each of 36 study locations of burrowing owls in North America. Population acronyms are shown in Table 3.

| Population | $N_a$ | $N_e$ | $N_p$ | $H_O$ | $H_E$ | $F$ |
|---|---|---|---|---|---|---|
| ALB | 13.40±1.72 | 7.24±1.09 | 0.20±0.13 | 0.83±0.02 | 0.84±0.02 | 0.00±0.02 |
| BCS | 11.00±1.26 | 6.36±0.96 | 0.20±0.13 | 0.81±0.04 | 0.82±0.02 | 0.02±0.03 |
| BUC | 12.00±1.62 | 7.04±1.12 | 0.00±0.00 | 0.82±0.04 | 0.82±0.03 | 0.01±0.03 |
| BUF | 14.20±1.76 | 7.09±1.33 | 0.20±0.13 | 0.84±0.02 | 0.83±0.02 | -0.01±0.01 |
| CAB | 10.80±1.27 | 6.70±0.78 | 0.00±0.00 | 0.84±0.03 | 0.83±0.02 | -0.01±0.02 |
| CAG | 14.70±1.76 | 6.88±1.07 | 0.00±0.00 | 0.84±0.02 | 0.83±0.02 | -0.01±0.01 |
| CAR | 10.40±0.79 | 5.77±0.65 | 0.00±0.00 | 0.86±0.03 | 0.81±0.02 | -0.06±0.03 |
| CHI | 12.30±1.29 | 6.66±0.92 | 0.00±0.00 | 0.82±0.03 | 0.83±0.02 | 0.01±0.02 |
| COM | 13.40±1.76 | 7.42±1.15 | 0.00±0.00 | 0.87±0.03 | 0.84±0.02 | -0.04±0.02 |
| CUL | 13.00±1.81 | 7.29±1.28 | 0.00±0.00 | 0.81±0.04 | 0.82±0.04 | 0.02±0.01 |
| DEL | 11.20±1.11 | 6.60±0.87 | 0.30±0.21 | 0.83±0.03 | 0.82±0.02 | -0.01±0.03 |
| DIX | 10.00±1.03 | 6.17±0.72 | 0.00±0.00 | 0.86±0.03 | 0.82±0.02 | -0.04±0.04 |
| DUG | 11.70±1.14 | 6.66±0.87 | 0.00±0.00 | 0.86±0.02 | 0.83±0.02 | -0.04±0.02 |
| EDW | 12.30±1.10 | 6.58±0.95 | 0.10±0.10 | 0.83±0.02 | 0.83±0.02 | 0.00±0.02 |
| FUE | 13.50±1.68 | 6.85±0.98 | 0.10±0.10 | 0.83±0.03 | 0.82±0.03 | 0.00±0.02 |
| GAL | 13.30±1.56 | 7.25±1.17 | 0.00±0.00 | 0.84±0.02 | 0.84±0.02 | -0.01±0.02 |
| GRL | 11.10±1.29 | 6.98±1.02 | 0.00±0.00 | 0.85±0.03 | 0.83±0.03 | -0.03±0.03 |
| HER | 13.40±1.30 | 6.92±1.09 | 0.00±0.00 | 0.83±0.02 | 0.83±0.02 | 0.00±0.02 |
| HOL | 10.70±1.18 | 6.81±1.03 | 0.00±0.00 | 0.86±0.04 | 0.83±0.02 | -0.04±0.03 |
| JAN | 14.10±1.63 | 7.22±1.21 | 0.20±0.13 | 0.86±0.02 | 0.83±0.02 | -0.03±0.01 |
| KIB | 11.90±1.34 | 6.80±1.05 | 0.00±0.00 | 0.80±0.03 | 0.82±0.03 | 0.03±0.02 |
| KIR | 15.00±1.56 | 7.34±1.11 | 0.30±0.30 | 0.84±0.02 | 0.84±0.02 | 0.00±0.02 |
| LAG | 14.20±1.73 | 7.42±1.19 | 0.20±0.13 | 0.83±0.03 | 0.84±0.02 | 0.01±0.03 |
| LEM | 12.60±1.50 | 6.82±1.27 | 0.10±0.10 | 0.83±0.03 | 0.82±0.02 | 0.00±0.02 |
| MEX | 13.70±1.67 | 7.20±1.22 | 0.10±0.10 | 0.83±0.03 | 0.83±0.02 | 0.00±0.02 |
| MNH | 14.50±1.90 | 7.36±1.29 | 0.00±0.00 | 0.84±0.03 | 0.83±0.02 | -0.01±0.01 |
| MOS | 14.20±1.36 | 7.37±1.15 | 0.50±0.40 | 0.84±0.03 | 0.84±0.02 | 0.00±0.01 |
| NEL | 12.50±1.34 | 6.15±0.57 | 0.00±0.00 | 0.83±0.02 | 0.82±0.02 | -0.01±0.01 |
| NTS | 11.30±1.24 | 6.95±0.70 | 0.00±0.00 | 0.81±0.03 | 0.84±0.02 | 0.04±0.03 |
| PAW | 14.20±1.65 | 7.82±1.37 | 0.00±0.00 | 0.84±0.02 | 0.84±0.02 | 0.00±0.02 |
| SAK | 15.70±2.09 | 7.64±1.38 | 0.20±0.13 | 0.84±0.02 | 0.84±0.02 | 0.00±0.03 |
| TCY | 13.10±1.68 | 7.13±0.93 | 0.00±0.00 | 0.86±0.03 | 0.84±0.02 | -0.02±0.03 |
| TUC | 9.40±1.13 | 5.70±0.76 | 0.00±0.00 | 0.78±0.04 | 0.79±0.03 | 0.01±0.03 |
| TXP | 9.50±1.26 | 5.95±0.93 | 0.00±0.00 | 0.78±0.05 | 0.78±0.04 | 0.00±0.04 |
| WSM | 11.70±1.09 | 7.11±0.98 | 0.10±0.10 | 0.85±0.03 | 0.84±0.02 | -0.02±0.02 |
| YAQ | 13.50±1.55 | 6.79±0.96 | 0.20±0.20 | 0.82±0.02 | 0.83±0.02 | 0.01±0.01 |

Figure 1. Weight of adult Burrowing Owls increased with increasing latitude after accounting for sex and the date on which the adult was captured.

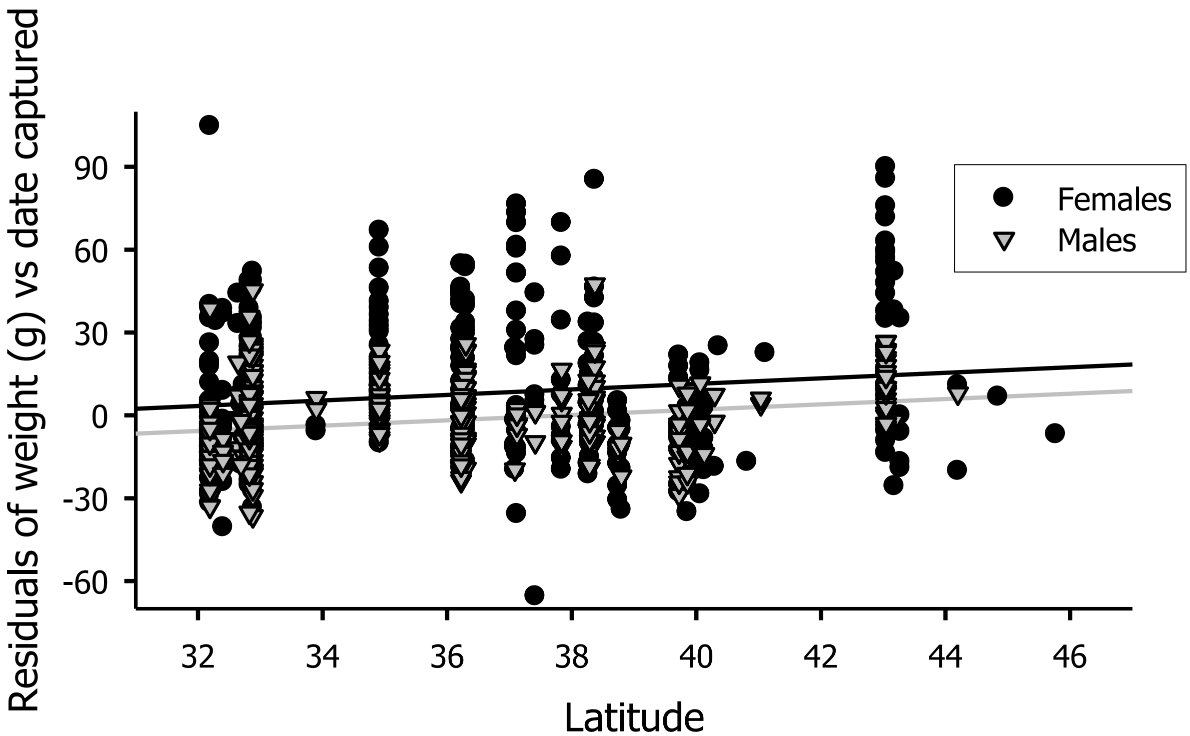


Figure 2. Size of adult Burrowing Owls (measured in wing-chord length) increased with increasing latitude after accounting for sex and the date on which the adult was captured.

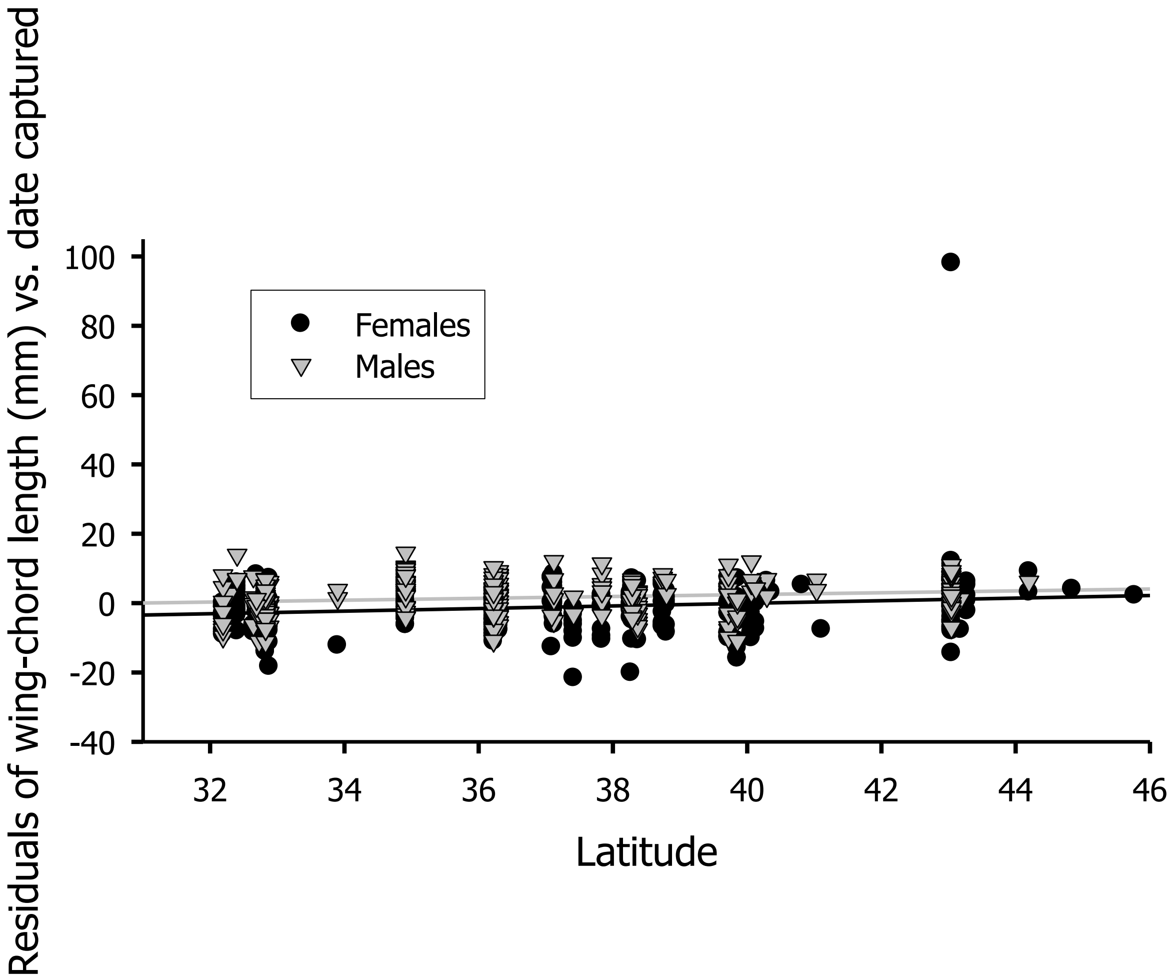


Figure 3. We did not find a significant change in size of adult Burrowing Owls (measured in metatarsal length) with increasing latitude after accounting for sex and the date on which the adult was captured.

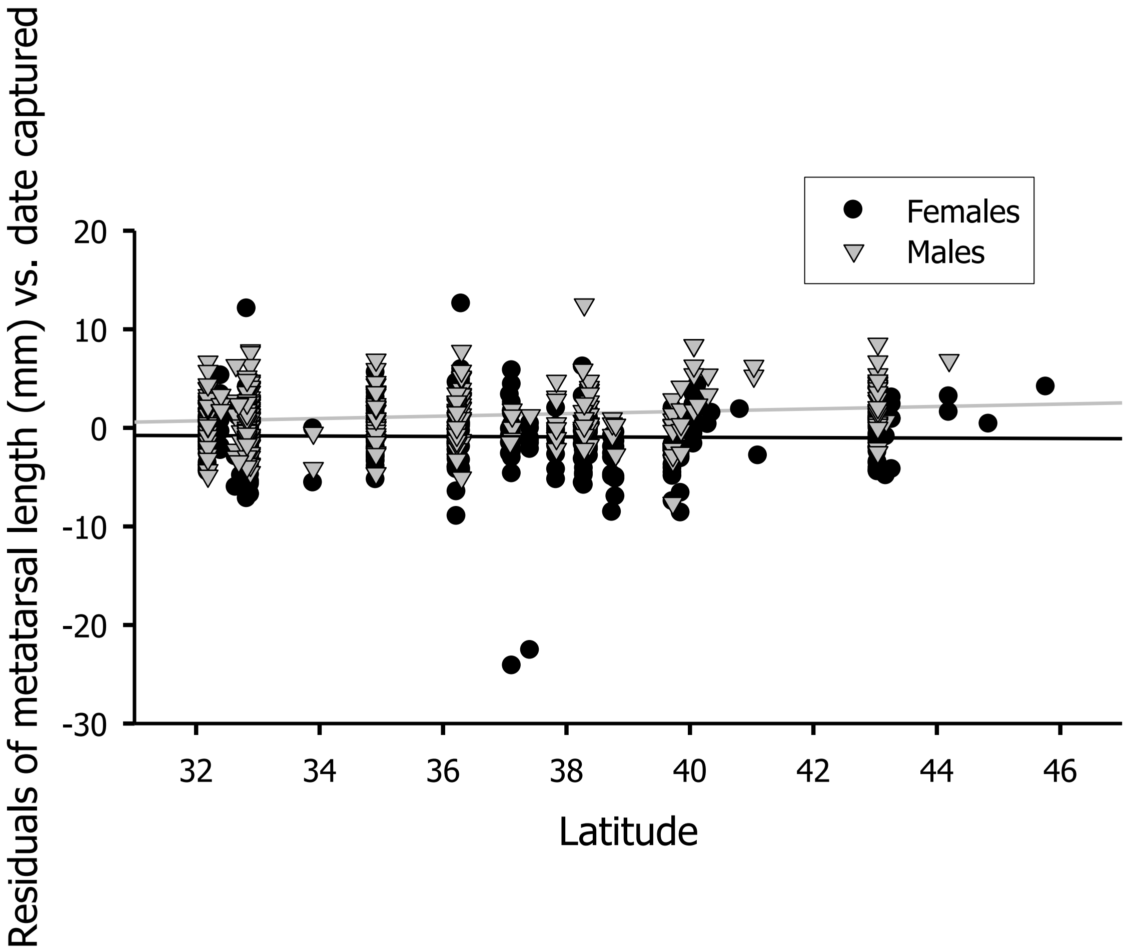


Figure 4. Weight of juvenile Burrowing Owls increased with increasing latitude after accounting for the age of the juvenile and the date on which it was captured.

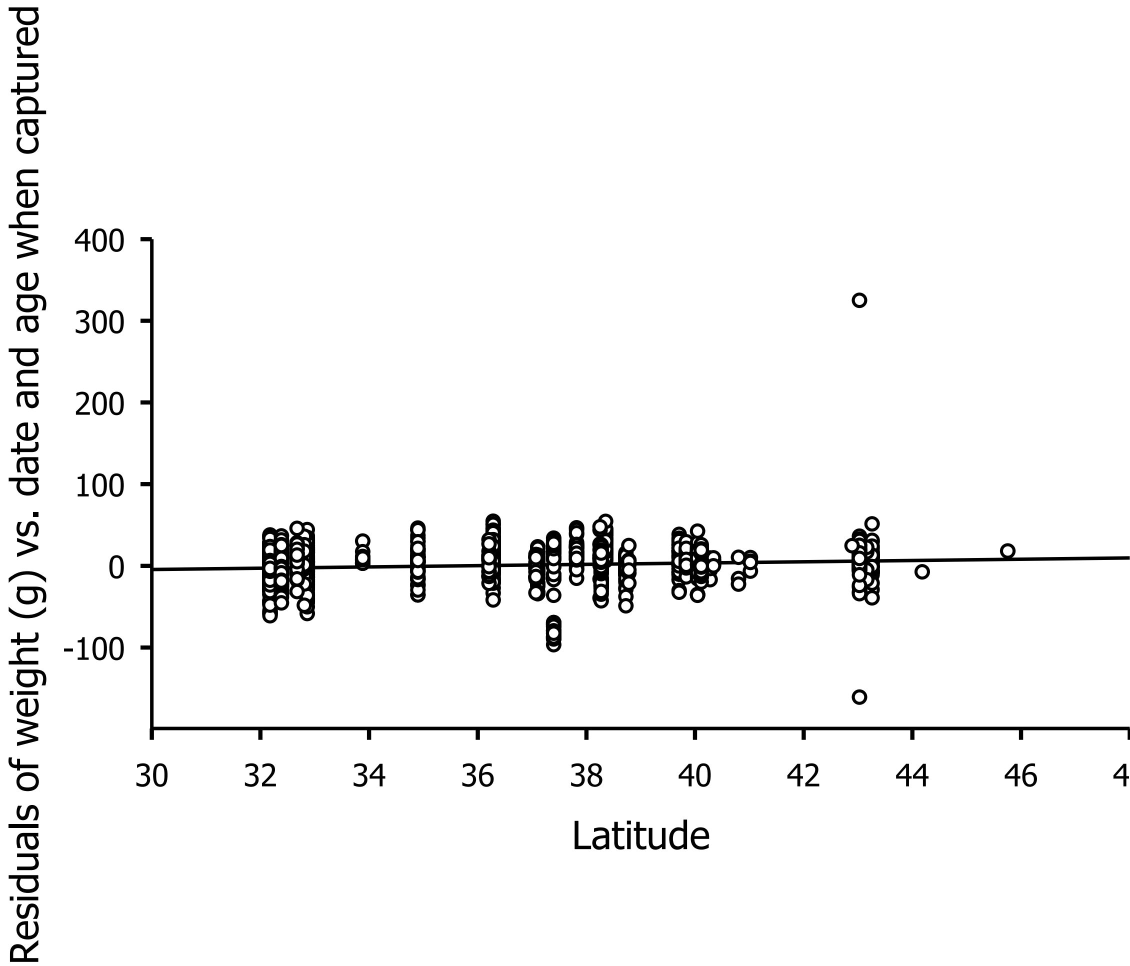


Figure 5. Estimated change in the breeding range of burrowing owls from 1967 to 2008 based on logistic regression of Breeding Bird Survey (BBS) data. The gray area denotes the owl's breeding range in 1967 as predicted by the model whereas the red area denotes the owl's breeding range in 2008 as predicted by the model. All dots show BBS routes at which >1 burrowing owl was detected. Empty dots indicate BBS routes where >1 burrowing owl was detected before 1987 but none after 1987. Black dots indicate BBS routes where >1 burrowing owl was detected after 1987 (regardless of how many were detected prior to 1987).

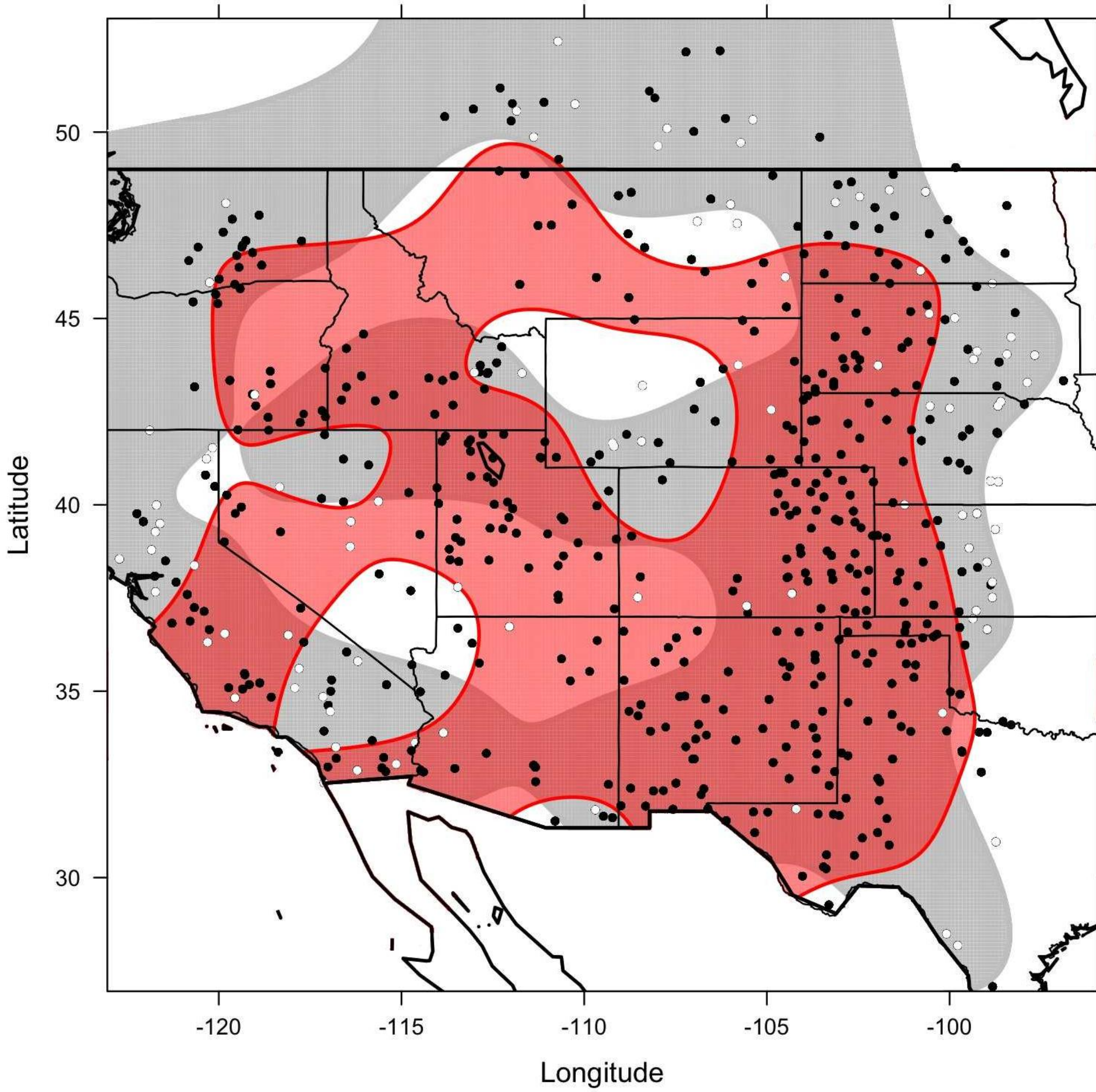


Figure 6. Scatterplot of actual differentiation D vs. geographic distances for all pairwise comparisons (n=630) among our 36 burrowing owl study locations across North America. Black dots indicate pairwise comparisons between northern study locations and southern agricultural locations, whereas empty dots indicate pairwise comparisons among the remainder of the study locations. Mantel correlation between geographic and genetic distance is not significantly different from zero (95% C. I. from -0.05 to 0.08).

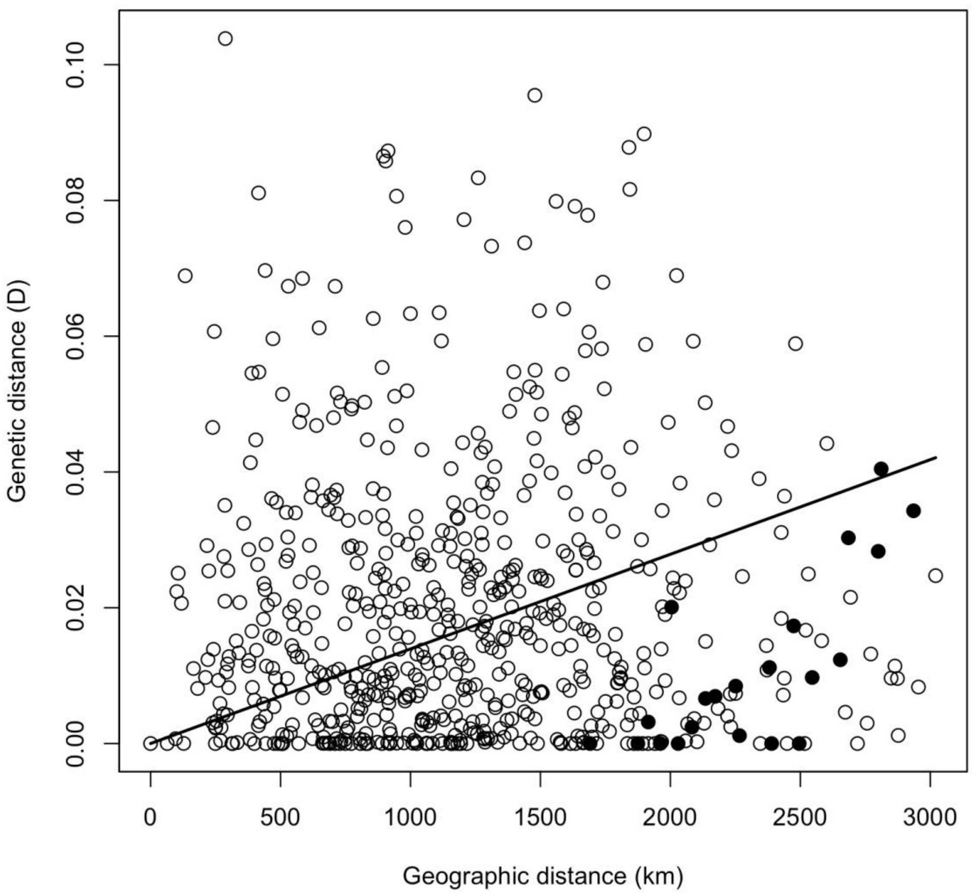


Figure 7. Geographic variation among study locations in the posterior probability of membership to each of the 3 populations inferred by program STRUCTURE. Pie chart sizes are proportional to the number of individuals genotyped at each study location.

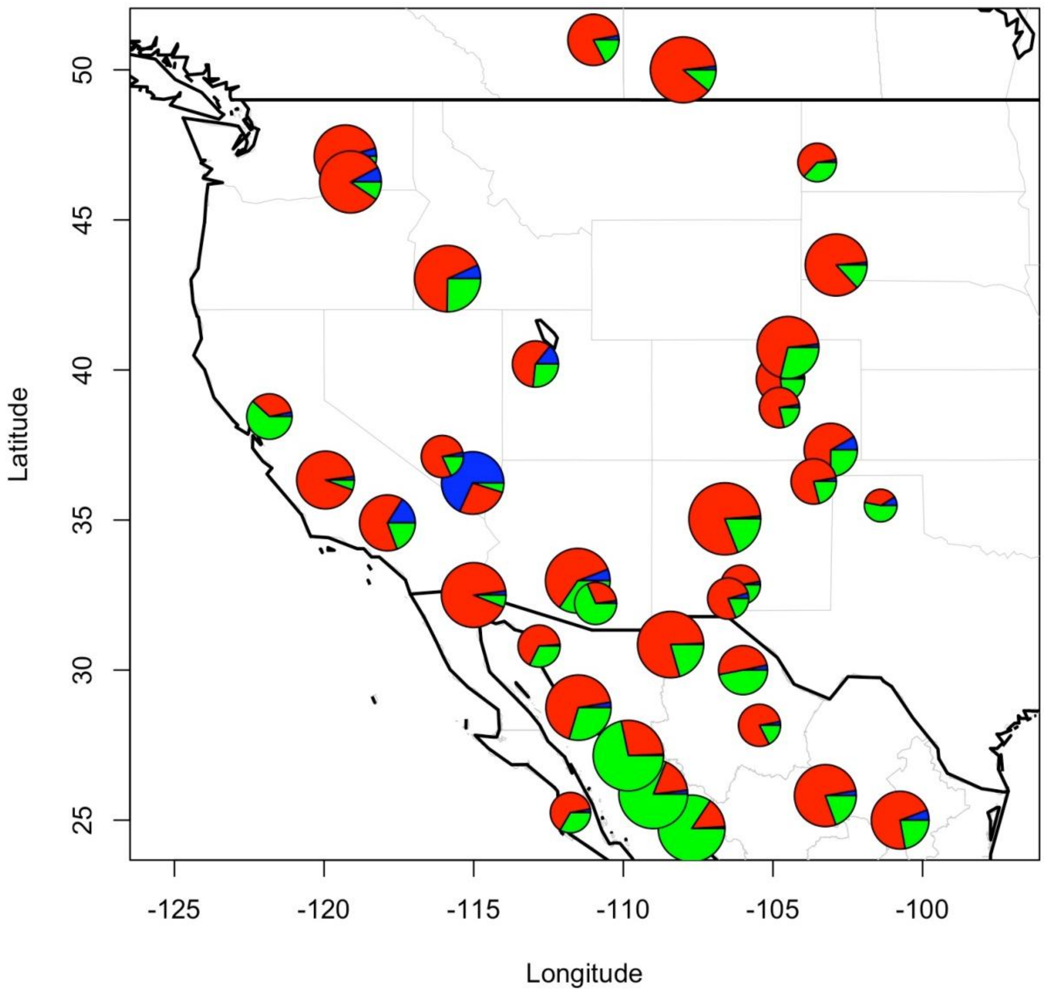
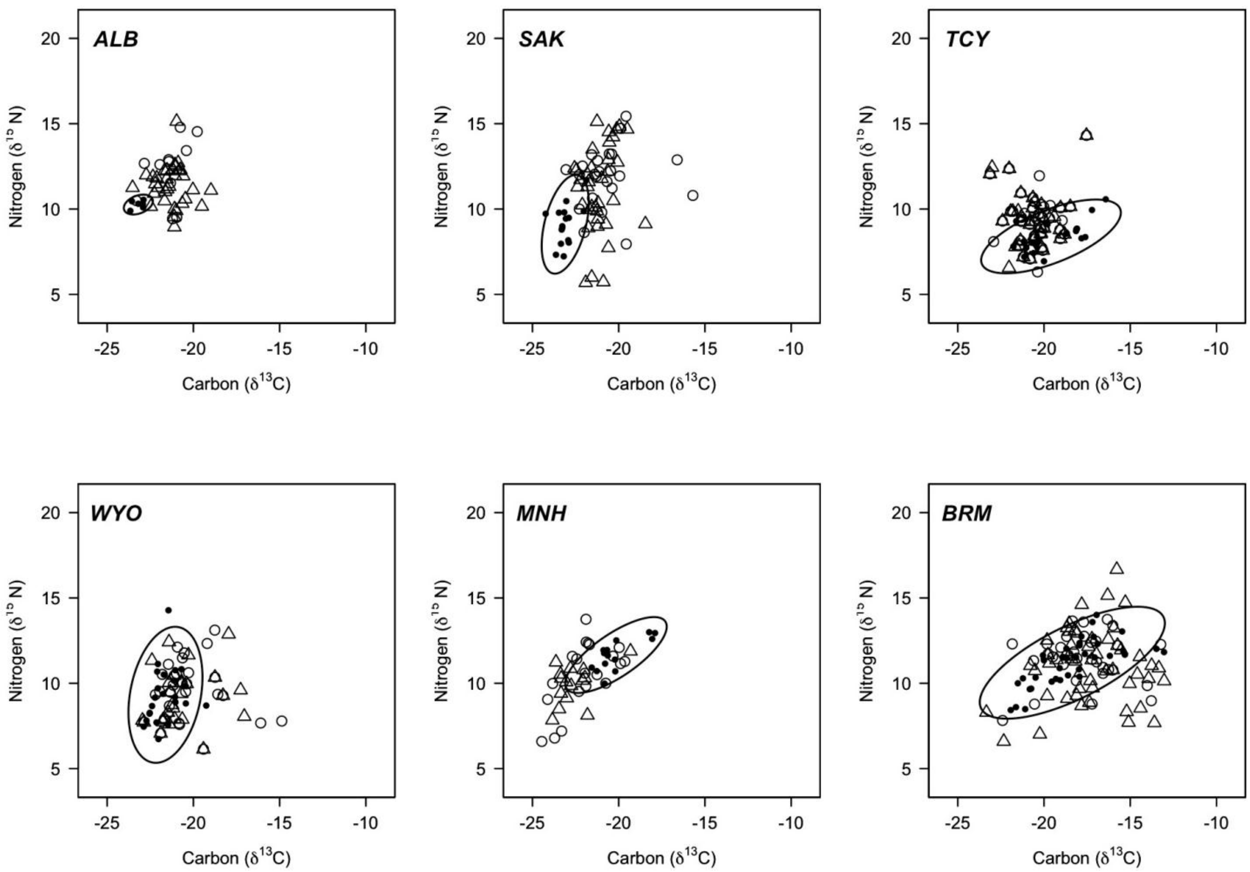
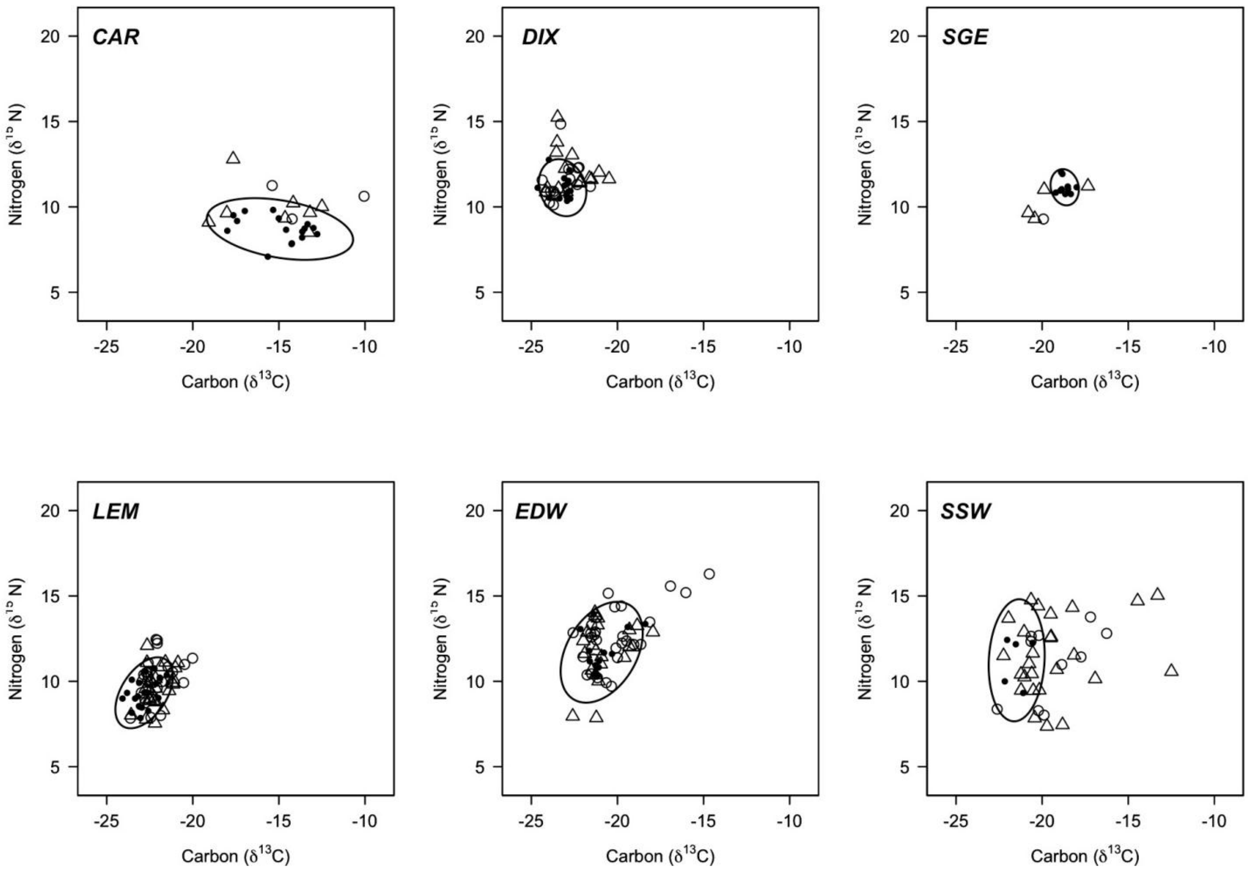
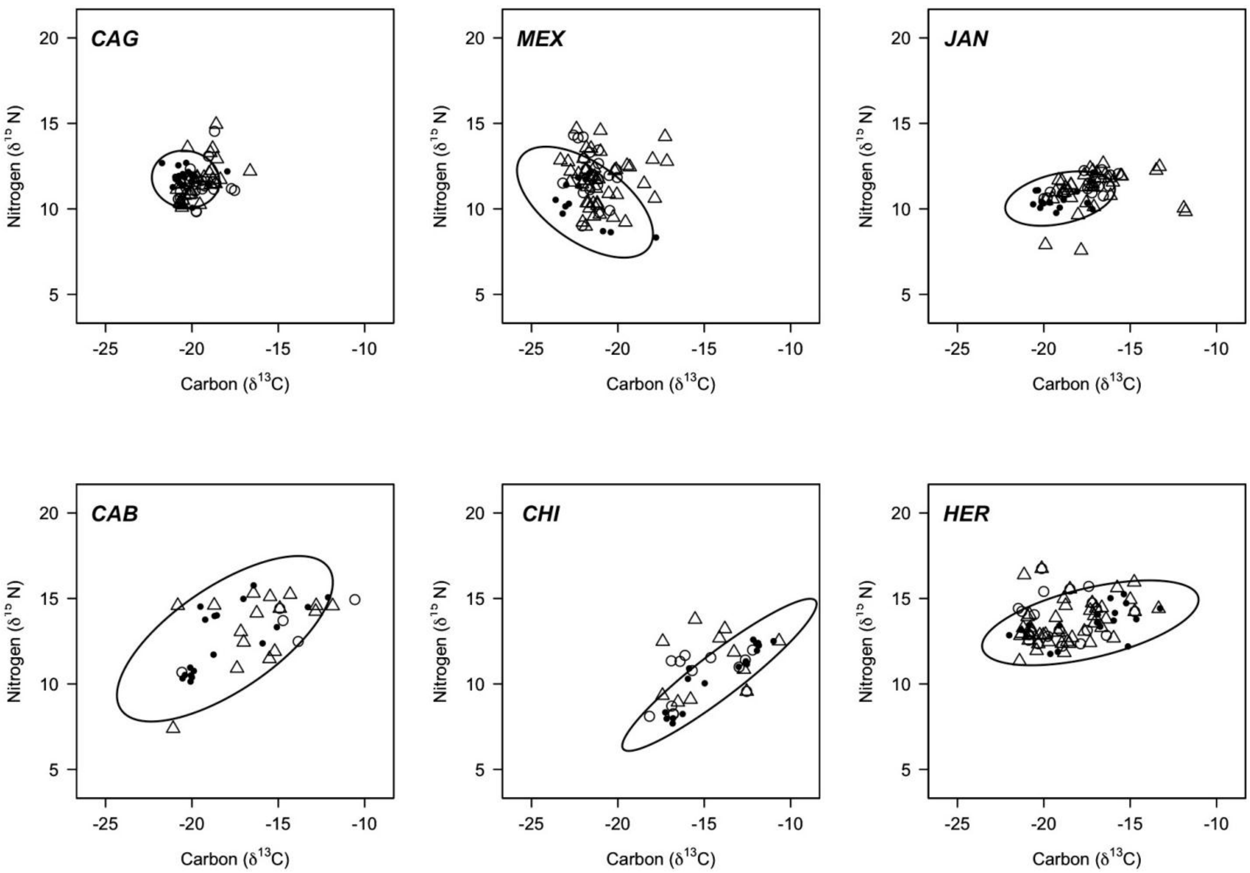


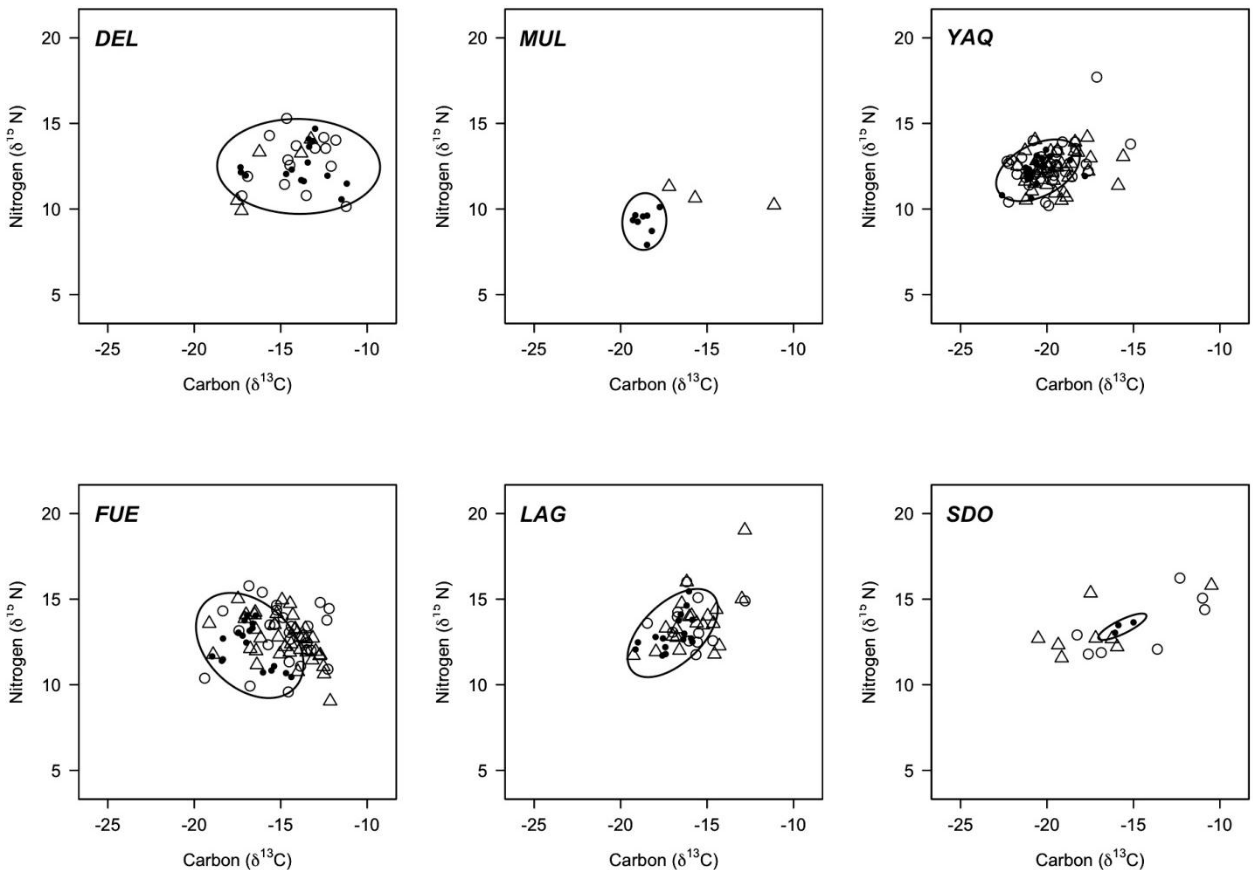
Figure 8. Stable isotope signatures of 13C and 15N in nesting and adult feathers collected in 27 burrowing owl study populations. Filled and open circles show the isotope signature of nestling and adult feathers, respectively. Circles and triangles denote males and females, respectively. Ellipses show the 95th-percentile ellipses for the bivariate normal distribution based on isotope data on nestling feathers. Study population acronyms are shown in Table 3.




CAR
DIX
SGE
LEM
EDW
SSW
Nitrogen (δ15 N)
Carbon (δ13C)
20
15
10
5
-25
-20
-15
-10



CAG
MEX
JAN
CAB
CHI
HER
Nitrogen (δ15 N)
Carbon (δ13C)
20
15
10
5
-25
-20
-15
-10


DEL
MUL
YAQ
FUE
LAG
SDO
Nitrogen (δ15 N)
Carbon (δ13C)
20
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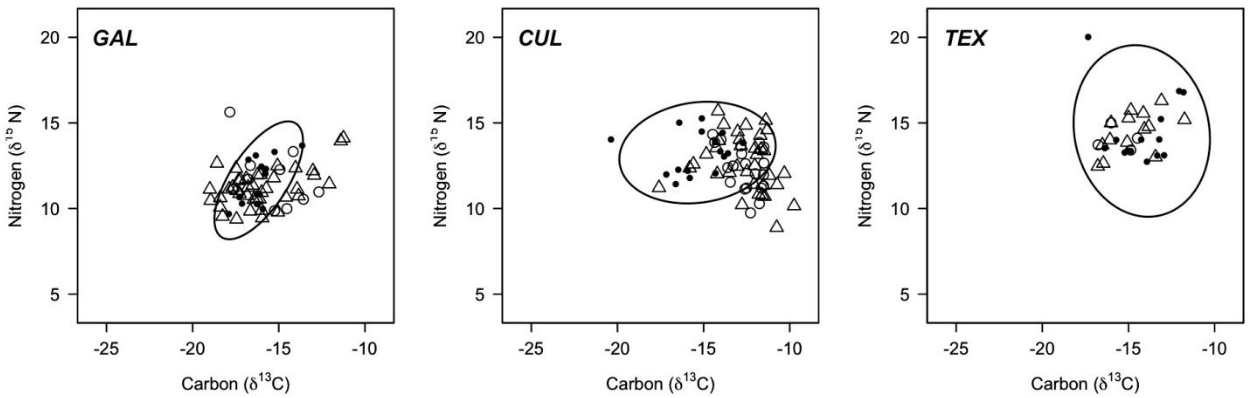
-20
-15
-10



GAL
CUL
TEX
Nitrogen (δ15N)
Carbon (δ13C)
20
15
10
5
-25
-20
-15
-10

Figure 9. Geographic patterns of philopatry and immigration in burrowing owl populations across North America, as suggested by stable isotopes 13C and 15N. Each pie chart shows the proportion of phylopatric (gray) and immigrant (black) burrowing owls at each study population. The area of each pie chart is proportional to sample size ($n_{max}$ = 83).

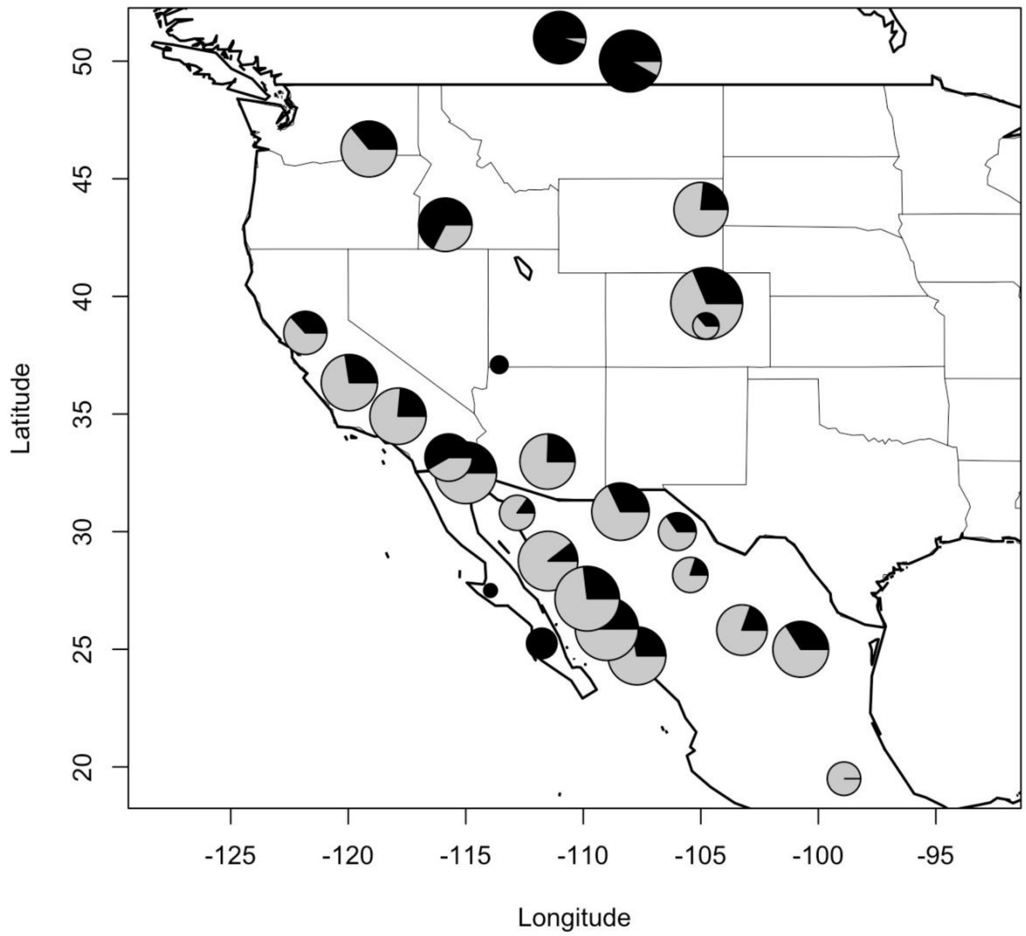


Figure 10. Base maps of $\delta^2H$, $\delta^{13}C$, and $\delta^{15}N$ (from left to right) for nestling feathers as inferred by local regression analysis (LOESS) with latitude and longitude as explanatory variables. Black dots represent sampling locations.

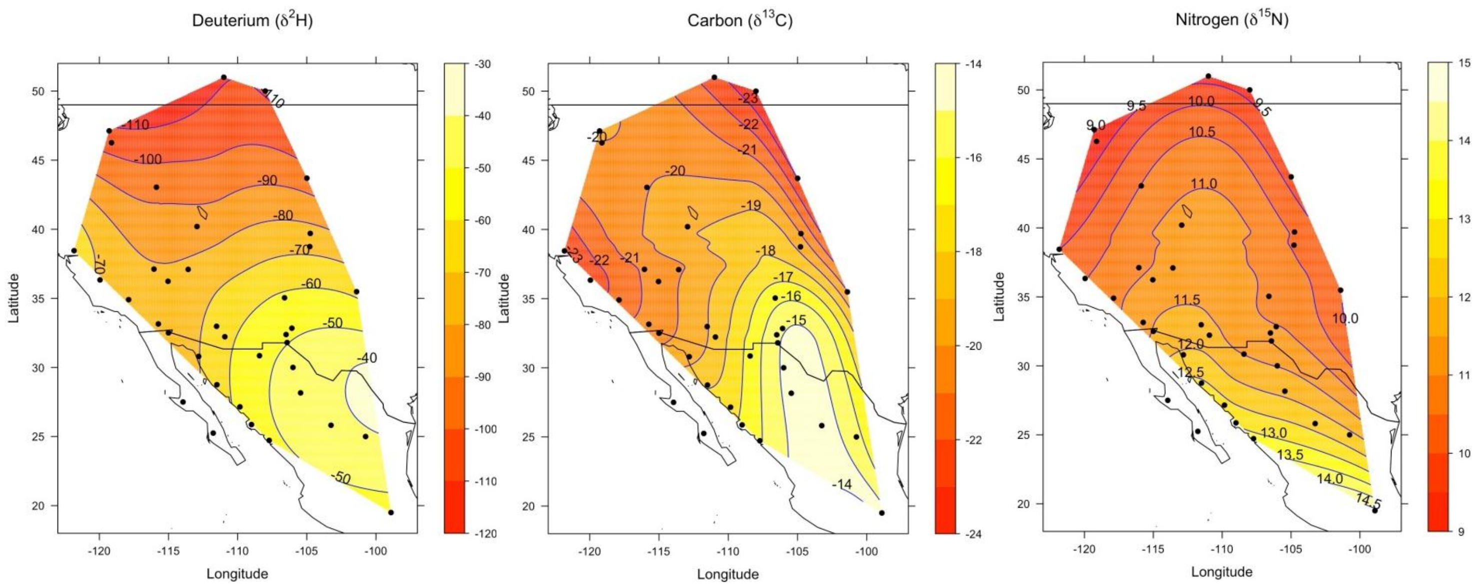


Figure 2. Latitudinal variation in $\delta^2H$ values in burrowing owl nestling feathers. The black dots represent individual feathers sampled from different latitudes. Samples from the lower Colorado River valley in Mexicali and Salton Sea deviate noticeably from the general latitudinal pattern. Longitude introduces variation $\delta^2H$ not illustrated in this graph (Figure 10).

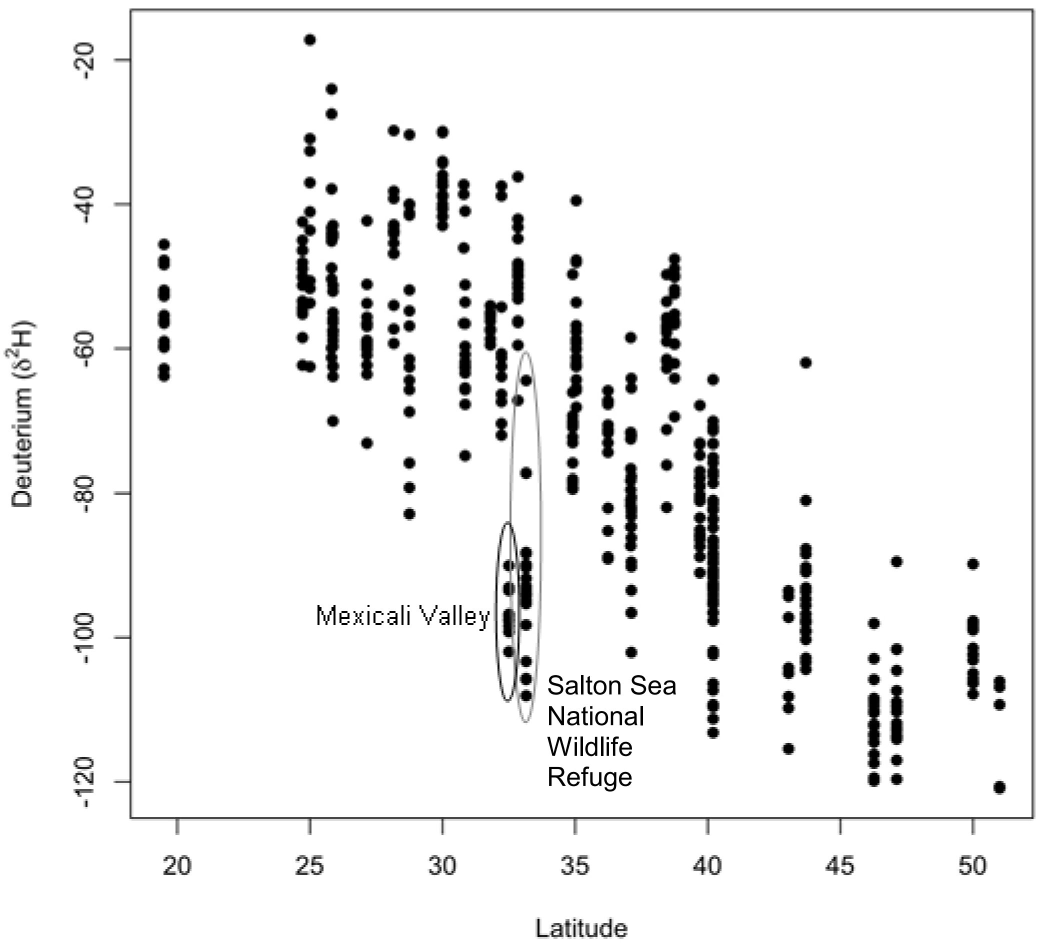
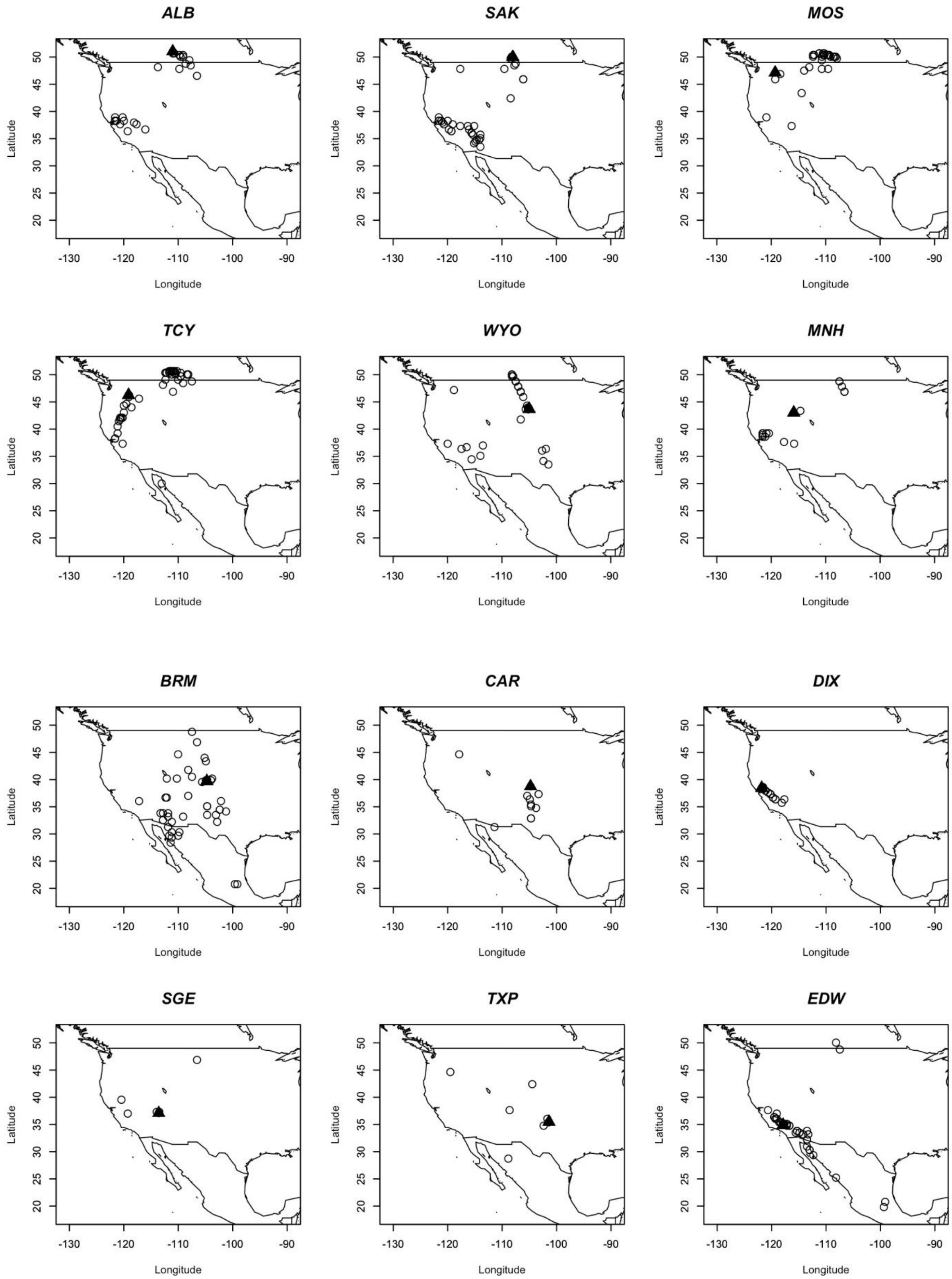
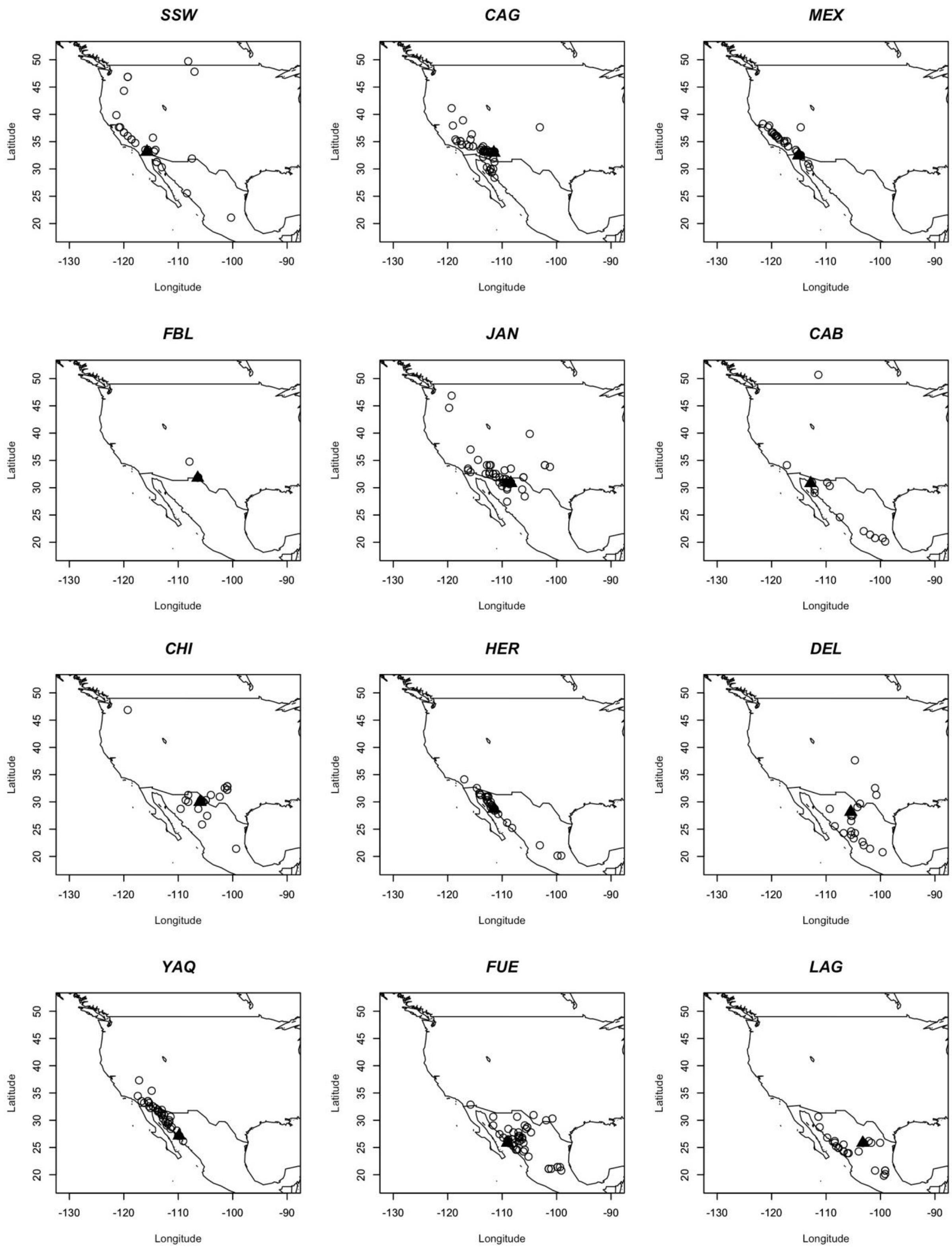


Figure 3. Geographic origin of breeding adult burrowing owls (open circles) at each of 21 study populations (triangles), as inferred from base maps of $\delta^{2}H$, $\delta^{13}C$ and $\delta^{15}N$ data.





SSW
CAG
MEX
FBL
JAN
CAB
CHI
HER
DEL
YAQ
FUE
LAG
Latitude
Longitude
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35
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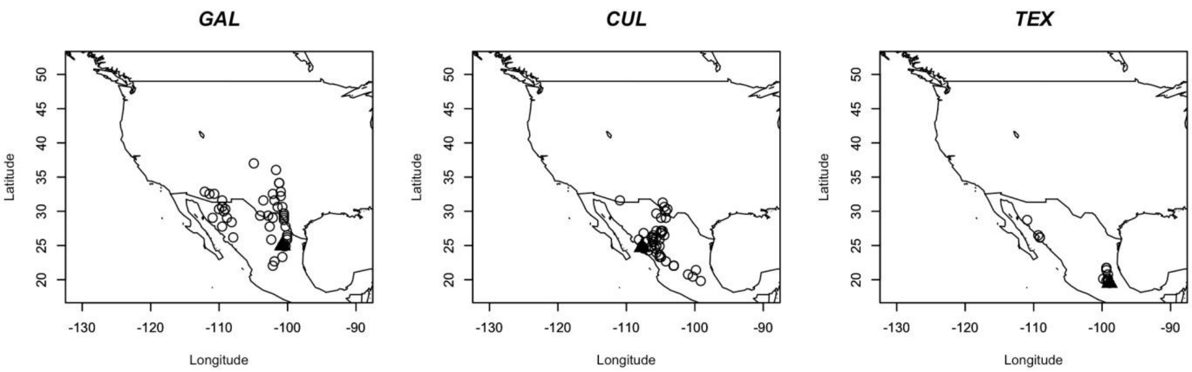
-130
-120
-110
-100
-90



GAL
CUL
TEX
Latitude
Longitude
50
45
40
35
30
25
20
-130
-120
-110
-100
-90

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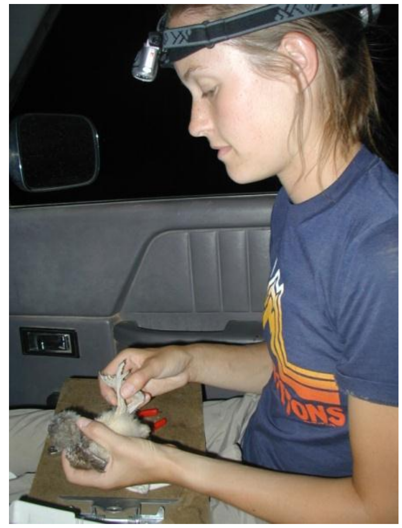
## Appendix 1: Protocols

# Standardized Monitoring Strategies for Burrowing Owls on DoD Installations



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*Foreword*

Burrowing Owls (*Athene cunicularia*) were once a common breeder in grasslands and deserts throughout the western U.S. and Canada. However, some populations have declined and Burrowing Owls have been extirpated from areas on the western, northern, and eastern periphery of their breeding range. Habitat loss and fragmentation due to agricultural or urban development, the reduction of prairie in the United States, and the control of burrowing mammals such as prairie dogs (*Cynomys spp.*) and ground squirrels (*Spermophilus spp*.) are thought to be the causes for the decline in Burrowing Owls (Sheffield 1997, Desmond et al. 2000, Klute et al. 2000). Due to concerns about persistence of remaining Burrowing Owl populations, Burrowing Owls are now federally endangered in Canada, and are listed as a Species of National Conservation Concern in the U.S. (U.S. Fish and Wildlife Service 2002).

Despite the declines in some portions of their range, Burrowing Owls appear to be increasing in other areas. One possible explanation for this paradox is that Burrowing Owls are becoming less migratory; owls which once migrated to northern breeding locations during the summer are becoming year-round residents in the southwestern U.S. and northern Mexico. In other words, breeding owl populations might be redistributing rather than declining. If this hypothesis is correct, it has implications for the validity of current or future Burrowing Owl listing petitions and implications for the effectiveness of different conservation and management efforts. Burrowing Owls have been reported on many DoD installations in the southwestern U.S., and therefore the DoD may play a key role in the maintenance or recovery of Burrowing Owl populations if declines continue. However, we currently lack information on the extent to which Burrowing Owl populations on DoD installations are self-contained and how much dispersal occurs among locations. In 2005, we initiated a project with support from the DoD Legacy program to help fill these needs. We are using stable isotopes of owl feathers, genetics from blood samples, and radio telemetry to quantify the importance of DoD lands to Burrowing Owl populations in the region, document the extent to which Burrowing Owls disperse between populations, and quantify land-use of migrating and wintering owls in the region. We are working with DoD installations in the western U.S. that have records of Burrowing Owls to test this hypothesis and to develop a coordinated, multi-agency program to help determine the extent to which Burrowing Owl populations are redistributing throughout North America.

As part of this project, we developed the following protocols for monitoring Burrowing Owl populations on DoD installations. The level of monitoring effort will undoubtedly vary among DoD installations, but these protocols provide a complete package such that each installation can use some or all of these protocols depending on their own needs or goals. We provide information for conducting standardized roadside surveys, conducting nest visits (intense monitoring), and banding Burrowing Owls. These protocols can be used singly or in combination. Additionally, natural resources staff may choose to decrease (or increase) the suggested frequencies of tasks depending on their particular programmatic goals. This project is funded by the following: DoD Legacy Resource Management Program, U.S. Department of Energy, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, National Park Service, Sonoran Joint Venture, World Wildlife Fund, University of Arizona, Canadian Wildlife Service, University of Alberta, National Council of Science and Technology (Mexico), T&E, Inc., DSCESU.

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# Standardized Roadside Survey Protocol

The goal of these surveys is two-fold: to locate as many owls as possible, as quickly as possible; and to establish a standardized, repeatable survey protocol with high detection probability, low (temporal) variation in detection probability, and low observer variability.

**Systematic Survey Routes**

Surveys should be conducted periodically (e.g., every morning, every morning and evening, once per week, twice per week) and should attempt to cover as much of the area as possible, while making it as likely as possible to find owls if owls are present. Therefore, if you have to cover a large area, you will have to stop at survey stations less often. Based on the distance to be covered, you should decide ahead of time how far apart your survey stations will be. However, you may alter this distance if you find you have overestimated or underestimated how much ground you can cover in the given time.

Identify systematic survey routes on topographic maps or road maps using all presumed passable roads (i.e., no 4-wheel drive or 2-tracks) within the area. How often you stop to survey will depend on how large the study area that you have to cover is. Minimum distance should be 400 m between points. If you have to cover a very large area, you may just drive very slowly, without ever stopping unless you locate an owl.

Observers should drive 24 km/hr (15 mi/hr) while looking for owls. If an owl is suspected or located, observers should stop the vehicle, and attempt to locate the burrow. If the burrow cannot be located after 30 minutes of searching, observers should take the GPS coordinates of the location where the owl was first seen. Observers should then continue the survey, but return later (at dusk or dawn) to attempt to locate the burrow of the owl that was just seen.

Recording the starting UTMs:

Start a new line every time you locate an owl, anytime to stop at a survey point, or anytime you change roads.

When choosing the exact location of a survey point you are allowed to move the point up to 200 additional meters along the road to allow a location with optimal viewing radius of the surrounding habitat. Adjacent survey points may be located more than 400 m (0.25 miles) apart if no Burrowing Owl habitat is available, but should not be located substantially less than 400 m (0.25 miles) apart. The location of each survey station must be accurately marked on a 7.5 minute topographic map or a gazetteer. Once downloaded to Map Source from GPS units the survey points' exact locations can also be seen by printing out maps from the program. A verbal description of its location (road and cross roads) and the UTMs recorded using the GPS receiver will also be recorded on the data sheet so that the exact survey location can be re-surveyed in future years.

At each survey station, the observer pulls off the road, parks on the road shoulder, exits the vehicle, and performs a 2-minute survey. During the 2-minute period, the observer will scan the surrounding landscape. Observers scan the landscape in a $360^{o}$ arc around the survey station during the entire survey. The observer may move around a bit to ensure that the vehicle does not obstruct their view of the surrounding area. For each owl that is detected, observers record whether each bird is heard and/or seen.

Observers also record the azimuth (degrees) and distance (m) to each owl detected, and whether the bird was at a nest burrow. Record whether each owl was detected visually, vocally, or both. Each adult owl detected at a survey point gets its own line, juveniles associated with one nest get one line for all juveniles. Hence, one nest detected at a point may produce 3 lines of data - one for the male, one for the female, and one for the juveniles. If no owls are detected at the survey point, there is one line filled out.

Once the 2-minute survey is complete, record the habitat types (See **Insert 1**) within a 200 m radius surrounding the survey point. Also record the percent of surrounding landscape (within the 200 m radius circle) that is visible from the survey point, and the percent of **the visible landscape** that is potential owl habitat.

**Timing**

Surveys will be conducted mid-March – mid-July. Surveys should be conducted between first light (typically ½ hour before sunrise) until 11:00am and between 5:00pm until dark. Do not conduct surveys during excessive rain or when wind speed is >20 mi/hr.

### Insert I: Habitat Types/Land uses (*to be used on roadside surveys*)

**Abandon Field (af):** Fields which have been disturbed from their natural state and are now covered by non agricultural plants (most commonly invasive grasses and forbs which establish quickly in disturbed areas). These areas include abandon agriculture and other open fields. Areas with old development (gravel piles, cement slabs, old foundations) are not classified as abandon fields (see Vacant Lot). Areas with shrubs steppe or other large native plants are not classified as abandon fields (see Shrub Steppe, Paloverde-Cacti Scrub, Invaded Grassland, Creosote Flat).

**Agriculture (ag):** Any land being tilled, planted, harvested or other wise disturbed for agricultural purposes. This includes tilled fields, fields with crop stubble but little other vegetation, crops and orchards. Fields which have been inactive for long enough to have non-agricultural plants covering the majority of the field are not grouped in this category (see abandon field).

**Airplane storage (as):** Areas of AMARC - Tucson only.

**Airport (ap):** Self explanatory.

**Creosote-Flats (cf):** This is a desert habitat in Arizona which is dominated by tall creosote bush and little other vegetation. The substrate is normally sand.

**Dry Wash (dw):** This is a desert habitat in Arizona. It is any area which has evidence of running water (eroded banks, under cut banks) but is dry for most of the year and has vegetation (commonly paloverde, mesquite, and grasses) growing on the dry wash bed. This also includes dry rivers. This does not include irrigation canals or other man made ditches (see Irrigation Canal).

**Feed Storage (fs):** Any permanent buildings or areas where livestock feed is being stored (grain bins, grain elevators). Any non-permanent feed storage (hay bails, grain piles) are not included in this or any definition as they are not permanent and are not likely involved in the owls choice of burrow location.

**Feedlot (fl):** Areas with little to no ground vegetation, and where animals are fed using means other than grazing. These areas are usually completely trampled mud or dirt and do not have any vegetation which could be grazed. This includes pig pens.

**Golf course (gc):** Self explanatory.

**Gravel Road (gr):** Any public road which has a gravel surface. This does not include two tracks.

**Housing Development (hd):** Residential development and anything associated with the residential development. This includes houses, apartments, trailers, garages, barns, driveways, and yards/lawns. This does not include development such as industry or shopping malls not associated with a residence (see Industry/Development).

**Industry/Development (id):** Any non-residential buildings or anything associated with the non-residential buildings. This includes industry, shopping centers/gas stations, businesses, parking lots, parks and sports fields.

**Irrigation Canal (ic):** The main canals used to transport water for the purposes of irrigation. This category does not include small cement irrigation troughs found directly adjacent to crops. Irrigation canals are large enough that one would have to jump to cross the canal and are normally not lined with cement.

**Rangeland (rl):** Area dominated by native short grasses (in Arizona this area may be invaded with mesquite but shrubs are absent in other areas). This area may or may not be grazed by livestock and may be fenced by barbwire or electric wire. Differs from pasture in that it is not irrigated and not planted with unnatural grasses for grazing purposes.

**Shrub Steppe (ss):** Areas containing sagebrush and rabbit brush. Sagebrush and rabbit brush are often in low densities and the area between each shrub may consist of sand, grasses or forbs. The entire area between the area which has sparse shrub growth is considered shrub steppe (including vegetation, sand, etc, found between shrubs). Shrub steppe may be disturbed and is often found in the uncultivated corners of pivot or circle crops.

**Paloverde-Cacti Scrub (pc):** This is a desert habitat in Arizona which consists mainly of various cacti (Saguaro and Cholla) and shrubs (mainly paloverde). The substrate is usually gravel-sand and covered sparsely with grasses or low lying plants.

**Pasture (pa):** Any field which is used for grazing livestock (cows, horse, sheep, etc). This includes fields which are currently not in use but have unnatural (irrigated or planted) grasses being grown for the purpose of grazing. Often these fields are fenced with barbwire or electric wire and are irrigated. Feedlots or areas where livestock are fed using means other than grazing and contain little to no ground vegetation are not considered pastures (see feedlot).

**Paved Road (pr):** Any public road which is paved. This includes highways, off ramps, and any other paved road.

**Prairie Dog Towns (pd):** An area dominated by prairie dogs with high burrow density, large burrow mounds, very low vegetation height and large patches of bare ground.

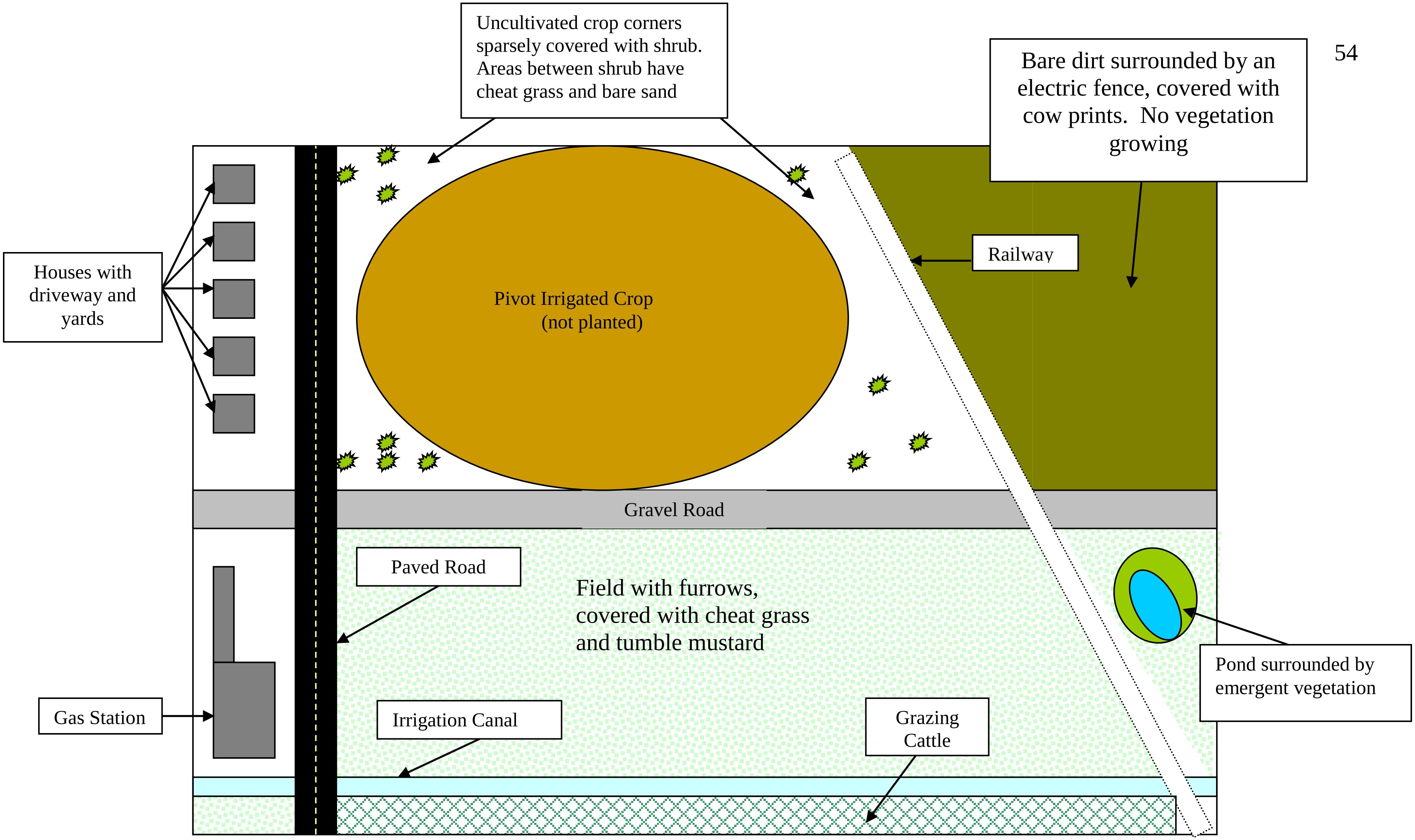
**Railway (rw):** Any rail road tracks. Rail yards with a lot of activity buildings, grain elevators, etc should be classified as industry/development. The railway leading in and out of a rail yard is classified as railway.

**Resource Development (rd):** Coalbed-methane, natural gas, oil pumpjack development and anything associated with the development (gravel roads, pump-houses, holding tanks, well markers).

**Vacant Lot (vl):** Areas which were once developed but have been abandoned leaving remains of foundations, gravel, old pavement, mounds of dirt, and other human debris. This may include areas which are currently under construction for development. These areas have sparse vegetation normally consisting of invasive plants such as cheat grass.

**Wetland/Riparian (wr):** Any area where the substrate is saturated or covered with water and contains emergent vegetation (such as cattails and rushes) and/or water dependent shrubs and trees (Red Osier Dogwood, Willows, Cotton wood). Irrigation canals are not considered wetlands (see irrigation canal).

**Other (ot):** When using other please evaluate all of the above explanations to be sure that you are not able to categorize the other as one of the above selections. If you are sure the other does not fit into any of the above categories record other on the data sheet followed by a description.




**How would this area be classified?** Roadside survey (*note the above area covers a 200m radius from the center for the purpose of roadside surveys*): Fallow agriculture, Agriculture, Feedlot, Shrub Steppe, Housing Development, Industry/Development, Pasture, Gravel Road, Paved Road, Railway, Wetland

**Sample datasheet for Burrowing Owl Standardized Survey**

Study Site: ____________ Year: ____________ Frequency of survey: ______________________________________

Entered by: ____________
Date: ____________
Checked by: ____________
Date: ____________

Driving Survey Data Sheet
V = Visual, C = Call, A = Alarm, P = Possible Nest, 0 = Nothing Detected
UA = Unknown Sex Adult, UNK = Unknown Age/Sex Owl, M=Male, F=Female, #J=Number of Juvies
Each adult BUOW = 1 line
All juvies from 1 brood = 1 line

**Habitat types:**
**AG**-Agriculture, AP- Airplane storage,**PA**-Pasture, **VL**-Vacant lot, **WR**-Wetland/Riparian, **RW**-Railway, **AP**-Airport, **AF**-Abandoned field, **FL**-Feedlot, **PR**-Paved road, **HD**-Housing development, **GC**-Golf course, **IC**-Irrigation Canal, **FS**-Feed storage, **GR**-Gravel road, **ID**-Industry/development, **SS**-Shrub-steppe (WA/WY), **DW**-Dry wash (AZ), **PC**-Palo Verde-cacti shrub (AZ), **CF**-Creosote flat (AZ), **RL**-Rangeland(WY/AZ), **PT**-Prairie Dog Town (WY), **RD**-Resource development (WY), **OT**-Other

| Road/Crossroads Start | Start UTMs | Odometer | Observer | Date | Start time | V, C, A, 0 | Present? M, F, #J, UA, UNK | Distance (m) | Direction (degrees) | At Burrow? | Paired with other owl detected? | Repeat owl? | Nest Location Confirmed? | Nest location UTMs | NestID of new nest | Habitat type within 200m | # Livestock? | # Marmot? | # Ground squirrel? | # Prairie Dogs | End time | Road/Crossroads End | End UTMs | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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**Protocol for Recording Roadside Survey Data**

| Field Name | Entry Example | Description |
|---|---|---|
| **Road/Crossroads** | *NELSON (RDA/RDB)* | Record the road on which the roadside survey was initiated  Crossroads should also be recorded in parenthesis, separated by a forward slash (/).  For example if you are on Nelson road between Road A and Road B the following should be recorded: Nelson (RdA/RdB).  If the roadside survey start was at the intersection of two roads, both roads should be recorded separated by a slash (/). |
| **Start UTMs** | *0330868 5220296* | Record the UTMs of the location of the start of the roadside survey. |
| **Odom** | *15006* | Record the odometer reading on the vehicle used for the roadside survey.  The reading should be taken at each survey point.  This combined with the road information will help future surveyors locate the points without using a GPS. |
| **Observer** | *CPN* | The initials (three letters) of the individual who conducted the roadside survey. |
| **Date** | *15-MAR-02* | Record the date the roadside survey took place.  This should be recorded as day-month (use three letter abbreviation to avoid confusion with month and day)-year. |
| **Start Time** | *0930* | The time at which the roadside survey began. The number should be recorded as a four-digit number in 24-hour time. |
| **V, C, A, 0** | *V* | Record what was heard or seen during this portion of the survey. Note that each adult owl detected gets its own line at the datasheet and all juveniles detected are grouped on one line. |
| **Sex Present** | *M* | If owls were observed during the trial, record the sex/age of the owl in this field using the codes at the top of the roadside survey datasheet.  Note that each adult owl gets its own line on the datasheet and all juveniles are grouped on one line. |
| **Distance** | *100* | If owls were observed during the survey estimate the distance to the owl and record it |

| Field Name | Entry Example | Description |
|---|---|---|
| | | in this field. |
| **Direction** | *120* | If owls were observed during the survey, use a compass to determine the azimuth to the owl and record it in this field. |
| **At Burrow?** | *Y* | If the owls observed during the survey were at or near a burrow, put a Y (yes) in this column. If the owls were not at or near a burrow put an N (no). |
| **Paired w/ other owl detected?** | *N* | If the owl being referred to on the current line was detected with a mate that was also detected (this includes owls detected at previous points) record Y (yes) in this field. If no mate was detected, record N (no). |
| **Repeat owl?** | *N* | If the owl detected was observed from a previous point record Y (yes) in this field. If this is the first time the owl was observed during the survey, record N (no) in this field. |
| **Nest Location Confirmed?** | *Y* | If owls were detected, you should make an attempt to locate the owl's burrow after the survey at that point has been completed. If you are able to locate the nest Y (yes) should be recorded in this field. If you were not able to locate the nest N (no) should be recorded. It may take several tries to find the nest. Once the nest is found be sure to change this to Y. |
| **Nest location UTMs** | *0362528 5523693* | Record the UTMs of the nest found. |
| **Habitat Type within 200m** | | View the area within a 200m radius around the survey point and record the habitat types using the codes on the top of the roadside survey datasheet. (see **Insert I** for definitions). Habitat types should be listed in descending order from the habitat type covering the most area to the habitat type covering the least area. |
| **Livestock?** | *Y* | Record Y (yes) if there is evidence of livestock within a 200m radius of the survey point. Electric fences, cow patties, irrigated pastures are all evidence of livestock. Record N (no) if there is no evidence of livestock. |

| Field Name | Entry Example | Description |
|---|---|---|
| **Marmot?** | *Y* | Record Y (yes) if there is any evidence of marmots within a 200m radius of the roadside survey point. Record N (no) if there is no evidence of marmots within 200 m. |
| **Ground squirrel?** | *Y* | Record Y (yes) if there is any evidence of Ground Squirrels within a 200m radius of the roadside survey point. Record N (no) if there is no evidence of Ground Squirrels within 200 m. |
| **# of Prairiedogs** | *25* | Record the number of prairie dogs seen |
| **End Time** | *15:30* | Record the time you stopped surveying this section. |
| **Road/Crossroads End** | *Rd B/ Rd A* | Record the location where you ended this section of the survey. |
| **End UTMs** | *0362528 5523693* | Record the UTMs where you ended the this section of the survey. |
| **Comments** | | Record any comments. |

# Nest Visit Protocol

Nest visits are one of the most important and most frequent activity conducted in monitoring birds during the breeding season. By visiting the known burrows on a frequent basis you can estimate a variety of parameters including nest success, timing, and clutch size. All other activities should be combined with nest checks whenever possible.

## *FREQUENCY*

Visit all active nests every **3-4** days and unoccupied burrows every **7** days throughout the season. Once juveniles begin to fledge, unoccupied burrows can be visited every **10** days because the likelihood of the burrows becoming occupied at that stage is slim. Keep in mind that owls will use some of these burrows while migrating through the area, so it is still important to continue checking them. Burrows that have been unoccupied for two years in a row can be checked every **2** weeks. If there is no owl activity or sign at a previously occupied burrow, (e.g., a lack of whitewash/feces, pellets, feathers, etc.) on 3 subsequent visits (**3-4** days in between) then visit the nest once a week. If a burrow that was active goes inactive then becomes active again, return to visiting the nest every **3-4** days. Every other visit must include a nest approach to collect pellets, etc. An effort should be made to combine other activities (trapping, detection trials, etc.) with the nest approach visit to minimize disturbance to the owls. Spend as little time as possible around the nest and area in order to prevent trampling of the burrow and mound. Also, try to avoid making obvious trails to burrows. Leaving your sign and scent around the burrow may attract predators to the burrow, so your activity at the burrow should be limited.

If you visit a nest without doing a nest approach, please record "**DA**" for "didn't approach" in the **comments** section under each heading. If you are driving by a nest that is not scheduled for a visit but happen to observe owl activity (e.g., 2 adults standing on the mound), record your observations on the nest card and make sure to record it as a "drive by" visit in the comments section under each heading. Try to make every other nest visit at dawn or dusk.

### Naming and Recording Info of Nests and Satellites

*Fill out a nest card only for each pair (or resident male), not each nest burrow and each of its satellites.* The idea is to monitor a pair of owls at their burrow and keep track of all satellite burrows the pair is using. All activities for this pair and the pair's offspring are recorded on the nest card. If/when the owls start using a satellite burrow (or many), the satellite burrows are to remain on the pair's nest card, not a new nest card for the satellite burrow. Example: Two owls from nest30 start using a satellite burrow, nest30B. When they are at nest30B, record all observations on the nest30 card, making sure to note that they are using satellite B. If a satellite burrow is being used for the first time, map the location of the satellite burrow in relation to the nest burrow so that others can easily find it in the future.

However, some burrows used as satellites will have their own nest card because the burrow may have previously been a nest of its own. For example: One year nest30 began using another satellite, nest40. Nest40 was a nest last year and already has its own nest card. If an owl uses one of the burrows that has a nest card as a satellite burrow, you still record the info on the nest burrow nest card (nest30). On the satellite burrow nest card (nest40), you only need to record that the owls from nest30 are using the burrow as a satellite.

If a satellite already named (given an A, B, C etc. designation) becomes occupied by a separate pair or you discover you were actually dealing with 2 pairs, the satellite should be **renamed** and get its own nest card. A note should be made on both nest cards indicating the change and on what date it occurred. For example: It is discovered that in fact there are 2 pairs using nest30 (one at A and one at B). Nest 30B should not keep this name but get a new designation such as nest31.

Using the GPS unit, make a new waypoint for each new burrow (nest and satellites) and name the waypoint after the **Nest ID** (the same name used on the nest card; the nest name with A, B, C for satellites). To obtain the most accurate coordinates possible, leave the unit at the burrow on "average" mode while completing the nest check. Nest names should be somewhat descriptive (use road names or area name followed by a number). This helps keep burrows organized and helps new people locate burrows that are grouped together.

## RECORDING INFO ON THE FRONT NEST CARD

***Fill out the front of the nest card to completion. Nest ID and Site (e.g., Ft. Carson)) as well as State are the first to be recorded. The sections for UTMs, Year, Date, Satellite burrows + UTMs, Years Occupied also need to be completed.***

Be sure to record how the nest was found (**H** = historic, **I** = incidental, roadside **RS** = survey, **WOM** = word of mouth, **LY** = Last Year). Record the nest type the owls are using with one of the following burrow types: Artificial, Badger, Coyote, Culvert, Ground Squirrel, Irrigation trough/Badger, Irrigation trough/Unknown, Man-made, Man-made/Badger, Man-made/Coyote, Man-made/Ground Squirrel, Man-made/Marmot, Marmot, Prairie Dog, Other (if there is another animal burrow that can be identified that is not on the list) and Unknown (if it is impossible to determine what kind of burrow it is).
Badger burrows typically are flatter on the bottom of the entrance and more rounded at the top. They are usually found near the base of a slope or road cut, but can be found on level ground in Washington. Coyote burrows are fairly large and oval shaped (largest diameter from top to bottom). Marmot burrows, smaller and more round, are found among rocky outcrops or near cement, often with old marmot scat around the entrance. Man-made burrows include culverts, cement or concrete slabs, piles of dug up concrete that resemble rocky outcrops, or holes/cracks along irrigation canals or troughs. Often the man-made category needs to be combined with another category to reflect that the burrow was created or modified by an animal (e.g., a marmot dug under a cement slab).
Directions and maps will most likely need to be revised until everybody is satisfied with them, so please write lightly. Make sure all the info makes it to the front nest card so that when others go to find the burrow all the information is there and they can add the coordinates to other GPS units. As new satellites are discovered fill in their designation and UTMs in **Satellites +UTMs.**

Finally, for all individuals (males, females, and juveniles) that are banded, re-sighted, or re-captured at a burrow, record the color and alphanumeric code and USFWS # of the bands in appropriate space of the front nest sheet. Record this regardless of whether you banded, recapped, or just re-sighted the bird. (Note: when re-sighting birds you will not likely be able to read the USFWS band so just record it as AL).

## *RECORDING INFO ON PAGE 2 OF THE NEST CARD*

### Before Approaching the Nest

Observe the owls in the nest area from 125 to 300m away (depending on the sensitivity of the owls) using a spotting scope or binoculars before moving closer to read bands. Record the activity of all owls: What are they doing? Record the exact locations of males, females, and juveniles in relation to the burrow entrance (**Adult / Juv act + location**). Be sure to state what owls are at which burrows (e.g., M and F at Sat A, 4 juvies at nest burrow, 2 juvies at Sat D). It is extremely important to record this information so that others will know which burrows are actively being used (**Active Satellites**) when they visit a nest, especially when setting traps.

Record the observed **stage** of the nest (**NS =** No Sign, **O =** Occupied, **SAT =** Satellite, **G =** Sign, and **J =** Juveniles) for each visit. In other words, record what you saw not what you believe is there. Record the sex and age of each owl present based on plumage, behavior, or some other clue (never use band combos to sex the owls).
Also, record band combos (or lack thereof) for all owls present (leg/color/alpha numeric code: UNB = unbanded; NL = no legs/meaning you couldn't see their legs to read the band; CRB = banded but couldn't read) in **Juv + bands** and **Adults + bands**. When recording the color and alphanumeric code and USFWS # for each leg make sure you distinguish between combos that are vertical and horizontal, and be sure to include the line between the codes (record to band combos as: horizontal = **Re-X3**, vertical = **Re-X OVER 3**, vertical with a bar = **Re-X BAR 3**; horizontal with a bar **Re-X VBAR 3**).

| | | | |
|---|---|---|---|
| Horizontal: X3 | Vertical: X 3 | Vertical with bar: X 3 | Horizontal with a bar: X 3 |

Record band colors with a two letter code:

| | | | | | |
|---|---|---|---|---|---|
| AL-Aluminum (USFWS) | Bk-Black | Bl-Blue | Br-Brown | Gr-Green | Ye-Yellow |
| Or-Orange | Pi-Pink | Pu-Purple | Re-Red | Wh-White | |

When trying to determine whether an owl is banded or unbanded, wait until the owl's feet are visible. Burrowing Owls have extremely long legs and it is often difficult to determine the band status without actually seeing the entire leg down to the toes. Also, they often stand on one leg and tuck the other under their body. In the beginning of the season, it is imperative to read band combinations until every owl is identified. Once identified you must *try* to read bands every visit. This is necessary to confirm that even owls that have been identified have not switched burrows, which they frequently do early in the season.

It may take several trips over a course of days to confirm the identity of some owls (this is in addition to scheduled nest checks). If an adult owl's bands can not be read within an hour or so, do other nest visits in the area and periodically check back at that burrow to see if that owl has moved into a better position. It may become necessary to trap an adult owl, or set up a blind, if the adult's bands are still unread after repeated failed attempts to resight. If a nest is active but one/or both of the adults have not had their band status confirmed after 3 days, we need to try to trap that adult.

When copulations are observed, record them under **comments.** When a male is observed delivering food to the burrow entrance, or adults are observed feeding young, record it under **comments.**

## Approaching the nest

### *JUVENILE ACTIVITY*

Estimate the age (**Age Est**) of the oldest and youngest juvenile owls seen, using the Juvenile Ageing Guide, on each visit (don't EVER back-date age from a previous nest visit). If you think the juvenile is between 21-23 days, record the age as 22 days. Scan the nest area and record use of all satellite burrows under **Juv activity + location.** Record whether juveniles **Flush or Retreat** to a burrow and specifically to which burrow (nest burrow, satellite A, B, C). Record any evidence of juvenile flight under **Flight des** (**J** = flight jumps or wing flapping with or without leaving the ground, **W** = wobbly flights, **S** = short flights, **L** = long flights).

### *ADULT ACTIVITY*

Before approaching the nest, listen for owls calling (coo-cooo, quick-quick). While approaching the nest on foot, note any owl activity as you approach and record under **Adult activity + location** (be sure to include satellite designation). Make sure you always keep an eye on the nest burrow. If an adult flushes from the nest burrow, keep an eye on where it goes so that you do not 'count' it as an owl from another nest. This is especially important at nest clusters as owls often flush toward other occupied nests (which makes differentiating between one owl and the next difficult without reading bands). Record each owl's response to your approach (**Flush or Retreat?**).

Note if owl calls are given. Record whether the male or female **alarm (A)** calls (quick, quick, quick) or **coo-cooos (C)**. Under **F/M Behvr**, record whether the owl 'swoops' or hovers over the observer during the nest visit by circling '**S**'. Record whether the owl 'bobs' after landing ('bob' = owl moves their body vertically up and down) by circling '**B**' on the data sheet. They may do this several times in succession, often while giving the alarm call. Record whether adults display the 'white-and-tall' stance ('white-and-tall'= owl stands completely vertical and contracts the white feathers around its face so they stand out) by circling '**W**'. Record whether the owl (usually the male) assumes the "territorial posture" by circling '**P**' (body horizontal and feathers puffed up, with "whites" display, usually accompanied by a coo-cooo and body rotation).

## At the Nest: General Nest Area Observations

In the **Burrow Condition** section:

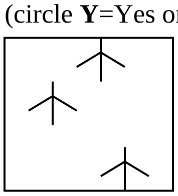
Be sure to include the satellite designation for all observations!

Record whether nest **lining** is present, as well as what type (horse/cow manure, grass etc. Note that shredded horse/cow manure looks like shredded grass, so examine the lining closely to be sure it is identified properly.) and the quantity (**N**=None, **S**=Some, **L**=Lots). Record whether nest decorations (**décor**) are present, as well as the type and the quantity (2 pieces of tin foil, 6 pinecones). Lining usually lines the tunnel and part of the mound near the entrance and is often shredded material. Decorations are usually single items found on the mound. Be sure to record items each visit even if they have been recorded previously. The presence of **scat** should also be recorded. This means canine scat, which is hypothesized to be brought to the burrow by the owls to discourage predators. Marmot scat can also be present on the mound but this should not be recorded under **scat**. Marmot scat is a sign that marmots are frequenting that burrow, not that the owls seek it out and place it on the mound. Marmot scat should be recorded in the comments.

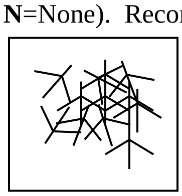
Type and quantity of lining and décor is recorded because they indicate nest initiation. Remove all lining and décor at the first visit to a burrow unless the burrow was found after nest initiation. This avoids confusing lining or décor remaining from last year's nest. On subsequent visits, remove lining or décor if it is questionable whether it is new or from an owl. If it reappears on the next visit you should not remove it. Most burrows will not require a second removal, as nest initiation will be obvious from visual sightings of the owls (or by the use of the infrared scope).

Record any evidence of fresh **prey remains** on or in the burrow or satellite burrow (1/2 rodent, frog guts, insects, etc.- try to ID prey items if possible). Check for **pellets** (circle **Y** if there are pellets or **N** for none). Collect 2-4 whole fresh pellets each time you approach a nest burrow. Pellets disintegrate at different rates dependent upon composition. Pellets consisting of mainly insect remains disintegrate quickly and easily fall apart compared to pellets consisting mainly of mammal remains. This may make it tempting to not collect pellets consisting mainly of insect remains. Please make an effort to collect pellets that are representative of the types of pellets present at the burrow. Always remove all pellets, even those not collected. When you collect pellets put them in a paper bag and write the Nest ID, the date, and how many whole pellets were collected on the bag (circle **C**=collected pellets on the datasheet). Make sure to record the satellite designation of where the pellets were collected.

Record the amount of new whitewash seen on the burrow mounds and perches (specify the satellite designation or specific perch if applicable) (**Feces: N**one**, S**ome**, L**ots). Do not include old whitewash on surfaces that it cannot be removed from (e.g., rock). Also, record any Burrowing Owl feathers lying around the burrow area under **Feathers** (circle **Y**=Yes or **N**=None). Record if there appears to be owl footprints on and around the burrow mound. There can be both adult prints (**Ad Prints?**) and juvenile prints (**Juv Prints?**) present (circle **Y**=Yes or **N**=None). Adult prints generally occur spaced out over the mound while juvenile prints occur in a specific pattern close together at the burrow entrance. Adult prints can be useful to show the presence of owls when there may be no other sign (i.e., the owls may be perching and leaving whitewash and pellets elsewhere). The presence of juvenile prints indicates when the juveniles begin emerging.



Adult Prints



Juvie Prints

Record whether any eggshell fragments or eggs were seen outside the burrow (evidence that eggs were laid).

Record any evidence of depredation (**Signs of depred**) or any owl death, including piles of owl feathers, predator footprints on mound, etc. Search the surrounding area within 10-30m of the burrow closely. Collect any and all remains of deceased Burrowing Owls, place them in a plastic bag, and label the bag with the Nest ID, bands, cause of death and the date. Record what type of remains were found, note where in relation to burrow the remains were found, and what may have happened on the data sheet. Often the type of remains found can determine the type of predation. The following are examples of what various predators will leave behind. Raptors: piles of feathers with little other remains; Owls: decapitate bodies; Mammals: dismembered body parts usually the wings or the legs. If banded legs are found, record band numbers. If it is a banded bird, it should also be recorded on the front nest card.

Clear all sign on each visit by scuffing away the whitewash and prints, and removing the feathers and pellets. Do the same for satellite burrows. Note that you did this on the nest card (**Sign remo**, circle **Y**=Yes or **N**=No). If for some reason you do not remove all sign note that sign was not removed. Make sure that for all burrow conditions you record the satellite where they were observed.

Video probe all occupied burrows once every 7 days on the approach visit. Draw a map of the tunnels and record lengths of each on the back of the **front** nest card during the first scoping visit to the nest so the next person to scope will have it as a reference. If there are any changes to the burrow description update the map and record it in **Map updated** (circle **Y**=Yes or **N**=No).

Record the **Scope info**. This includes what was seen (e.g., 1 egg, 4 chicks <8 days old + female) and the tunnel description (e.g., 3m, no branches). Use the Juvenile Ageing Guide to best determine the age of the chicks. Burrowing Owls lay one egg an average of every 36 hours and generally have a clutch size of 7-10. Since Burrowing Owls may begin incubating after laying their first egg (usually on 4-7 eggs), the chicks will hatch asynchronously (at different times) meaning there will be chicks of various ages in the brood. Record any problems with the burrow – if you couldn't reach the chamber, if there was loose dirt, etc.

Finally, if **trapping**, record whether spring traps, 2-way traps or both were used. Make sure that when you trap at a burrow you specify which burrow(s) were trapped at (nest, Sat A, B and E, etc.) and how many/age/sex were caught at each on the nest card.

### If there is no sign of owl activity

If no owl activity is observed, check the burrow entrance for cobwebs. Cobwebs that are in the burrow entrance but will allow a Burrowing Owl to pass are OK, but cobwebs that would prevent an owl from passing are a sign that the burrow is not in use and need to be recorded in the comments section. Scan the nest area and record any evidence of depredation of adult or juvenile owls (owl feathers, predator foot prints on mound, etc.) as above.

Before leaving the nest area, check the nest card and make sure everything that you observed was recorded and that nothing was missed.

| **Nest ID:** | Site: | State: |
|---|---|---|

| UTMs: | Year: |
|---|---|

Satellite burrows + UTMs :

| How Found: | Nest Type: |
|---|---|

Directions

Map

**Adult Bands**

| Sex | Date | Yr. Banded | Bled | Left Leg | Right Leg | Dead |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Juvenile Bands**

| Date | Freq. | Bled | Left Leg | Right Leg | Dead |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |

| Nest ID: | Site: | | | |
|---|---|---|---|---|
| Date | | | | |
| Time | | | | |
| Obs | | | | |
| Stage | NS G O J SAT | NS G O J SAT | NS G O J SAT | NS G O J SAT |
| Active Satellites | | | | |
| ***Juvenile Activity- Observations without peeper*** | | | | |
| # Juvs + bands | | | | |
| Age Est | Old: Yng: | Old: Yng: | Old: Yng: | Old: Yng: |
| Old/Young act + location | Old: | Old: | Old: | Old: |
| | Yng: | Yng: | Yng: | Yng: |
| Flush or Retreat? | # Flush<br># retreat | # Flush<br># retreat | # Flush<br># retreat | # Flush<br># retreat |
| Flight des | J W S L | J W S L | J W S L | J W S L |
| Comment | | | | |
| ***Adult Activity- Observations without peeper*** | | | | |
| #Adults + bands | | | | |
| Adult act + location | M<br>F | M<br>F | M<br>F | M<br>F |
| Flush or Retreat? | M Flsh / retrt<br>F Flsh / retrt | M Flsh / retrt<br>F Flsh / retrt | M Flsh / retrt<br>F Flsh / retrt | M Flsh / retrt<br>F Flsh / retrt |
| Dist away when flsh | M<br>F | M<br>F | M<br>F | M<br>F |
| Calls M | A C | A C | A C | A C |
| Calls F | A C | A C | A C | A C |
| M Behvr | S B W P | S B W P | S B W P | S B W P |
| F Behvr | S B W P | S B W P | S B W P | S B W P |
| Comment | | | | |
| ***Burrow Condition*** | | | | |
| Lining | N S L<br>Type: | N S L<br>Type: | N S L<br>Type: | N S L<br>Type: |
| Décor | | | | |
| Scat | | | | |
| Prey remains | | | | |
| Pellets | N Y C | N Y C | N Y C | N Y C |
| Feces? | N S L | N S L | N S L | N S L |
| Ad Prints? | Y N | Y N | Y N | Y N |
| Juv Prints? | Y N | Y N | Y N | Y N |
| Feathers? | Y N | Y N | Y N | Y N |
| Sign remo | Y N | Y N | Y N | Y N |
| Signs of depred? | | | | |
| Comment | | | | |
| Trapping inform | | | | |
| Scope info: birds + tunnel desc | | | | |

# Banding Protocol

We band adult and juvenile Burrowing Owls in order to estimate population parameters such as annual survival, annual burrow fidelity, and dispersal distances. Each bird receives an aluminum USFWS band and an ACRAFT color band with a unique alphanumeric code. These bands allow individual identification of owls, which allows us to re-sight individuals and estimate population parameters. Banding is not overly stressful to the owls and allows a non-invasive way to individually identify the owl in the future. Many studies have looked at the effect of banding on survivorship and productively and have found no negative effects.

Because we use re-sight information to estimate these parameters, it is exceedingly important that band numbers and codes (the correct combination/number, color, and orientation) are recorded correctly during both banding and re-sighting. We have had field personnel make mistakes in recording band combinations each year. The models used to estimate these parameters, such as survival, are very sensitive so just a few mistakes can drastically bias our estimates. For this reason, please use the utmost care in recording the correct band combination both when banding owls and when re-sighting owls. Be as neat and clear as possible. Common mistakes are recording the number incorrectly on the USFWS band or mixing up the recording of letters and numbers on the ACRAFT bands (P & R, 5 & S, U & V, K & X, Z & 2 etc.), not recording the OVER or BAR for the orientation, or incorrectly recording which leg received which band. These mistakes take a long time to resolve and some are not resolvable.

After each bird has been banded, make sure that you double check that the leg and band combination that you just recorded on the data sheet (combination/number, color, and orientation) matches the band that you just put on the bird. To do this, the recorder must read the leg and band combo back to bander, while recorder confirms the combo is what was written on the data sheet. The bander also must confirm that the leg and color and numbers/letters are legible on the data sheet (re-write if not completely clear). Check off and date the ACRAFT band on the inventory list. Use the bands in sequential order because we are responsible for accounting for them to the National Bird Banding Laboratory and bands used out of sequence will help identify errors made in the field (although there shouldn't be any!) and resolve discrepancies.

When re-sighting a banded bird, make sure that you are 100% sure of the leg, color, combination, and orientation. If you are not 100%, you should follow what you think the band is with a "?". Even just a color and leg can be helpful in determining what bird you have seen. Colors can be difficult to distinguish at a distance and some colors, especially purple, fade over time. You may only be able to see the leg with the USFWS band, in which case you should record which leg that band is on and return later to try to read the ACRAFT. Additionally, when recording the sex of the bird, record what sex you believe the bird is, not the way it is banded or what the last person recorded.

## *TRAPPING*

There are a variety of traps and techniques used to trap Burrowing Owls. The most common are the two-way trap and the spring trap. The two-way trap is a box trap with a one-way door on either side. The trap is placed in the burrow entrance and catches the owl as it goes in or out of the burrow. The advantages of this trap are that it can usually be left unattended for longer periods of time (2 hour max) and it can catch multiple owls at the same time. The spring trap uses a rodent (gerbil or mouse) in a cage to attract the owl. When the owl attempts to capture the rodent, the trap is tripped and a mesh dome springs over the owl. The spring trap is usually set in front of the burrow or on a level surface in close proximity to the burrow. The spring trap should not be left unattended for longer than 15 minutes at a time. When an owl is caught in the spring trap, the trapper should be as quick as possible getting to the trap to reduce the risk of injury to owl.

Both traps are very effective but can be used more efficiently at different times of the day and year. Early in the season spring traps are effective as owls are not always using one burrow and may be shy of going through a two-way. Also, food is less abundant early in the season making the rodent much more attractive. As owls begin to initiate nests, two-ways become very effective. Often the two-way works best when set a half-hour to an hour before dark and is checked about an hour after dark (although both the spring trap and the two way are effective at any time of day). *Note: Female owls who are known to be laying **should not** be trapped as they may lay an egg in the trap.* When juvenile owls begin to emerge two-way traps are very effective. It is very important to try to trap juveniles shortly after they emerge (age 20-25 days), as they are much easier to trap at a young age. However, trapping juveniles too young (less than 20 days) is not productive because their tarsus is too short to receive an ACRAFT band, which requires them to be recaptured for the ACRAFT to be added. As juveniles get older, spring traps may become more effective. If juveniles have not been trapped at a nest it is very important to keep trying a variety of methods.

It is important to try a variety of trapping techniques on individuals who are not falling for the usual tricks. Banding all the adult owls observed is an important part of the study, and owls that are not trapped soon after their first observation may leave without ever being banded. It is often effective to set a two-way in the burrow entrance upside down, covering the doors with dirt, for a period of time before properly setting the two-way. This allows the owl to go in and out of the burrow and trap, making the owl accustomed to the trap's presence. When the trap is flipped over the owl will not be shy and will normally walk into the trap. Other techniques include mist nets accompanied by broadcast calls and/or a stuffed burrowing or great horned owl, or noose carpets. If you have made 3 attempts with conventional spring trap and/or two-way methods some of these techniques should be attempted to increase your chances of catching the owl.

Be careful when setting traps on the edge of agricultural areas or in horse or cow pastures. Livestock are often curious and farmers on equipment may not see traps. If you suspect the trap could be damaged or worse, an owl be killed in a trap by livestock or farm equipment, monitor the trap from a distance or trap at a later date.

## *HANDLING AND BANDING*

To avoid injuring the owl, be careful when removing it from any trap. This may require you to pry open feet or untangle legs, wings or head from the trap. After removing the owl, place it in a bird bag or sock. While banding and performing measurements, always pay close attention to the bird. Placing the owl in a sock during the actual banding and measuring makes handling easier, reduces stress for the owl, and reduces the chance of escape and injury. Banding and all measurements will be demonstrated in the field as well as described in attached descriptions and keys. Try to minimize handling time to reduce any stress to the owl.

Each time you catch or re-catch a bird, determine its sex, weigh it, and estimate its age (juveniles only). This allows you to look at the change of weight with age over the breeding season and between breeding seasons. Morphological measurements (tail length, meta-tarsus, wing chord) are made on adult birds that allow comparison of body size between sexes and sites. Age estimations are very important in determining success of nests and feather emergence is helpful in determining age. Follow the codes at the top of the banding sheet.

**Protocol for Recording Bands**

| Field Name | Entry Example | Description |
|---|---|---|
| **Left Leg** | *Pu-G OVER 2*<br>*Pu-CRB* | Record the band number and color of the band on the left leg. USFWS bands should be recorded as they appear on the band including the hyphen.<br><br>For Acraft bands record the color abbreviation, followed by a hyphen (-), followed by the alphanumeric code. Alphanumeric codes should be recorded as follows.<br><br>Horizontal: **AS**; looks like **A S**<br><br>Vertical: **A OVER S**; looks like **A** / **S** (stacked)<br><br>Vertical separated by a line: **A BAR S**; looks like **A** / **S** (stacked, separated by a line)<br><br>Horizontal separated by a line: **A VBAR S**; looks like **A** \| **S**<br><br>Please be extremely careful when recording Acraft numbers and orientations. Record all band numbers clearly, anything that is unclear should be re-written. |
| **Right Leg** | *Al: 0844-12456*<br>*Al* | Record the band number and color of the band on the right leg. See above. |

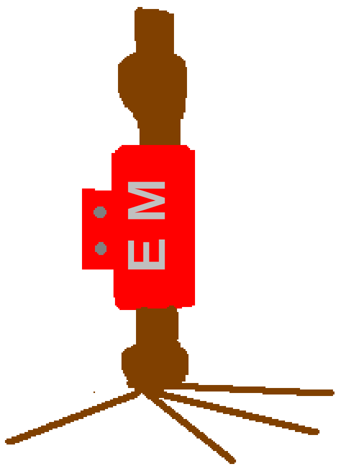
**BAND COLORS** *(Banding and Nest Cards)*

| | | | | | |
|---|---|---|---|---|---|
| **AL** | Aluminum | **Re** | Red | **Bk** | Black |
| **Pu** | Purple | **Bl** | Blue | **Gr** | Green |
| **Or** | Orange | **Br** | Brown | | |

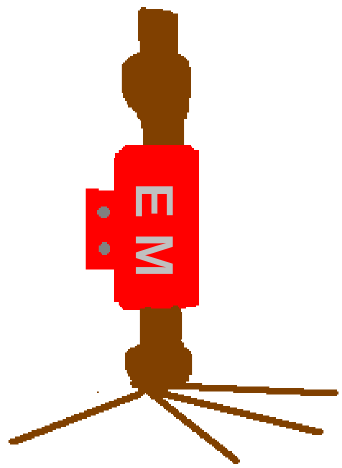
**OTHER SITUATIONS**

**M - NL –** a male, but you could not see his legs to determine if he is banded or not.
**M - CRB –** a banded male, but you cannot read the bands on either leg.
**M - UNB –** an unbanded male.
**M - L:Re A OVER ? –** A male with an Acraft on the left leg, but you cannot read the lower number on the band.

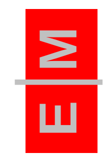
## Guide to reporting ACRAFT bands



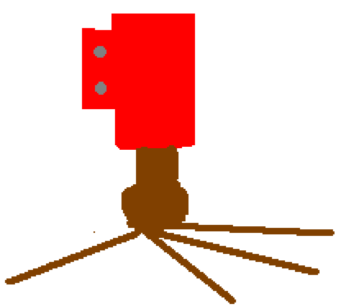

***Re–EM***
**(This is the correct orientation for this type of band: foot to body)**

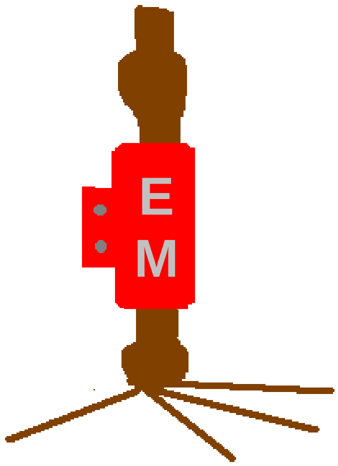



***Re–EM (body to foot)***
**(But sometimes bands are placed this way by mistake; please make a note that the band is oriented body to foot)**

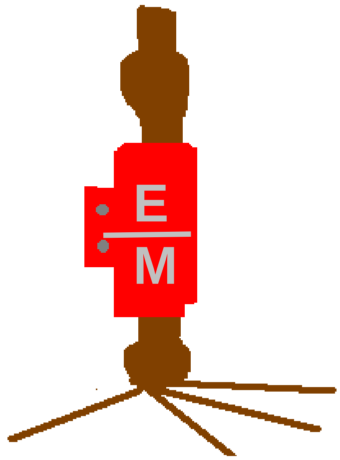



***Re–E VBAR M***
**(This is the correct orientation for this type of band: foot to body. Sometimes they are placed body to foot by mistake. If so, please make a note of it.)**






***Re–E OVER M***




***Re–E BAR M***

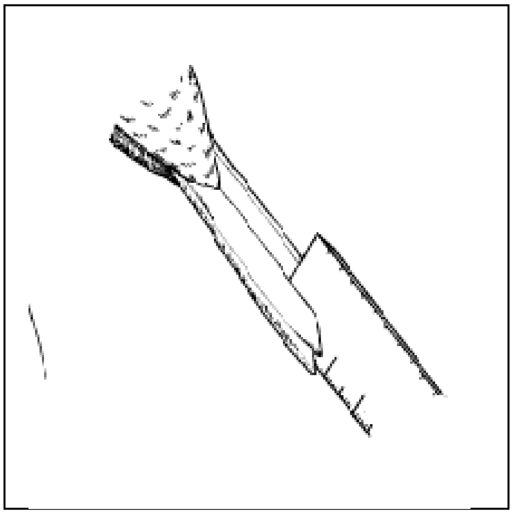
**Protocol for Recording Banding Data**

| Field Name | Entry Example | Description |
|---|---|---|
| **NESTID** | *STEE3A* | Record the nestid (including satellite designation if applicable) for where the captured owl is from. This should be the nest or natal burrow and is not necessarily the same as the burrow at which the bird was captured. This field must be recorded for recaptures. |
| **BURROW CAUGHT AT IF NOT NEST** | *STEE5* | If the owl was not caught at the natal burrow record the burrow where the owl was captured (include satellite designation if applicable). This field must be recorded for recaptures. |
| **DATE** | *10-Jun-03* | Record the date for when the banding took place. This should be recorded as day-month (use three letter abbreviation to avoid confusion with month and day)-year. This field must be recorded for recaptures. |
| **OBSERVER** | *CPN* | Record the initials (three letters) of the individual who actually banded the owl and took the measurements. Only one set of initials should be recorded. This field must be recorded for recaptures. |
| **LEFT LEG** | *0844-39782* | The band number and color of the band placed on the left leg. USFWS bands should be recorded as they appear on the band including the hyphen. For acraft bands record the color abbreviation, followed by a hyphen (-), followed by the alphanumeric code. Alphanumeric codes should be recorded as follows.<br>Horizontal: **AS**<br>Vertical: **A** *or* **A OVER S**<br>**S**<br>Separated by a line**:** **A** *or* **A BAR S**<br>**S**<br>Be sure to triple check all bands before releasing the bird. Record all band numbers clearly, anything that is unclear should be re-written. This field must be recorded for recaptures. |
| **RIGHT LEG** | *Bl-2 OVER 3* | The band number and color of the band placed on the right leg. See the above description for the proper format. This field must be recorded for recaptures. |
| **RE-CAP?** | *Y* | Record whether the owl captured is a recapture or has been captured for the first time. Put a Y (yes) in the field if the owl is a recapture and N (no) if the owl is not a recapture. |

| Field Name | Entry Example | Description |
|---|---|---|
| | | Record the information for all data fields in caps when dealing with recaptures. |
| **BIRD-BAG WGHT** | *190* | Record the combined weight (in grams) of the bird and the bag or sock the bird was weighed in. This must be recorded for adult recaptures. |
| **BAG WGHT** | *2* | Record the weight (in grams) of the sock or bag the bird was weighed in. This field must be recorded for adult recaptures. |
| **SEX** | *M* | Record the sex/age (M, F, J) of the owl captured. We do not attempt to sex juvenile owls, we simply record them as J. This must be recorded for recaptures. |
| **HOW SEXED** | *PL* | Record the method used to sex the owl. Accepted methods are listed at the top of the banding datasheet. This only needs to be recorded for adult owls and must be recorded for recaptures. |
| **Brood Patch?** | *0* | Examine the owl for signs of a brood patch (see **Insert III** for brood patch picture). Using one of the codes at the top of the banding datasheet, record the stage of the owl's brood patch. Note only adult female Burrowing Owls will have a brood patch. |
| **Adult Left Wing** | *180* | Use the method shown in **Insert II** to measure the owl's left wing chord length. Record the measurement in millimeters (mm). This measurement is only taken on adult owls. |
| **Adult Right Wing** | *178* | Use the method shown in **Insert II** to measure the owl's right wing chord length. Record the measurement in millimeters (mm). This measurement is only taken on adult owls. |
| **Adult Left Meta-tarsus** | *72* | Using the method shown in **Insert II** measure the owl's left meta-tarsus. Record the measurement in millimeters (mm). This measurement is only taken on adult owls. |
| **Adult Right Meta-tarsus** | *68* | Using the method shown in **Insert II** measure the owl's right meta-tarsus. Record the measurement in millimeters (mm). This measurement is only taken on adult owls. |
| **JUVIE AGE RANGE** | *24-27* | Use the Aging Guide to estimate the age of the juvenile Burrowing Owls. This is only recorded for juvenile owls and must be recorded for recaptures. |
| **# of Feathers Collected?** | *Y* | Record the number of feather collected from each body region. |
| **Wing Pics?** | *Y* | Take a picture of the outside of the owl's out stretched wing. Be sure the picture includes a piece of paper with the owl's |

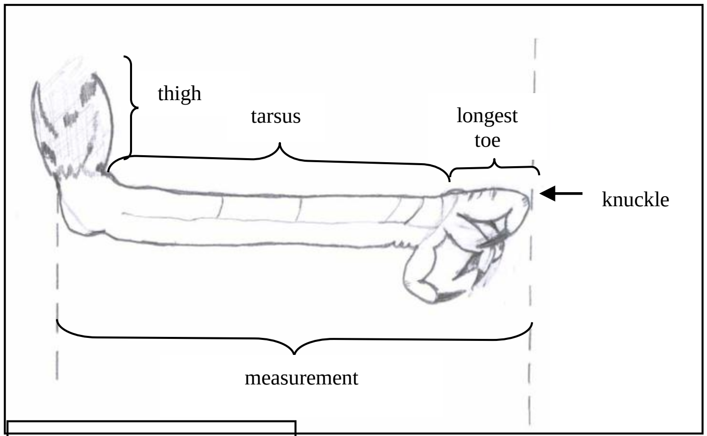
| Field Name | Entry Example | Description |
|---|---|---|
| | | acraft band written on it. Take a picture of both wings. Pictures are only taken on adult owls. |
| **Blood Taken?** | *Y* | Take blood from the owl's brachial vein and record Y (yes) in this field. Someone who is experienced taking blood should show you and watch you take blood for the first few times. Do not attempt to take blood if you are not completely confident you know what you are doing. This is an intrusive procedure and could cause serious injury or infection to the owl. Record N (no) in this field if you did not take blood. |
| **Comments** | | Any comments applicable to the banding data should be entered in this field (injuries to bird, bands put on upside down or on the wrong legs, etc). |

## *INSERT II*
## Morphological Measurements of Burrowing Owls



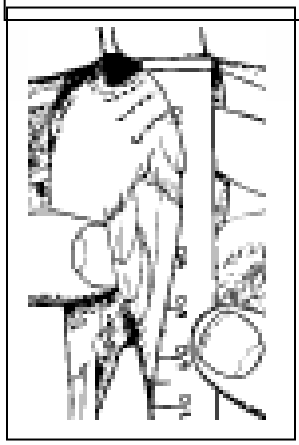
### How to Take Tail Measurements of Burrowing Owls

- Gently separate the tail feathers in approximately the middle of the tail.
- Insert the ruler perpendicular to the axis of the tail feathers (if the owl were standing the ruler would be vertical) until it touches the body where the tail feathers originate.
- Be sure the ruler is held parallel to the length of the feathers and read the measurement at the tip of the longest feather.
- Record the measurement in millimeters (mm).




### How to Measure Metatarsal Length of Burrowing Owls

- Bend the leg to form a 90 degree angle with the thigh and tarsus.
- Bend the longest toe (third digit or middle of the three front digits) at the knuckle *(owls will usually have done this themselves as they normally clench their feet closed while being handled).*
- Extend the bent toe to form a straight line with the toe and the tarsus
- Measure from the back of the joint between the thigh and tarsus to the knuckle of the extended toe.
- Record the measurement in millimeters (mm).



### How to Measure Wing Chord (unflattened wing) Length of Burrowing Owls

- Let the wing lay naturally on the bird's side.
- Slide the ruler under the wing with the lip of the ruler on the joint above the primaries. (If you are not using a universal wing ruler be sure to use the correct ruler for the side you are measuring. Marking the rulers "left" and "right" will help stop mistakes).
- Holding the ruler against the joint, move the tip of the longest feather onto the ruler. Let the wing lay naturally on the ruler and record the measurement.
- Record the measurement in millimeters (mm).

Note: Be sure not to flatten the wing on the ruler. This is a different measurement and will cause inflated results in wing chord length.

***Insert III***
**Brood Patch Picture**

Female Burrowing Owl with large vascularized brood patch. Note the blue/purple coloration in the middle of the brood patch. The intensity of the color will vary but the presence of the blue/purple coloration is key to recognizing a vascularized brood patch.

## Burrowing Owl Banding Data Sheet

**Codes:** How Sexed: BP=Brood Patch; PL=Plumage (Females: darker, bars extend far down sides; Males: lighter, bars ending further up sides);
Brood Patch?: 0=none; P=yes, but not vascularized; V=vascularized; W=Wrinkly/Scaly; R=Receding/new feather growth.

Entered by:____________
Date:__________
Checked by:____________
Date:__________

**Note:** When dealing with recaps please record all the columns that are in CAPS (Nest ID, Burrow caught at, Date, Obs, bands on both Right and Left Legs (USFWS and Acraft bands), Bird-bag Weight and Bag Weight (for Adults), Sex, How Sexed, and Juvie Age Range). Recaps from a previous year (rather than from this year) also should have feathers pulled and wing pics taken.

**FOR ACRAFTS, WRITE OUT "OVER", "BAR" and "VBAR" – do not abbreviate or use slashes. Eg., Bk-5 VBAR 2 is correct.**

**Site:** ________________________ **Year:**__________ **Map datum** (e.g., NAD 27 Conus): __________ **Zone** (from UTMs, e.g. 11 S): __________

| NEST ID | BURROW CAUGHT AT | UTMS OF BURROW CAUGHT AT | DATE | OBS | LEFT LEG | RIGHT LEG | RE-CAP? | BIRD&BAG WT (g) | BAG WT (g) | SEX (M, F, J) | HOW SEXED | Brood Patch? | Adult Left wing (mm) | Adult Right Wing (mm) | Adult Left Meta-tarsus (mm) | Adult Right Meta-tarsus (mm) | JUVIE AGE RANGE | # OF FEATHERS COLLECTED (collect once per year per BUOW) | | | | WING PICS Y/N (once/year/Adult) | Blood Taken Y/N (once/BUOW) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | WHOLE TAIL (ad:1) | PARTIAL TAIL | BODY (ad&J:3&3) | HEAD (ad:1) | | | |
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**Protocol for Recording Trapping Log Data**

| Field Name | Entry Example | Description |
|---|---|---|
| **NestID** | *STEE3A* | Record the nestid including the satellite designation, if applicable, for the burrow where the trap was set. |
| **Date** | *17-MAR-02* | Record the date when the trap was set. This should be recorded as day-month (use three letter abbreviation to avoid confusion with month and day)-year. |
| **Observer** | *CPN* | Record the initials (three letters) of all the individuals involved in the trapping process. |
| **Start Time** | *0730* | Record the time when the trap was set. Use 4-digit military (24 hour) time. |
| **End Time** | *1310* | Record the time trapping activities stopped. Use 4-digit military (24 hour) time. |
| **Trap Type** | 2W | Record the trap type used. Abbreviations for the traps types are: **2W**: two way, **ST**: spring trap, **NC**: noose carpet, **MN**: mist net. |
| **Time Chck'd** | *0830* | Record the time (4-digit military format) each time the trap is checked. |
| **# Caught** | *2* | Record the number of owls caught for each time the trap is checked. |
| **Comments** | *Banded 1 J and recaptured F* | Record any comments relevant to the trapping activities which were not recorded above. Record the number and sex/age (**M**, **F** or **J**), the leg (L or R) and the acraft alphanumeric code for all the owls captured. Also be sure to note if any of the owls were recaptures. |

**Burrowing Owl Trapping Log**

Trap type: 2W = 2-way Trap; ST = Spring Trap; MN = Mist Net; HH = Have a Heart.
Record an entry on each trapping attempt even if the attempt is unsuccessful.

Study Area: ___________________ Year:_______________

| Nest ID | Date | Obs. | Start time | End time | Trap type | Time chck'd | # caught | Time chck'd | # caught | Time chck'd | # caught | Time chck'd | # caught | Time chck'd | # caught | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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*Quick Reference for Codes and Acronyms on Datasheets*

## Nest Information

**HOW NESTS WERE FOUND** *(Front Nest Cards)*

| | | | |
|---|---|---|---|
| **H** | Historic | ***I*** | Incidental |
| **PDTS** | Prairie dog town surveys | **RS** | Roadside survey |
| **LY** | Last year | | |
| **WOM** | Word of mouth | | |

**SUBSTRATE** *(Front Nest Card)*

| | | |
|---|---|---|
| Artificial | Badger | Coyote |
| Marmot | Ground Squirrel | Prairie Dog |
| Man made | Man made/Badger | Man made/Ground Squirrel |
| Man made/Marmot | Man made/Coyote | Irrigation trough/Unknown |
| Irrigation trough/ Badger | Culvert | Other |

**STAGES** *(Nest Cards)*

| | | | |
|---|---|---|---|
| **NS** | No sign | ***G*** | Sign |
| **O** | Occupied | **J** | Juveniles |
| **SAT** | Satellite | | |

* *Record the stage as you observed it, not what you believe the stage to be based on previous visits*

**VISIT TYPES** *(Nest Cards)*

| | | | |
|---|---|---|---|
| **DA** | Didn't approach the nest | ***DRIVE BY*** | Observed birds at a nest incidentally on route to another location |

* *Visit type descriptions need to be placed in the all the comment sections when applicable.*

## Banding information

**BAND COLORS** *(Banding and Nest Cards)*

| | | | | | |
|---|---|---|---|---|---|
| **AL** | Aluminum | ***RE*** | Red | **Ye** | Yellow |
| **Pi** | Pink | **Bl** | Blue | **Gr** | Green |
| **Or** | Orange | **Wh** | White | **Bk** | Black |

**BANDED STATUS** *(Banding and Nest Cards)*

| | | | |
|---|---|---|---|
| **UNB** | Unbanded | ***NL*** | No legs (could not tell if banded) |
| **CRB** | Banded but couldn't read the band | | |

All resighted bands should be recorded in the following manner:
Sex (**M** or **F** or **J**) : Leg (**R** or **L**) : Color (see above) – Alphanumeric code (written as it appears on the band)

Horizontal: **AS**
Vertical: **A** *or* **A OVER S**
**S**
Separated by a line: **<u>A</u>** *or* **A BAR S**

***S***

| **LAND-USE AND HABITAT TYPES** *(Roadside Surveys)* | | | | | |
|---|---|---|---|---|---|
| **AG** | Agriculture | **GR** | Gravel road | **PA** | Pasture |
| ***Af*** | Abandoned field | **GC** | Golf course | **PC** | Paloverde-cacti scrub |
| **AP** | Airport | **HD** | Housing development | **PR** | Paved road |
| **CF** | Creosote flat | ***Ic*** | Irrigation canal | **RW** | Railway |
| **DW** | Dry wash | **ID** | Industry/development | **SS** | Shrub steppe |
| **FL** | Feedlot | **IG** | Invaded grassland | **VL** | Vacant lot |
| **FS** | Feed storage | **OT** | Other | **WR** | Wetland/riparian |

## Appendix 2: UTMs of nests and active satellite burrows on DoD installations and their surroundings

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Yuma Marine Corps Air Station | AZ | 2006 | 10e01 | 11S | 735868 | 3604896 |
| Yuma Marine Corps Air Station | AZ | 2006 | co19 | 11S | 735319 | 3599246 |
| Yuma Marine Corps Air Station | AZ | 2006 | orco01 | 11S | 726466 | 3614164 |
| Yuma Marine Corps Air Station | AZ | 2006 | orco02 | 11S | 726350 | 3614219 |
| Yuma Marine Corps Air Station | AZ | 2006 | rad01 | 11S | 738696 | 3598266 |
| Yuma | AZ | 2006 | trx01 | 11S | 726855 | 3618051 |
| Yuma | AZ | 2006 | wew01 | 11S | 721822 | 3623414 |
| Yuma | AZ | 2006 | wew02 | 11S | 721813 | 3623412 |
| Yuma | AZ | 2006 | wew03 | 11S | 721556 | 3623687 |
| Yuma | AZ | 2006 | wew04 | 11S | 721569 | 3623687 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix01 | 10S | 607039 | 4247758 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix01 | 10S | 607040 | 4247807 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix02 | 10S | 607040 | 4247807 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix03 | 10S | 606957 | 4247881 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix03 | 10S | 607014 | 4247824 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix05 | 10S | 606957 | 4247833 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix06 | 10S | 606919 | 4247833 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix08 | 10S | 606477 | 4247822 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix09 | 10S | 606991 | 4248242 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix14 | 10S | 607848 | 4247183 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix19 | 10S | 607093 | 4247539 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix20 | 10S | 607084 | 4247521 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix21 | 10S | 607093 | 4247477 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix22 | 10S | 607006 | 4247527 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix22 | 10S | 607047 | 4247456 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix23 | 10S | 607099 | 4246904 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix25 | 10S | 607070 | 4247649 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix26 | 10S | 607156 | 4247472 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dix30 | 10S | 607003 | 4247140 |
| Dixon Navy Radio Transmitter Facility | CA | 2006 | dixsg | 10S | 607047 | 4247456 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | babe | 10S | 607072 | 4247370 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | cinco | 10S | 606631 | 4247839 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | crab01 | 10S | 607006 | 4247493 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | crab01 | 10S | 607108 | 4247487 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | crab01 | 10S | 607180 | 4247487 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | crab02 | 10S | 607006 | 4247493 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | dix05 | 10S | 606957 | 4247833 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | dix13 | 10S | 607060 | 4247267 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | dix30 | 10S | 607003 | 4247140 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | enclosed | 10S | 606631 | 4247839 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | enclosed | 10S | 606978 | 4247515 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | enclosed | 10S | 607164 | 4247515 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | pipe | 10S | 607050 | 4247755 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | rbbit | 10S | 607077 | 4247618 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | warn01 | 10S | 607030 | 4247851 |
| Dixon Navy Radio Transmitter Facility | CA | 2007 | warn03 | 10S | 606631 | 4247839 |
| Edwards AFB | CA | 2006 | arnp01 | 11S | 416000 | 3864029 |
| Edwards AFB | CA | 2006 | ball01 | 11S | 415673 | 3863936 |
| Edwards AFB | CA | 2006 | ball02 | 11S | 415649 | 3863975 |
| Edwards AFB | CA | 2006 | bmx02 | 11S | 415877 | 3863862 |
| Edwards AFB | CA | 2006 | commb01 | 11S | 414967 | 3864980 |
| Edwards AFB | CA | 2006 | commc01 | 11S | 414908 | 3864998 |
| Edwards AFB | CA | 2006 | commd01 | 11S | 414959 | 3864979 |
| Edwards AFB | CA | 2006 | haz01 | 11S | 419295 | 3869113 |
| Edwards AFB | CA | 2006 | haz04 | 11S | 419259 | 3869023 |
| Edwards AFB | CA | 2006 | haz05 | 11S | 419221 | 3868975 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Edwards AFB | CA | 2006 | haz07 | 11S | 419292 | 3869148 |
| Edwards AFB | CA | 2006 | haz09 | 11S | 419282 | 3869118 |
| Edwards AFB | CA | 2006 | inpit02 | 11S | 412306 | 3867788 |
| Edwards AFB | CA | 2006 | inpit02 | 11S | 412310 | 3867783 |
| Edwards AFB | CA | 2006 | inpit02 | 11S | 412338 | 3867761 |
| Edwards AFB | CA | 2006 | inpit03 | 11S | 412416 | 3867850 |
| Edwards AFB | CA | 2006 | inpit04 | 11S | 412436 | 3867837 |
| Edwards AFB | CA | 2006 | inpit05 | 11S | 412299 | 3867847 |
| Edwards AFB | CA | 2006 | inpit05 | 11S | 412460 | 3867825 |
| Edwards AFB | CA | 2006 | inpit06 | 11S | 412593 | 3867640 |
| Edwards AFB | CA | 2006 | ldfl01 | 11S | 412997 | 3868002 |
| Edwards AFB | CA | 2006 | museum02 | 11S | 415787 | 3863484 |
| Edwards AFB | CA | 2006 | nasa01 | 11S | 418777 | 3867835 |
| Edwards AFB | CA | 2006 | nasa02 | 11S | 418741 | 3867858 |
| Edwards AFB | CA | 2006 | nasa03 | 11S | 418716 | 3867838 |
| Edwards AFB | CA | 2006 | nb01 | 11S | 419656 | 3871505 |
| Edwards AFB | CA | 2006 | nb02 | 11S | 420175 | 3871472 |
| Edwards AFB | CA | 2006 | nb04 | 11S | 420203 | 3871471 |
| Edwards AFB | CA | 2006 | nb05 | 11S | 420206 | 3871472 |
| Edwards AFB | CA | 2006 | nb06 | 11S | 419978 | 3871475 |
| Edwards AFB | CA | 2006 | pit02 | 11S | 412539 | 3867850 |
| Edwards AFB | CA | 2006 | pit02 | 11S | 412540 | 3867540 |
| Edwards AFB | CA | 2006 | pit03 | 11S | 412227 | 3867856 |
| Edwards AFB | CA | 2006 | pit03 | 11S | 412230 | 3867857 |
| Edwards AFB | CA | 2006 | pit06 | 11S | 412285 | 3867845 |
| Edwards AFB | CA | 2006 | pit06 | 11S | 412299 | 3867847 |
| Edwards AFB | CA | 2006 | tp02 | 11S | 415517 | 3863787 |
| Edwards AFB | CA | 2006 | yea01 | 11S | 414580 | 3865972 |
| Edwards AFB | CA | 2007 | bike01 | 11S | 416125 | 3864850 |
| Edwards AFB | CA | 2007 | bike02 | 11S | 415970 | 3865016 |
| Edwards AFB | CA | 2007 | bike02b | 11S | 415923 | 3865059 |
| Edwards AFB | CA | 2007 | bike03 | 11S | 413043 | 3867533 |
| Edwards AFB | CA | 2007 | bike03 | 11S | 415730 | 3865031 |
| Edwards AFB | CA | 2007 | bike04 | 11S | 416078 | 3864686 |
| Edwards AFB | CA | 2007 | crwsh | 11S | 519673 | 3542521 |
| Edwards AFB | CA | 2007 | hous01 | 11S | 412985 | 3865448 |
| Edwards AFB | CA | 2007 | hous02 | 11S | 412996 | 3865469 |
| Edwards AFB | CA | 2007 | hrse | 11S | 413287 | 3866669 |
| Edwards AFB | CA | 2007 | hrse | 11S | 413431 | 3866835 |
| Edwards AFB | CA | 2007 | hrse02 | 11S | 413636 | 3866672 |
| Edwards AFB | CA | 2007 | inpit06-02 | 11S | 412562 | 3867676 |
| Edwards AFB | CA | 2007 | inpit-i | 11S | 412410 | 3867840 |
| Edwards AFB | CA | 2007 | jns | 11S | 419138 | 3861365 |
| Edwards AFB | CA | 2007 | landfl | 11S | 413043 | 3867533 |
| Edwards AFB | CA | 2007 | noba01 | 11S | 419655 | 3871504 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Edwards AFB | CA | 2007 | pig | 11S | 413431 | 3866835 |
| Edwards AFB | CA | 2007 | tire01 | 11S | 412622 | 3867953 |
| Edwards AFB | CA | 2007 | wood01 | 11S | 412265 | 3867845 |
| Edwards AFB | CA | 2007 | yeag02 | 11S | 415357 | 3865468 |
| March JARB | CA | 2006 | mar01 | 11S | 477440 | 3749988 |
| March JARB | CA | 2006 | mar02 | 11S | 477246 | 3748658 |
| March JARB | CA | 2006 | mar03 | 11S | 477446 | 3749980 |
| March JARB | CA | 2006 | oldm01 | 11S | 476445 | 3751894 |
| El Centro, NAF | CA | 2006 | 7st01 | 11S | 625380 | 3631065 |
| El Centro, NAF | CA | 2006 | 7st02 | 11S | 625404 | 3631055 |
| El Centro, NAF | CA | 2006 | coto01 | 11S | 624409 | 3632486 |
| El Centro, NAF | CA | 2006 | cst01 | 11S | 623856 | 3632486 |
| El Centro, NAF | CA | 2006 | cst02 | 11S | 623835 | 3632568 |
| El Centro, NAF | CA | 2006 | cst02 | 11S | 623835 | 3632586 |
| El Centro, NAF | CA | 2006 | ent01 | 11S | 624421 | 3630989 |
| El Centro, NAF | CA | 2006 | ent04 | 11S | 624411 | 3630574 |
| El Centro, NAF | CA | 2006 | ent05 | 11S | 623954 | 3630939 |
| El Centro, NAF | CA | 2006 | ent05 | 11S | 624008 | 3630927 |
| El Centro, NAF | CA | 2006 | ent06 | 11S | 623954 | 3630939 |
| El Centro, NAF | CA | 2006 | ent06 | 11S | 624008 | 3630927 |
| El Centro, NAF | CA | 2006 | ent07 | 11S | 624194 | 3630932 |
| El Centro, NAF | CA | 2006 | ent08 | 11S | 623812 | 3630930 |
| El Centro, NAF | CA | 2006 | finn01 | 11S | 625916 | 3633334 |
| El Centro, NAF | CA | 2006 | fuel01(atnafec) | 11S | 625549 | 3631262 |
| El Centro, NAF | CA | 2006 | fuel02(atnafec) | 11S | 625555 | 3631001 |
| El Centro, NAF | CA | 2006 | fuel03(atnafec) | 11S | 625751 | 3631365 |
| El Centro, NAF | CA | 2006 | n40-01 | 11S | 623913 | 3632988 |
| El Centro, NAF | CA | 2006 | nef01 | 11S | 626258 | 3632586 |
| El Centro, NAF | CA | 2006 | nef02 | 11S | 626500 | 3632590 |
| El Centro, NAF | CA | 2006 | nst02 | 11S | 624070 | 3632473 |
| El Centro, NAF | CA | 2006 | rat01 | 11S | 624594 | 3632206 |
| El Centro, NAF | CA | 2006 | rat01 | 11S | 624594 | 3632486 |
| El Centro, NAF | CA | 2006 | sef01 | 11S | 626016 | 3631547 |
| El Centro, NAF | CA | 2006 | sef02 | 11S | 626014 | 3631418 |
| El Centro, NAF | CA | 2006 | sef03 | 11S | 626788 | 3630861 |
| El Centro, NAF | CA | 2006 | unk nest | 11S | 623999 | 3632516 |
| El Centro, NAF | CA | 2006 | unk nest | 11S | 624067 | 3632491 |
| El Centro, NAF | CA | 2007 | 7st01 | 11S | 625380 | 3631065 |
| El Centro, NAF | CA | 2007 | aentr | 11S | 623771 | 3630943 |
| El Centro, NAF | CA | 2007 | bank01 | 11S | 624415 | 3630230 |
| El Centro, NAF | CA | 2007 | bank05 | 11S | 624406 | 3630742 |
| El Centro, NAF | CA | 2007 | beale01 | 11S | 624071 | 3632471 |
| El Centro, NAF | CA | 2007 | dead01 | 11S | 624474 | 3629745 |
| El Centro, NAF | CA | 2007 | drn01a | 11S | 625588 | 3631359 |
| El Centro, NAF | CA | 2007 | ent03 | 11S | 624414 | 3630427 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| El Centro, NAF | CA | 2007 | entr | 11S | 624133 | 3630493 |
| El Centro, NAF | CA | 2007 | entr | 11S | 624133 | 3630943 |
| El Centro, NAF | CA | 2007 | fuel02 | 11S | 625555 | 3631001 |
| El Centro, NAF | CA | 2007 | grade01 | 11S | 624010 | 3630915 |
| El Centro, NAF | CA | 2007 | hay01 | 11S | 626249 | 3629753 |
| El Centro, NAF | CA | 2007 | hay01 | 11S | 626749 | 3629753 |
| El Centro, NAF | CA | 2007 | hay03 | 11S | 626554 | 3629744 |
| El Centro, NAF | CA | 2007 | hay03t | 11S | 626598 | 3629742 |
| El Centro, NAF | CA | 2007 | hayrail03 | 11S | 626323 | 3629728 |
| El Centro, NAF | CA | 2007 | hayrail06 | 11S | 626100 | 3629757 |
| El Centro, NAF | CA | 2007 | hayrail07 | 11S | 626330 | 3629745 |
| El Centro, NAF | CA | 2007 | hayrail08 | 11S | 626331 | 3629716 |
| El Centro, NAF | CA | 2007 | hella01 | 11S | 625588 | 3631359 |
| El Centro, NAF | CA | 2007 | hella01 | 11S | 625614 | 3631353 |
| El Centro, NAF | CA | 2007 | nohe01 | 11S | 626015 | 3631428 |
| El Centro, NAF | CA | 2007 | nohe01a | 11S | 626015 | 3631428 |
| El Centro, NAF | CA | 2007 | off01 | 11S | 626749 | 3629753 |
| El Centro, NAF | CA | 2007 | off01 | 11S | 626784 | 3629752 |
| El Centro, NAF | CA | 2007 | ostrg01 | 11S | 624370 | 3632488 |
| El Centro, NAF | CA | 2007 | pole01 | 11S | 623842 | 3632538 |
| El Centro, NAF | CA | 2007 | pole01 | 11S | 623852 | 3632488 |
| El Centro, NAF | CA | 2007 | rubble01 | 11S | 625716 | 3631149 |
| El Centro, NAF | CA | 2007 | rubble02 | 11S | 625722 | 3631294 |
| El Centro, NAF | CA | 2007 | rwbl | 11S | 621640 | 3629146 |
| El Centro, NAF | CA | 2007 | sentr | 11S | 623973 | 3630933 |
| El Centro, NAF | CA | 2007 | yellow01 | 11S | 624411 | 3630372 |
| NAS Lemoore | CA | 2006 | llw02 | 11S | 234786 | 4024219 |
| NAS Lemoore | CA | 2006 | llw04 | 11S | 234843 | 4024009 |
| NAS Lemoore | CA | 2006 | llw05 | 11S | 235084 | 4023461 |
| NAS Lemoore | CA | 2006 | llw06 | 11S | 234720 | 4024031 |
| NAS Lemoore | CA | 2006 | lrw01-01 | 11S | 235422 | 4025593 |
| NAS Lemoore | CA | 2006 | lrw02 | 11S | 235385 | 4025712 |
| NAS Lemoore | CA | 2006 | lrw04 | 11S | 235182 | 4025675 |
| NAS Lemoore | CA | 2006 | lrw06 | 11S | 235170 | 4026146 |
| NAS Lemoore | CA | 2006 | lrw07-02 | 11S | 235422 | 4025593 |
| NAS Lemoore | CA | 2006 | nl01 | 11S | 234203 | 4027647 |
| NAS Lemoore | CA | 2006 | nl02 | 11S | 234063 | 4028104 |
| NAS Lemoore | CA | 2006 | nl03 | 11S | 234203 | 4028370 |
| NAS Lemoore | CA | 2006 | nl07 | 11S | 234109 | 4028059 |
| NAS Lemoore | CA | 2006 | nl08 | 11S | 234188 | 4027628 |
| NAS Lemoore | CA | 2006 | nl10 | 11S | 234314 | 4027353 |
| NAS Lemoore | CA | 2006 | nl11 | 11S | 233992 | 4028126 |
| NAS Lemoore | CA | 2006 | nl14 | 11S | 234069 | 4027976 |
| NAS Lemoore | CA | 2006 | nl15 | 11S | 233988 | 4028200 |
| NAS Lemoore | CA | 2006 | nl18 | 11S | 234093 | 4027887 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| NAS Lemoore | CA | 2006 | sas02 | 11S | 236309 | 4020851 |
| NAS Lemoore | CA | 2006 | sr01 | 11S | 236242 | 4020886 |
| NAS Lemoore | CA | 2006 | sr03 | 11S | 236250 | 4020748 |
| NAS Lemoore | CA | 2006 | srw01 | 11S | 236322 | 4020767 |
| NAS Lemoore | CA | 2006 | srw03 | 11S | 236250 | 4020526 |
| NAS Lemoore | CA | 2006 | srw05 | 11S | 236280 | 4020540 |
| NAS Lemoore | CA | 2006 | srw11 | 11S | 236222 | 4020871 |
| NAS Lemoore | CA | 2006 | srw14 | 11S | 236176 | 4020308 |
| NAS Lemoore | CA | 2006 | srw15 | 11S | 236094 | 4020507 |
| NAS Lemoore | CA | 2006 | srw16 | 11S | 236111 | 4020554 |
| NAS Lemoore | CA | 2006 | srw17 | 11S | 236127 | 4020695 |
| NAS Lemoore | CA | 2007 | flg | 11S | 234251 | 4028052 |
| NAS Lemoore | CA | 2007 | frogatlem | 11S | 234124 | 4028228 |
| NAS Lemoore | CA | 2007 | hide | 11S | 234124 | 4028571 |
| NAS Lemoore | CA | 2007 | hill | 11S | 234377 | 4028584 |
| NAS Lemoore | CA | 2007 | lrw04a | 11S | 235182 | 4025675 |
| NAS Lemoore | CA | 2007 | nl04 | 11S | 238836 | 4027093 |
| NAS Lemoore | CA | 2007 | skull | 11S | 234393 | 4027584 |
| NAS Lemoore | CA | 2007 | slvrflt | 11S | 237940 | 4027938 |
| NAS Lemoore | CA | 2007 | sthflg | 11S | 234343 | 4027761 |
| NAS Lemoore | CA | 2007 | sthflg02 | 11S | 234350 | 4027863 |
| NAS Lemoore | CA | 2007 | tank01 | 11S | 236426 | 4021038 |
| NAS Lemoore | CA | 2007 | tank01 | 11S | 236426 | 4027093 |
| NAS Lemoore | CA | 2007 | tankgrp | 11S | 236255 | 4021311 |
| NAS Lemoore | CA | 2007 | thundr | 11S | 234689 | 4026931 |
| Naval Base Coronado | CA | 2005 | awac1 | 11S | 480731 | 3616888 |
| Naval Base Coronado | CA | 2005 | beach2 | 11S | 480565 | 3616709 |
| Naval Base Coronado | CA | 2006 | lifeguard01/occ01 | 11S | 480057 | 3616557 |
| Naval Base Coronado | CA | 2006 | nolf01/occ14 | 11S | 488575 | 3602819 |
| Naval Base Coronado | CA | 2006 | occ5B | 11S | 479559 | 3617239 |
| Naval Base Coronado | CA | 2006 | radar01/art03 | 11S | 480754 | 3616874 |
| Naval Base Coronado | CA | 2006 | radar02/art04 | 11S | 480731 | 3616887 |
| Naval Base Coronado | CA | 2006 | radar02/art04occ | 11S | 480701 | 3616881 |
| Naval Base Coronado | CA | 2006 | testline02/occ15 | 11S | 479399 | 3617518 |
| Naval Base Coronado | CA | 2007 | art05 | 11S | 480703 | 3616885 |
| Naval Base Coronado | CA | 2007 | art05 | 11S | 480731 | 3616887 |
| Naval Base Coronado | CA | 2007 | occ34 | 11S | 480574 | 3616720 |
| Naval Base Coronado | CA | 2007 | radar01/art03 | 11S | 480754 | 3616874 |
| Naval Base Coronado | CA | 2008 | art03occ | 11S | 480754 | 3616874 |
| Sharpe Depot | CA | 2007 | aaf | 10S | 652543 | 4188231 |
| Sharpe Depot | CA | 2007 | d09 | 10S | 652577 | 4188469 |
| Sharpe Depot | CA | 2007 | east26 | 10S | 625139 | 4188149 |
| Sharpe Depot | CA | 2007 | east26 | 10S | 652139 | 4188149 |
| Sharpe Depot | CA | 2007 | est26 | 10S | 652139 | 4188149 |
| Sharpe Depot | CA | 2007 | estcmo | 10S | 652061 | 4189501 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Sharpe Depot | CA | 2007 | fence | 10S | 652049 | 4188366 |
| Sharpe Depot | CA | 2007 | fence03 | 10S | 652029 | 4188498 |
| Sharpe Depot | CA | 2007 | nrthcmo | 10S | 652035 | 4189495 |
| Sharpe Depot | CA | 2007 | o16 | 10S | 652858 | 4188294 |
| Sharpe Depot | CA | 2007 | pb26 | 10S | 652090 | 4188140 |
| Sharpe Depot | CA | 2007 | pb26 | 10S | 652090 | 4188170 |
| Sharpe Depot | CA | 2007 | r-rd04 | 10S | 652123 | 4188052 |
| Sharpe Depot | CA | 2007 | seven | 10S | 652040 | 4188901 |
| Sharpe Depot | CA | 2007 | seven | 10S | 6520404 | 4188901 |
| Sharpe Depot | CA | 2007 | st26 | 10S | 652087 | 4188112 |
| Sharpe Depot | CA | 2007 | sth26 | 10S | 652108 | 4188114 |
| Sharpe Depot | CA | 2007 | sthstk | 10S | 652850 | 4188433 |
| Sharpe Depot | CA | 2007 | sthstk02 | 10S | 652848 | 4188351 |
| Sharpe Depot | CA | 2007 | sthstk02 | 10S | 652858 | 4188351 |
| Sharpe Depot | CA | 2007 | under | 10S | 652030 | 4188306 |
| Travis AFB | CA | 2007 | 4babes | 10S | 591519 | 4235926 |
| Travis AFB | CA | 2007 | 721 | 10S | 594108 | 4236682 |
| Travis AFB | CA | 2007 | claw | 10S | 591476 | 4235867 |
| Travis AFB | CA | 2007 | claw | 10S | 594108 | 4236682 |
| Travis AFB | CA | 2007 | ditch02 | 10S | 591351 | 4235907 |
| Travis AFB | CA | 2007 | emerg | 10S | 595003 | 4236440 |
| Travis AFB | CA | 2007 | piper | 10S | 591377 | 4235849 |
| Travis AFB | CA | 2007 | schl | 10S | 591393 | 4235801 |
| Travis AFB | CA | 2007 | schl | 10S | 591393 | 4235849 |
| Travis AFB | CA | 2007 | seow | 10S | 591377 | 4235849 |
| Buckley AFB | CO | 2006 | drm01 | 13S | 518667 | 4396540 |
| Buckley AFB | CO | 2006 | drm02 | 13S | 518559 | 4396322 |
| Buckley AFB | CO | 2006 | drm03 | 13S | 518595 | 4396122 |
| Buckley AFB | CO | 2006 | glfbatbuafb01 | 13S | 518703 | 4395836 |
| Buckley AFB | CO | 2006 | stea03 | 13S | 520911 | 4395995 |
| Buckley AFB | CO | 2006 | stea04 | 13S | 522245 | 4394679 |
| Buckley AFB | CO | 2006 | stea05 | 13S | 522131 | 4394679 |
| Buckley AFB | CO | 2006 | stea07 | 13S | 520543 | 4396562 |
| Buckley AFB | CO | 2006 | stea08 | 13S | 520486 | 4396837 |
| Buckley AFB | CO | 2006 | stea09 | 13S | 522469 | 4395212 |
| Buckley AFB | CO | 2006 | stea10 | 13S | 522057 | 4395021 |
| Buckley AFB | CO | 2006 | stea11 | 13S | 520006 | 4396835 |
| Buckley AFB | CO | 2006 | stea12 | 13S | 521923 | 4394419 |
| Buckley AFB | CO | 2006 | stea13 | 13S | 519901 | 4396676 |
| Buckley AFB | CO | 2006 | vailatbuafb01 | 13S | 519691 | 4396665 |
| Buckley AFB | CO | 2007 | buk01 | 13S | 519986 | 4396801 |
| Buckley AFB | CO | 2007 | buk02 | 13S | 520340 | 4396669 |
| Buckley AFB | CO | 2007 | buk03 | 13S | 522294 | 4394667 |
| Buckley AFB | CO | 2007 | buk04 | 13S | 522279 | 4394504 |
| Buckley AFB | CO | 2007 | buk05 | 13S | 522096 | 4394282 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Buckley AFB | CO | 2007 | buk06 | 13S | 522169 | 4394728 |
| Fort Carson | CO | 2006 | abr02 | 13S | 511225 | 4254574 |
| Fort Carson | CO | 2006 | butt01 | 13S | 521290 | 4257635 |
| Fort Carson | CO | 2006 | car01 | 13S | 512198 | 4253426 |
| Fort Carson | CO | 2006 | car02 | 13S | 512502 | 4252093 |
| Fort Carson | CO | 2006 | car03 | 13S | 512626 | 4253131 |
| Fort Carson | CO | 2006 | car04 | 13S | 510397 | 4254057 |
| Fort Carson | CO | 2006 | car05 | 13S | 509734 | 4252719 |
| Fort Carson | CO | 2006 | car06 | 13S | 510231 | 4252070 |
| Fort Carson | CO | 2006 | rt08-01 | 13S | 511199 | 4262718 |
| Fort Carson | CO | 2007 | car06a | 13S | 510231 | 4252070 |
| Fort Carson | CO | 2007 | pc32b | 13S | 519191 | 4259355 |
| Fort Carson | CO | 2007 | pc53a | 13S | 519907 | 4262481 |
| Fort Carson | CO | 2007 | rng451 | 13S | 521677 | 4281173 |
| Fort Carson | CO | 2007 | ta11 | 13S | 518924 | 4278219 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms01 | 13S | 592597 | 4144651 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms02 | 13S | 589585 | 4144651 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms03 | 13S | 574615 | 4140961 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms04 | 13S | 592151 | 4145215 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms05 | 13S | 588485 | 4139634 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms06 | 11T | 592382 | 4145029 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms07 | 13S | 582563 | 4140905 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms08 | 13S | 589977 | 4145113 |
| Pinon Canyon Maneuver Site | CO | 2006 | pcms09 | 13S | 589172 | 4144714 |
| Pinon Canyon Maneuver Site | CO | 2007 | biern02 | 13S | 596296 | 4319075 |
| Pinon Canyon Maneuver Site | CO | 2007 | crossranch01 | 13S | 598184 | 4153776 |
| Pinon Canyon Maneuver Site | CO | 2007 | joel01 | 13S | 584704 | 4139475 |
| Pinon Canyon Maneuver Site | CO | 2007 | joella01 | 13S | 584707 | 4139492 |
| Pinon Canyon Maneuver Site | CO | 2007 | lockwoodcorral01a | 13S | 603526 | 4152781 |
| Pinon Canyon Maneuver Site | CO | 2007 | minsics01 | 13S | 601906 | 4146506 |
| Pinon Canyon Maneuver Site | CO | 2007 | rock04 | 13S | 592673 | 4144231 |
| Pinon Canyon Maneuver Site | CO | 2007 | rockcrossing01 | 13S | 592597 | 4144205 |
| Pinon Canyon Maneuver Site | CO | 2007 | rockcrossing02 | 13S | 592181 | 4144452 |
| Pinon Canyon Maneuver Site | CO | 2007 | rockcrossing03 | 13S | 592590 | 4144334 |
| Pinon Canyon Maneuver Site | CO | 2007 | rockcrossing04 | 13S | 592238 | 4144958 |
| Pinon Canyon Maneuver Site | CO | 2007 | rockcrossing05 | 13S | 592408 | 4144535 |
| Pinon Canyon Maneuver Site | CO | 2007 | tyrone01 | 13S | 574653 | 4140750 |
| Pinon Canyon Maneuver Site | CO | 2007 | tyrone02 | 13S | 574745 | 4140812 |
| Pinon Canyon Maneuver Site | CO | 2007 | windmill03 | 13S | 577106 | 4144605 |
| Pinon Canyon Maneuver Site | CO | 2007 | wnd02 | 13S | 588822 | 4139117 |
| Pinon Canyon Maneuver Site | CO | 2007 | xrnch01n | 13S | 597991 | 4154209 |
| Pinon Canyon Maneuver Site | CO | 2007 | xrnch06 | 13S | 598187 | 4153467 |
| Pinon Canyon Maneuver Site | CO | 2007 | xrnch07 | 13S | 597984 | 4153803 |
| Pinon Canyon Maneuver Site | CO | 2007 | xrnch07a | 13S | 598043 | 4153671 |
| Pueblo Chemical Depot | CO | 2006 | dog01 | 13S | 562796 | 4238801 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Pueblo Chemical Depot | CO | 2006 | dog02 | 13S | 560892 | 4241124 |
| Pueblo Chemical Depot | CO | 2006 | dog03 | 13S | 558945 | 4238243 |
| Pueblo Chemical Depot | CO | 2006 | dog05 | 13S | 559776 | 4236728 |
| Pueblo Chemical Depot | CO | 2006 | dog06 | 13S | 562771 | 4239926 |
| Pueblo Chemical Depot | CO | 2006 | dog07 | 13S | 562384 | 4239485 |
| Pueblo Chemical Depot | CO | 2006 | dog08 | 13S | 562756 | 4237879 |
| Pueblo Chemical Depot | CO | 2006 | lynr01 | 13S | 561443 | 4239362 |
| Pueblo Chemical Depot | CO | 2006 | muga01 | 13S | 558412 | 4243842 |
| Pueblo Chemical Depot | CO | 2006 | muga02 | 13S | 557993 | 4243885 |
| Pueblo Chemical Depot | CO | 2006 | muga03 | 13S | 557334 | 4243893 |
| Pueblo Chemical Depot | CO | 2006 | muga04 | 13S | 557343 | 4243921 |
| Pueblo Chemical Depot | CO | 2006 | muga05 | 13S | 557206 | 4243730 |
| Pueblo Chemical Depot | CO | 2006 | muga06 | 13S | 557213 | 4243054 |
| Pueblo Chemical Depot | CO | 2006 | psb01 | 13S | 557985 | 4238625 |
| Pueblo Chemical Depot | CO | 2006 | psb02 | 13S | 558316 | 4238588 |
| Pueblo Chemical Depot | CO | 2006 | psb03 | 13S | 559120 | 4238995 |
| Pueblo Chemical Depot | CO | 2006 | pueb03 | 13S | 556861 | 4241750 |
| Pueblo Chemical Depot | CO | 2006 | pueb07 | 13S | 556886 | 4241286 |
| Pueblo Chemical Depot | CO | 2006 | swh01 | 13S | 558688 | 4236500 |
| Pueblo Chemical Depot | CO | 2006 | swh02 | 13S | 559260 | 4236364 |
| Pueblo Chemical Depot | CO | 2007 | north01 | 13S | 557282 | 4243850 |
| Pueblo Chemical Depot | CO | 2007 | north02a | 13S | 558962 | 4243650 |
| Pueblo Chemical Depot | CO | 2007 | psb04 | 13S | 556988 | 4239600 |
| Pueblo Chemical Depot | CO | 2007 | psb05 | 13S | 558598 | 4238691 |
| Pueblo Chemical Depot | CO | 2007 | psb06 | 13S | 558951 | 4238883 |
| Pueblo Chemical Depot | CO | 2007 | psb07 | 13S | 558751 | 4238913 |
| Pueblo Chemical Depot | CO | 2007 | pueb08 | 13S | 556353 | 4241484 |
| Pueblo Chemical Depot | CO | 2007 | sw01a | 13S | 556931 | 4237491 |
| Pueblo Chemical Depot | CO | 2007 | sw02 | 13S | 557296 | 4237250 |
| Pueblo Chemical Depot | CO | 2007 | sw03 | 13S | 557202 | 4238025 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c01 | 13S | 511524 | 4409338 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c02 | 13S | 511419 | 4410809 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c03 | 13S | 511572 | 4491726 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c04 | 13S | 511616 | 4411636 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c07a | 13S | 513109 | 4412821 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c07a | 13S | 513135 | 4412733 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c08 | 13S | 512597 | 4412888 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c09a | 13S | 511649 | 4411494 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c10 | 13S | 513300 | 4412579 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c11 | 13S | 517872 | 4409181 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c16 | 13S | 516423 | 4411782 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c18 | 13S | 511503 | 4412400 |
| Rocky Mountain Arsenal NWR | CO | 2007 | c19 | 13S | 511248 | 4411669 |
| Schriever AFB | CO | 2006 | offs02 | 13S | 543652 | 4293160 |
| Schriever AFB | CO | 2006 | offs03 | 13S | 539647 | 4294115 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Schriever AFB | CO | 2006 | sch01 | 13S | 539946 | 4294293 |
| Schriever AFB | CO | 2006 | sch04 | 13S | 540300 | 4293362 |
| Schriever AFB | CO | 2006 | sch05 | 13S | 543599 | 4293990 |
| Schriever AFB | CO | 2006 | sch06 | 13S | 543503 | 4293925 |
| Hwy 26/Blackfoot | ID | 2007 | bf01 | 12T | 375727 | 4794447 |
| Hwy 26/Blackfoot | ID | 2007 | bf03 | 12T | 378236 | 4792322 |
| Hwy 26/Blackfoot | ID | 2007 | bf04 | 12T | 371843 | 4797580 |
| Hwy 26/Blackfoot | ID | 2007 | bf05 | 12T | 371766 | 4797632 |
| Hwy 26/Blackfoot | ID | 2007 | bf06 | 12T | 371783 | 4797560 |
| Hwy 26/Blackfoot | ID | 2007 | bf08 | 12T | 364404 | 4786305 |
| Hwy 26/Blackfoot | ID | 2007 | bf09 | 12T | 364259 | 4784431 |
| Hwy 26/Blackfoot | ID | 2007 | bf12 | 12T | 366656 | 4786658 |
| Hwy 26/Blackfoot | ID | 2007 | bf13 | 12T | 366625 | 4786182 |
| Hwy 26/Blackfoot | ID | 2008 | bf16 | 12T | 367768 | 4794096 |
| Hwy 26/Blackfoot | ID | 2008 | bf17 | 12T | 367308 | 4794417 |
| Hwy 26/Blackfoot | ID | 2008 | bf18 | 12T | 377149 | 4788409 |
| Hwy 26/Blackfoot | ID | 2008 | bf19 | 12T | 369321 | 4793024 |
| Crooked Creek Ranch | ID | 2007 | cc01 | 12T | 366340 | 4896943 |
| Crooked Creek Ranch | ID | 2007 | cc02 | 12T | 368265 | 4895042 |
| Elmore | ID | 2008 | elm01 | 11T | 607505 | 4781168 |
| Elmore | ID | 2008 | elm02 | 11T | 607385 | 4781250 |
| Elmore | ID | 2008 | elm04 | 11T | 607935 | 4779955 |
| Mountain Home AFB | ID | 2007 | ab01 | 11T | 593142 | 4769780 |
| Mountain Home AFB | ID | 2007 | air01 | 11T | 591104 | 4767633 |
| Mountain Home AFB | ID | 2007 | air02 | 11T | 590759 | 4767273 |
| Mountain Home AFB | ID | 2007 | air03 | 11T | 591103 | 4767097 |
| Mountain Home AFB | ID | 2007 | air04a | 11T | 591277 | 4766957 |
| Mountain Home AFB | ID | 2007 | air05a | 11T | 591312 | 4766939 |
| Mountain Home AFB | ID | 2007 | air06 | 11T | 591464 | 4766746 |
| Mountain Home AFB | ID | 2007 | air06a | 11T | 591464 | 4766746 |
| Mountain Home AFB | ID | 2007 | air09 | 11T | 591744 | 4766520 |
| Mountain Home AFB | ID | 2007 | air09b | 11T | 591759 | 4766487 |
| Mountain Home AFB | ID | 2007 | air10 | 11T | 591945 | 4766254 |
| Mountain Home AFB | ID | 2007 | air11 | 11T | 592120 | 4766165 |
| Mountain Home AFB | ID | 2007 | air12 | 11T | 592155 | 4766130 |
| Mountain Home AFB | ID | 2007 | air14 | 11T | 592401 | 4765881 |
| Mountain Home AFB | ID | 2007 | air16 | 11T | 592652 | 4765635 |
| Mountain Home AFB | ID | 2007 | air19 | 11T | 593380 | 4764929 |
| Mountain Home AFB | ID | 2007 | air22 | 11T | 590298 | 4767575 |
| Mountain Home AFB | ID | 2007 | air23 | 11T | 590539 | 4767268 |
| Mountain Home AFB | ID | 2007 | gate02 | 11T | 590138 | 4768571 |
| Mountain Home AFB | ID | 2007 | golf01 | 11T | 594518 | 4766080 |
| Mountain Home AFB | ID | 2007 | golf03 | 11T | 594510 | 4766213 |
| Mountain Home AFB | ID | 2007 | golf04 | 11T | 594451 | 4766426 |
| Mountain Home AFB | ID | 2007 | golf04 | 11T | 594457 | 4766246 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Mountain Home AFB | ID | 2007 | golf04 | 11T | 594457 | 4766426 |
| Mountain Home AFB | ID | 2007 | golf04a | 11T | 594451 | 4766426 |
| Mountain Home AFB | ID | 2007 | golf05 | 11T | 594358 | 4766005 |
| Mountain Home AFB | ID | 2007 | golf05b | 11T | 594346 | 4765947 |
| Mountain Home AFB | ID | 2007 | gv01 | 11T | 584937 | 4767802 |
| Mountain Home AFB | ID | 2007 | gv02 | 11T | 585472 | 4768059 |
| Mountain Home AFB | ID | 2007 | heat01 | 11T | 591731 | 4767508 |
| Mountain Home AFB | ID | 2007 | mw01a | 11T | 591521 | 4767795 |
| Mountain Home AFB | ID | 2007 | mw02 | 11T | 591379 | 4767840 |
| Mountain Home AFB | ID | 2007 | mw02a | 11T | 591379 | 4767840 |
| Mountain Home AFB | ID | 2007 | mw02a | 11T | 591384 | 4767843 |
| Mountain Home AFB | ID | 2007 | mw03 | 11T | 591132 | 4767838 |
| Mountain Home AFB | ID | 2007 | stbl01 | 11T | 593635 | 4766153 |
| Mountain Home AFB | ID | 2007 | stbl03 | 11T | 593420 | 4765966 |
| Mountain Home AFB | ID | 2007 | stbl04 | 11T | 594188 | 4765771 |
| Mountain Home AFB | ID | 2007 | stbl05 | 11T | 593610 | 4765969 |
| Mountain Home AFB | ID | 2007 | stbl07 | 11T | 594129 | 4765797 |
| Mountain Home AFB | ID | 2007 | tower01 | 11T | 590840 | 4766105 |
| Mountain Home AFB | ID | 2007 | tower01a | 11T | 590838 | 4766103 |
| Mountain Home AFB | ID | 2007 | ww01 | 11T | 590117 | 4767032 |
| Mountain Home AFB | ID | 2007 | ww02 | 11T | 590068 | 4766413 |
| Mountain Home AFB | ID | 2007 | ww03 | 11T | 590111 | 4766874 |
| Mountain Home AFB | ID | 2008 | air08a | 11T | 591620 | 4766639 |
| Mountain Home AFB | ID | 2008 | air32 | 11T | 591182 | 4767049 |
| Mountain Home AFB | ID | 2008 | air38 | 11T | 591491 | 4767471 |
| Mountain Home AFB | ID | 2008 | drmo01 | 11T | 592179 | 4767639 |
| Mountain Home AFB | ID | 2008 | golf03 | 11T | 594510 | 4766213 |
| Mountain Home AFB | ID | 2008 | golf03 | 11T | 654510 | 4766213 |
| Mountain Home AFB | ID | 2008 | golf07 | 11T | 594547 | 4766680 |
| Mountain Home AFB | ID | 2008 | land01 | 11T | 590609 | 4764951 |
| Mountain Home AFB | ID | 2008 | land02 | 11T | 590609 | 4964207 |
| Mountain Home AFB | ID | 2008 | land02 | 11T | 590609 | 4964207 |
| Mountain Home AFB | ID | 2008 | mw01a | 11T | 591521 | 4767795 |
| Mountain Home AFB | ID | 2008 | mw05a | 11T | 591470 | 4767714 |
| Mountain Home AFB | ID | 2008 | pol01 | 11T | 591722 | 4767155 |
| Mountain Home AFB | ID | 2008 | stable04 | 11T | 594199 | 4759767 |
| Mountain Home AFB | ID | 2008 | stbl08 | 11T | 593600 | 4765926 |
| Mountain Home AFB | ID | 2008 | ww05 | 11T | 590111 | 4766836 |
| Power | ID | 2008 | p01 | 12T | 328177 | 4745998 |
| Power | ID | 2008 | p02 | 12T | 328027 | 4746060 |
| Power | ID | 2008 | p02a | 12T | 328072 | 4746188 |
| Power | ID | 2008 | p03 | 12T | 328025 | 4752409 |
| Power | ID | 2008 | p04 | 12T | 327625 | 4753998 |
| White Sands Missile Range | NM | 2005 | omnd1 | 13S | 380662 | 3698241 |
| White Sands Missile Range | NM | 2006 | deadhorsemound | 13S | 380670 | 3698260 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| White Sands Missile Range | NM | 2006 | nike2 | 13S | 377267 | 3585379 |
| White Sands Missile Range | NM | 2006 | nike2 | 13S | 377267 | 3855379 |
| White Sands Missile Range | NM | 2006 | nike5a | 13S | 382299 | 3535823 |
| White Sands Missile Range | NM | 2006 | nike5a | 13S | 382299 | 3585823 |
| White Sands Missile Range | NM | 2006 | nike5b | 13S | 32282 | 3585694 |
| White Sands Missile Range | NM | 2006 | nike5b | 13S | 382282 | 3585694 |
| White Sands Missile Range | NM | 2006 | rr8/9 | 13S | 381262 | 3701379 |
| White Sands Missile Range | NM | 2007 | nike01 | 13S | 328653 | 3585363 |
| White Sands Missile Range | NM | 2007 | nike03 | 13S | 378573 | 3585527 |
| White Sands Missile Range | NM | 2007 | nike04 | 13S | 382275 | 3585714 |
| White Sands Missile Range | NM | 2007 | nike05 | 13S | 382233 | 3585465 |
| White Sands Missile Range | NM | 2007 | nike06 | 13S | 378497 | 3585588 |
| White Sands Missile Range | NM | 2007 | nike08 | 13S | 381076 | 3585534 |
| White Sands Missile Range | NM | 2007 | nike08 | 13S | 381106 | 3585534 |
| White Sands Missile Range | NM | 2007 | nike09 | 13S | 382316 | 3585800 |
| White Sands Missile Range | NM | 2008 | nike01 | 13S | 328653 | 3585363 |
| White Sands Missile Range | NM | 2008 | nike05 | 13S | 382233 | 3585465 |
| White Sands Missile Range | NM | 2008 | nike06 | 13S | 378497 | 3585588 |
| White Sands Missile Range | NM | 2008 | nike08 | 13S | 381076 | 3585534 |
| Nellis AFB | NV | 2006 | glfatnafb01 | 11S | 675365 | 4008729 |
| Nellis AFB | NV | 2006 | glfatnafb02 | 11S | 675315 | 4008401 |
| Nellis AFB | NV | 2006 | glfatnafb04 | 11S | 675348 | 4008308 |
| Nellis AFB | NV | 2006 | glfatnafb05 | 11S | 675639 | 4008183 |
| Nellis AFB | NV | 2006 | glfatnafb06 | 11S | 675728 | 4008173 |
| Nellis AFB | NV | 2006 | glfatnafb09 | 11S | 675842 | 4009817 |
| Nellis AFB | NV | 2006 | glfatnafb09 | 11S | 675842 | 5009817 |
| Nellis AFB | NV | 2006 | glfatnafb10 | 11S | 675591 | 4009768 |
| Nellis AFB | NV | 2006 | glfatnafb11 | 11S | 675464 | 4009664 |
| Nellis AFB | NV | 2006 | glfatnafb13 | 11S | 675336 | 4009627 |
| Nellis AFB | NV | 2006 | glfatnafb14 | 11S | 675148 | 4009697 |
| Nellis AFB | NV | 2006 | glfatnafb14 | 11S | 675239 | 4009682 |
| Nellis AFB | NV | 2006 | glfatnafb17 | 11S | 674853 | 4009868 |
| Nellis AFB | NV | 2006 | glfatnafb18 | 11S | 674706 | 4009859 |
| Nellis AFB | NV | 2006 | glfatnafb19 | 11S | 674357 | 4009998 |
| Nellis AFB | NV | 2006 | glfatnafb19 | 11S | 674359 | 4010033 |
| Nellis AFB | NV | 2006 | glfatnafb20 | 11S | 674351 | 4009995 |
| Nellis AFB | NV | 2006 | glfatnafb21 | 11S | 674349 | 4010347 |
| Nellis AFB | NV | 2006 | glfatnafb24 | 11S | 675313 | 4008775 |
| Nellis AFB | NV | 2006 | glfatnafb25 | 11S | 675251 | 4008924 |
| Nellis AFB | NV | 2006 | glfatnafb25 | 11S | 675251 | 4008942 |
| Nellis AFB | NV | 2006 | glfatnafb26 | 11S | 675832 | 4008871 |
| Nellis AFB | NV | 2006 | glfatnafb27 | 11S | 674541 | 4009870 |
| Nellis AFB | NV | 2006 | glfatnafb28 | 11S | 674362 | 4010273 |
| Nellis AFB | NV | 2006 | glfatnafb29 | 11S | 674346 | 4010487 |
| Nellis AFB | NV | 2006 | hol01 | 11S | 677965 | 4011311 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Nellis AFB | NV | 2006 | neap01 | 11S | 677464 | 4013585 |
| Nellis AFB | NV | 2007 | dog01 | 11S | 675681 | 4008163 |
| Nellis AFB | NV | 2007 | drng03 | 11S | 675324 | 4008436 |
| Nellis AFB | NV | 2007 | drngel | 11S | 675306 | 4008517 |
| Nellis AFB | NV | 2007 | glfatnafb01 | 11S | 675305 | 4008729 |
| Nellis AFB | NV | 2007 | glfatnafb04 | 11S | 675348 | 4008308 |
| Nellis AFB | NV | 2007 | glfatnafb06 | 11S | 674362 | 4010350 |
| Nellis AFB | NV | 2007 | glfatnafb08 | 11S | 675832 | 4009788 |
| Nellis AFB | NV | 2007 | glfatnafb19 | 11S | 674357 | 4009998 |
| Nellis AFB | NV | 2007 | glfatnafb21 | 11S | 674349 | 4010347 |
| Nellis AFB | NV | 2007 | glfatnafb25 | 11S | 675251 | 4008924 |
| Nellis AFB | NV | 2007 | glfatnafb27 | 11S | 674541 | 4009870 |
| Nellis AFB | NV | 2007 | glfatnafb28 | 11S | 674362 | 4010273 |
| Nellis AFB | NV | 2007 | glfatnafb29 | 11S | 674346 | 4010487 |
| Nellis AFB | NV | 2007 | newglf03 | 11S | 674369 | 4009614 |
| Nellis AFB | NV | 2007 | newglf05 | 11S | 674467 | 4009879 |
| Nellis AFB | NV | 2007 | newglf05 | 11S | 674563 | 4009847 |
| Nellis AFB | NV | 2007 | ng07 | 11S | 677539 | 4011484 |
| Nellis AFB | NV | 2007 | ng09 | 11S | 675239 | 4009726 |
| Nellis AFB | NV | 2007 | ng10 | 11S | 675340 | 4009614 |
| Nellis AFB | NV | 2007 | ng12 | 11S | 675576 | 4009767 |
| Nevada Test Site | NV | 2005 | airportrd#1 | 11S | 560708 | 4105734 |
| Nevada Test Site | NV | 2005 | orrdpada | 11S | 577622 | 4110888 |
| Nevada Test Site | NV | 2005 | u2-gga | 11S | 582580 | 4111032 |
| Nevada Test Site | NV | 2006 | 030ditch | 11S | 578979 | 4099657 |
| Nevada Test Site | NV | 2006 | 030wash | 11S | 579216 | 4099700 |
| Nevada Test Site | NV | 2006 | 18-03rd#2b | 11S | 562290 | 4109224 |
| Nevada Test Site | NV | 2006 | 2l18pada | 11S | 582700 | 4113100 |
| Nevada Test Site | NV | 2006 | 8dpada | 11S | 580594 | 4114509 |
| Nevada Test Site | NV | 2006 | airportrd#1b | 11S | 560710 | 4105753 |
| Nevada Test Site | NV | 2006 | airportrd#2 | 11S | 561350 | 4108330 |
| Nevada Test Site | NV | 2006 | bmrd | 11S | 553484 | 4111617 |
| Nevada Test Site | NV | 2006 | m27 | 11S | 590020 | 4067731 |
| Nevada Test Site | NV | 2006 | orpad | 11S | 577844 | 4110951 |
| Nevada Test Site | NV | 2006 | or-pad | 11S | 577844 | 4110951 |
| Nevada Test Site | NV | 2006 | u2gg | 11S | 582583 | 4111030 |
| Nevada Test Site | NV | 2007 | 18-03rd#1 | 11S | 561234 | 4109463 |
| Nevada Test Site | NV | 2007 | 18-03rd#3 | 11S | 560075 | 4109387 |
| Nevada Test Site | NV | 2007 | airportrd#2 | 11S | 561350 | 4108330 |
| Nevada Test Site | NV | 2007 | u20bb | 11S | 544673 | 4122030 |
| Nevada Test Site | NV | 2008 | 8dpada | 11S | 580594 | 4114509 |
| Nevada Test Site | NV | 2008 | airportrd#2 | 11S | 561350 | 4108330 |
| Nevada Test Site | NV | 2008 | bmrd | 11S | 553484 | 4111617 |
| Nevada Test Site | NV | 2008 | c56 | 11S | 585700 | 4078350 |
| Nevada Test Site | NV | 2008 | c56a | 11S | 585700 | 4078350 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Nevada Test Site | NV | 2008 | m27 | 11S | 590020 | 4067731 |
| Nevada Test Site | NV | 2008 | u20bb | 11S | 544673 | 4122030 |
| Boardman Bombing Range | OR | 2006 | bb08 | 11T | 291125 | 5071911 |
| Boardman Bombing Range | OR | 2006 | bb10 | 11T | 290919 | 5071742 |
| Antelope Island | UT | 2008 | ain03 | 12T | 395169 | 4543295 |
| Antelope Island | UT | 2008 | ain121 | 12T | 404510 | 4549274 |
| Antelope Island | UT | 2008 | ain65 | 12T | 399462 | 4541433 |
| Deseret Chemical Depot | UT | 2008 | dcd01 | 12T | 388560 | 4461173 |
| Deseret Chemical Depot | UT | 2008 | dcd01 | 12T | 388560 | 4461173 |
| Deseret Chemical Depot | UT | 2008 | dcd02 | 12T | 387144 | 4460830 |
| Dugway Proving Ground | UT | 2007 | dvg04 | 12T | 306942 | 4437243 |
| Dugway Proving Ground | UT | 2008 | dpg02 | 12T | 328001 | 4464116 |
| Dugway Proving Ground | UT | 2008 | dpg03 | 12T | 334991 | 4442163 |
| Dugway Proving Ground | UT | 2008 | dpg04 | 12T | 306271 | 4437130 |
| Dugway Proving Ground | UT | 2008 | dpg05 | 12T | 306943 | 4437598 |
| Dugway Proving Ground | UT | 2008 | dpg06 | 12T | 327821 | 4444395 |
| Dugway Proving Ground | UT | 2008 | dpg06 | 12T | 339317 | 4434729 |
| Dugway Proving Ground | UT | 2008 | dpg07 | 12T | 339317 | 4434729 |
| Dugway Proving Ground | UT | 2008 | dpg08 | 12T | 339609 | 4434723 |
| Dugway Proving Ground | UT | 2008 | dpg09 | 12T | 329197 | 4447638 |
| Dugway Proving Ground | UT | 2008 | dpg10 | 12T | 322729 | 4444949 |
| Dugway Proving Ground | UT | 2008 | dpg12 | 12T | 306786 | 4437695 |
| Dugway Proving Ground | UT | 2008 | dpg13 | 12T | 306779 | 4437698 |
| Hill AFB | UT | 2007 | hill01 | 12T | 340017 | 4552418 |
| Kennecott Mining Co | UT | 2007 | kn03 | 12T | 467770 | 4518166 |
| Stark Road | UT | 2008 | sr01 | 12T | 387274 | 4468018 |
| Stark Road | UT | 2008 | sr01 | 12T | 387274 | 4468018 |
| St. George | UT | 2007 | NONEST | 12S | 275873 | 4107456 |
| St. George | UT | 2007 | st02 | 12S | 276136 | 4107372 |
| St. George | UT | 2007 | st03 | 12S | 276072 | 4107440 |
| St. George | UT | 2007 | st03 | 12S | 276136 | 4107354 |
| St. George | UT | 2007 | st04 | 12S | 276072 | 4107440 |
| St. George | UT | 2007 | st05 | 12S | 276078 | 4107435 |
| St. George | UT | 2007 | st06 | 12S | 276091 | 4107390 |
| St. George | UT | 2007 | st06 | 12S | 276091 | 4187390 |
| St. George | UT | 2007 | st08 | 12S | 276006 | 4107367 |
| St. George | UT | 2007 | st11 | 12S | 276070 | 4107588 |
| St. George | UT | 2007 | stc | 12S | 276191 | 4107471 |
| Vernon | UT | 2008 | tc03 | 12T | 388147 | 4450595 |
| Vernon | UT | 2008 | tc04 | 12T | 388340 | 4450101 |
| Vernon | UT | 2008 | tc05 | 12T | 387912 | 4449544 |
| Vernon | UT | 2008 | tc06 | 12T | 388158 | 4448252 |
| Vernon | UT | 2008 | tc08 | 12T | 385032 | 4441673 |
| Vernon | UT | 2008 | tc09 | 12T | 396725 | 4444750 |
| Vernon | UT | 2008 | tc11 | 12T | 373255 | 4438300 |

| | | | | NAD 27 CONUS | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Sheridian Training Area | WY | 2007 | sh02 | 13T | 337456 | 4967328 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Fort Bliss AFB | NM | 2006 | 1 | 13 S | 428667 | 3588271 |
| Fort Bliss AFB | NM | 2006 | 1 | 13 S | 428667 | 3588271 |
| Holloman AFB | NM | 2006 | 4 | 13 S | 392112 | 3462531 |
| Holloman AFB | NM | 2006 | 4 | 13 S | 392112 | 3462531 |
| Holloman AFB | NM | 2006 | 4 | 13 S | 392112 | 3462531 |
| Holloman AFB | NM | 2006 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2006 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2006 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2006 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2006 | 7 (1A) | 13 S | 392098 | 3642876 |
| Kirtland AFB | NM | 2005 | 3 | 13 S | 358085 | 3879040 |
| Kirtland AFB | NM | 2005 | 4 | 13 S | 358165 | 3879048 |
| Kirtland AFB | NM | 2005 | 27 | 13 S | 357258 | 3879278 |
| Kirtland AFB | NM | 2005 | 38 | 13 S | 358324 | 3878871 |
| Kirtland AFB | NM | 2005 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2005 | 69 | 13 S | 357792 | 3878606 |
| Kirtland AFB | NM | 2005 | 73 | 13 S | 357874 | 3878686 |
| Kirtland AFB | NM | 2005 | 87 | 13 S | 357756 | 3878666 |
| Kirtland AFB | NM | 2005 | 88 | 13 S | 357747 | 3878566 |
| Kirtland AFB | NM | 2005 | 94 | 13 S | 358117 | 3879094 |
| Kirtland AFB | NM | 2005 | 95 | 13 S | 357801 | 3878784 |
| Kirtland AFB | NM | 2005 | 96 | 13 S | 358543 | 3877765 |
| Kirtland AFB | NM | 2005 | 97 | 13 S | 358607 | 3877813 |
| Kirtland AFB | NM | 2005 | 98 | 13 S | 358366 | 3878611 |
| Kirtland AFB | NM | 2005 | 99 | 13 S | 359204 | 3881261 |
| Kirtland AFB | NM | 2005 | 100 | 13 S | 359040 | 3881298 |
| Kirtland AFB | NM | 2005 | 101 | 13 S | 356904 | 3878820 |
| Kirtland AFB | NM | 2005 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2005 | 103 | 13 S | 356973 | 3879107 |
| Kirtland AFB | NM | 2005 | 104 | 13 S | 354432 | 3879771 |
| Kirtland AFB | NM | 2005 | 106 | 13 S | 356949 | 3879257 |
| Kirtland AFB | NM | 2005 | 107 | 13 S | 358261 | 3879186 |
| Kirtland AFB | NM | 2005 | 108 | 13 S | 361154 | 3877451 |
| Kirtland AFB | NM | 2005 | 109 | 13 S | 358558 | 3877810 |
| Kirtland AFB | NM | 2005 | 111 | 13 S | 360187 | 3875782 |
| Kirtland AFB | NM | 2005 | 112 | 13 S | 358847 | 3881315 |
| Kirtland AFB | NM | 2005 | 114 | 13 S | 361171 | 3877365 |
| Kirtland AFB | NM | 2005 | 115 | 13 S | 357723 | 3879070 |
| Kirtland AFB | NM | 2005 | 116 | 13 S | 356095 | 3879535 |
| Kirtland AFB | NM | 2005 | 117 | 13 S | 356845 | 3878682 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Kirtland AFB | NM | 2005 | 106B | 13 S | 354807 | 3880274 |
| Kirtland AFB | NM | 2006 | 48 | 13 S | 358194 | 3879044 |
| Kirtland AFB | NM | 2006 | 48 | 13 S | 358194 | 3879044 |
| Kirtland AFB | NM | 2006 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2006 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2006 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2006 | 73 | 13 S | 357874 | 3878686 |
| Kirtland AFB | NM | 2006 | 95 | 13 S | 357801 | 3878784 |
| Kirtland AFB | NM | 2006 | 95 | 13 S | 357801 | 3878784 |
| Kirtland AFB | NM | 2006 | 96 | 13 S | 358543 | 3877765 |
| Kirtland AFB | NM | 2006 | 100 | 13 S | 359040 | 3881298 |
| Kirtland AFB | NM | 2006 | 100 | 13 S | 359040 | 3881298 |
| Kirtland AFB | NM | 2006 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2006 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2006 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2006 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2006 | 102 | 13 S | 356858 | 3878789 |
| Kirtland AFB | NM | 2006 | 103 | 13 S | 356987 | 3879148 |
| Kirtland AFB | NM | 2006 | 103 | 13 S | 356987 | 3879148 |
| Kirtland AFB | NM | 2006 | 103 | 13 S | 356987 | 3879148 |
| Kirtland AFB | NM | 2006 | 104 | 13 S | 354432 | 3879771 |
| Kirtland AFB | NM | 2006 | 104 | 13 S | 354432 | 3879771 |
| Kirtland AFB | NM | 2006 | 104 | 13 S | 354432 | 3879771 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2006 | 121 | 13 S | 361505 | 3877210 |
| Kirtland AFB | NM | 2006 | 121 | 13 S | 361505 | 3877210 |
| Kirtland AFB | NM | 2006 | 121 | 13 S | 361505 | 3877210 |
| Kirtland AFB | NM | 2006 | 121 | 13 S | 361505 | 3877210 |
| Kirtland AFB | NM | 2006 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2006 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2006 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 125 | 13 S | 358199 | 3878878 |
| Kirtland AFB | NM | 2006 | 128 | 13 S | 358021 | 3879106 |
| Kirtland AFB | NM | 2006 | 128 | 13 S | 358021 | 3879106 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Kirtland AFB | NM | 2006 | 130 | 13 S | 357825 | 3879242 |
| Kirtland AFB | NM | 2006 | 130 | 13 S | 357825 | 3879242 |
| Kirtland AFB | NM | 2006 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2006 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2006 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2006 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2006 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 134 | 13 S | 359810 | 3880123 |
| Kirtland AFB | NM | 2006 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2006 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2006 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2006 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2006 | 136 | 13 S | 357865 | 3879083 |
| Kirtland AFB | NM | 2006 | 136 | 13 S | 357865 | 3879083 |
| Kirtland AFB | NM | 2006 | 136 | 13 S | 357865 | 3879083 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 137 | 13 S | 359359 | 3881329 |
| Kirtland AFB | NM | 2006 | 141 | 13 S | 358630 | 3878730 |
| Kirtland AFB | NM | 2006 | 141 | 13 S | 358630 | 3878730 |
| Kirtland AFB | NM | 2006 | 144 | 13 S | 358387 | 3878900 |
| Kirtland AFB | NM | 2006 | 152 | 13 S | 361783 | 3877581 |
| Kirtland AFB | NM | 2006 | 152 | 13 S | 361783 | 3877581 |
| Kirtland AFB | NM | 2006 | 152 | 13 S | 361783 | 3877581 |
| Kirtland AFB | NM | 2006 | 152 | 13 S | 361783 | 3877581 |
| Kirtland AFB | NM | 2006 | 152 | 13 S | 361783 | 3877581 |
| Kirtland AFB | NM | 2007 | 4 | 13 S | 358165 | 3879048 |
| Kirtland AFB | NM | 2007 | 4 | 13 S | 358165 | 3879048 |
| Kirtland AFB | NM | 2007 | 4 | 13 S | 358165 | 3879048 |
| Kirtland AFB | NM | 2007 | 4 | 13 S | 358165 | 3879048 |
| Kirtland AFB | NM | 2007 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2007 | 106 | 13 S | 356949 | 3879257 |
| Kirtland AFB | NM | 2007 | 117 | 13 S | 356845 | 3878682 |
| Kirtland AFB | NM | 2007 | 120 | 13 S | 361241 | 3877120 |
| Kirtland AFB | NM | 2007 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2007 | 122 | 13 S | 359879 | 3881313 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Kirtland AFB | NM | 2007 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2007 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2007 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2007 | 124 | 13 S | 358584 | 3878117 |
| Kirtland AFB | NM | 2007 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2007 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2007 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2007 | 135 | 13 S | 356042 | 3879658 |
| Kirtland AFB | NM | 2007 | 147 | 13 S | 361868 | 3877166 |
| Kirtland AFB | NM | 2007 | 151 | 13 S | 361641 | 3874700 |
| Kirtland AFB | NM | 2007 | 151 | 13 S | 361641 | 3874700 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 154 | 13 S | 358537 | 3877841 |
| Kirtland AFB | NM | 2007 | 155 | 13 S | 358509 | 3877707 |
| Kirtland AFB | NM | 2007 | 156 | 13 S | 358208 | 3878521 |
| Kirtland AFB | NM | 2007 | 156 | 13 S | 358208 | 3878521 |
| Kirtland AFB | NM | 2007 | 156 | 13 S | 358208 | 3878521 |
| Kirtland AFB | NM | 2007 | 156 | 13 S | 358208 | 3878521 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2007 | 160 | 13 S | 357938 | 3879226 |
| Kirtland AFB | NM | 2007 | 160 | 13 S | 357938 | 3879226 |
| Kirtland AFB | NM | 2007 | 160 | 13 S | 357938 | 3879226 |
| Kirtland AFB | NM | 2007 | 160 | 13 S | 357938 | 3879226 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 161 | 13 S | 359919 | 9879949 |
| Kirtland AFB | NM | 2007 | 162 | 13 S | 361648 | 3874829 |
| Kirtland AFB | NM | 2007 | 162 | 13 S | 361648 | 3874829 |
| Kirtland AFB | NM | 2007 | 162 | 13 S | 361648 | 3874829 |
| Kirtland AFB | NM | 2007 | 162 | 13 S | 361648 | 3874829 |
| Kirtland AFB | NM | 2007 | 163 | 13 S | 360566 | 3875931 |
| Kirtland AFB | NM | 2007 | 163 | 13 S | 360566 | 3875931 |
| Kirtland AFB | NM | 2007 | 163 | 13 S | 360566 | 3875931 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Kirtland AFB | NM | 2007 | 163 | 13 S | 360566 | 3875931 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2007 | 165 | 13 S | 361575 | 3874860 |
| Kirtland AFB | NM | 2007 | 166 | 13 S | 361587 | 3874918 |
| Kirtland AFB | NM | 2007 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2007 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2007 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2007 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2007 | 168 | 13 S | 361421 | 3874566 |
| Kirtland AFB | NM | 2007 | 168 | 13 S | 361421 | 3874566 |
| Kirtland AFB | NM | 2007 | 168 | 13 S | 361421 | 3874566 |
| Kirtland AFB | NM | 2007 | 168 | 13 S | 361421 | 3874566 |
| Kirtland AFB | NM | 2007 | 168 | 13 S | 361421 | 3874566 |
| Kirtland AFB | NM | 2008 | 68 | 13 S | 358091 | 3879132 |
| Kirtland AFB | NM | 2008 | 73 | 13 S | 357874 | 3878686 |
| Kirtland AFB | NM | 2008 | 73 | 13 S | 357874 | 3878686 |
| Kirtland AFB | NM | 2008 | 114 | 13 S | 361171 | 3877365 |
| Kirtland AFB | NM | 2008 | 114 | 13 S | 361171 | 3877365 |
| Kirtland AFB | NM | 2008 | 114 | 13 S | 361171 | 3877365 |
| Kirtland AFB | NM | 2008 | 114 | 13 S | 361171 | 3877365 |
| Kirtland AFB | NM | 2008 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2008 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2008 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2008 | 122 | 13 S | 359879 | 3881313 |
| Kirtland AFB | NM | 2008 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2008 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2008 | 131 | 13 S | 356334 | 3879655 |
| Kirtland AFB | NM | 2008 | 132 | 13 S | 358391 | 3877815 |
| Kirtland AFB | NM | 2008 | 132 | 13 S | 358391 | 3877815 |
| Kirtland AFB | NM | 2008 | 158 | 13 S | 358583 | 3878660 |
| Kirtland AFB | NM | 2008 | 161 | 13 S | 359919 | 3879949 |
| Kirtland AFB | NM | 2008 | 161 | 13 S | 359919 | 3879949 |
| Kirtland AFB | NM | 2008 | 162 | 13 S | 361648 | 3874829 |
| Kirtland AFB | NM | 2008 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2008 | 164 | 13 S | 361340 | 3874471 |
| Kirtland AFB | NM | 2008 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2008 | 167 | 13 S | 361545 | 3874939 |
| Kirtland AFB | NM | 2008 | 170 | 13 S | 359917 | 3881249 |
| Kirtland AFB | NM | 2008 | 171 | 13 S | 359979 | 3880805 |
| Kirtland AFB | NM | 2008 | 171 | 13 S | 359979 | 3880805 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Kirtland AFB | NM | 2008 | 171 | 13 S | 359979 | 3880805 |
| Kirtland AFB | NM | 2008 | 171 | 13 S | 359979 | 3880805 |
| Kirtland AFB | NM | 2008 | 171 | 13 S | 359979 | 3880805 |
| Kirtland AFB | NM | 2008 | 172 | 13 S | 358587 | 3878903 |
| Kirtland AFB | NM | 2008 | 173 | 13 S | 357128 | 3879033 |
| Kirtland AFB | NM | 2008 | 173 | 13 S | 357128 | 3879033 |
| Kirtland AFB | NM | 2008 | 173 | 13 S | 357128 | 3879033 |
| Kirtland AFB | NM | 2008 | 176 | 13 S | 358449 | 3877814 |
| Kirtland AFB | NM | 2008 | 176 | 13 S | 358449 | 3877814 |
| Kirtland AFB | NM | 2008 | 176 | 13 S | 358449 | 3877814 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 178 | 13 S | 359968 | 3880403 |
| Kirtland AFB | NM | 2008 | 179 | 13 S | 361317 | 3874459 |
| Kirtland AFB | NM | 2008 | 179 | 13 S | 361317 | 3874459 |
| Kirtland AFB | NM | 2008 | 181 | 13 S | 358617 | 3878209 |
| Kirtland AFB | NM | 2008 | 181 | 13 S | 358617 | 3878209 |
| Kirtland AFB | NM | 2008 | 181 | 13 S | 358617 | 3878209 |
| Kirtland AFB | NM | 2008 | 181 | 13 S | 358617 | 3878209 |
| Kirtland AFB | NM | 2008 | 181 | 13 S | 358617 | 3878209 |
| Kirtland AFB | NM | 2008 | 182 | 13 S | 359281 | 3881308 |
| Kirtland AFB | NM | 2008 | 182 | 13 S | 359281 | 3881308 |
| Kirtland AFB | NM | 2008 | 182 | 13 S | 359281 | 3881308 |
| Kirtland AFB | NM | 2008 | 183 | 13 S | 356893 | 3878841 |
| Kirtland AFB | NM | 2008 | 183 | 13 S | 356893 | 3878841 |
| Kirtland AFB | NM | 2008 | 184 | 13 S | 358447 | 3877782 |
| Kirtland AFB | NM | 2008 | 184 | 13 S | 358447 | 3877782 |
| Kirtland AFB | NM | 2008 | 185 | 13 S | 361641 | 3874722 |
| Kirtland AFB | NM | 2008 | 185 | 13 S | 361641 | 3874722 |
| Kirtland AFB | NM | 2008 | 185 | 13 S | 361641 | 3874722 |
| Kirtland AFB | NM | 2008 | 188 | 13 S | 359929 | 3880972 |
| Kirtland AFB | NM | 2008 | 188 | 13 S | 359929 | 3880972 |
| Kirtland AFB | NM | 2008 | 191 | 13 S | 359913 | 3881056 |
| Kirtland AFB | NM | 2008 | 191 | 13 S | 359913 | 3881056 |
| Kirtland AFB | NM | 2008 | 191 | 13 S | 359913 | 3881056 |
| Kirtland AFB | NM | 2008 | 191 | 13 S | 359913 | 3881056 |
| Kirtland AFB | NM | 2008 | 192 | 13 S | 355043 | 3879778 |
| Kirtland AFB | NM | 2008 | 192 | 13 S | 355043 | 3879778 |
| Kirtland AFB | NM | 2008 | 192 | 13 S | 355043 | 3879778 |
| Kirtland AFB | NM | 2008 | 192 | 13 S | 355043 | 3879778 |
| Kirtland AFB | NM | 2008 | 192 | 13 S | 355043 | 3879778 |
| Kirtland AFB | NM | 2008 | 193 | 13 S | 354974 | 3880237 |

| | | | | NAD 27 Central | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Kirtland AFB | NM | 2008 | 195 | 13 S | 361573 | 3874757 |
| Kirtland AFB | NM | 2008 | 195 | 13 S | 361573 | 3874757 |
| Kirtland AFB | NM | 2008 | 196 | 13 S | 354059 | 3880092 |
| Kirtland AFB | NM | 2008 | 196 | 13 S | 354059 | 3880092 |
| Kirtland AFB | NM | 2008 | Gourd | 13 S | 359822 | 3877924 |
| Kirtland AFB | NM | 2008 | Gourd | 13 S | 359822 | 3877924 |

| | | | | NAD 83 | | |
|---|---|---|---|---|---|---|
| Site | US State | year | Nest ID | Zone for UTMs | Easting | Northing |
| Cannon AFB | NM | 2008 | 5 | 13 S | 652876 | 3805497 |
| Cannon AFB | NM | 2008 | 5 | 13 S | 652876 | 3805497 |
| Cannon AFB | NM | 2008 | 6 | 13 S | 653052 | 3805360 |
| Cannon AFB | NM | 2008 | 7 | 13 S | 654523 | 3804388 |
| Cannon AFB | NM | 2008 | 9 | 13 S | 654606 | 3804243 |
| Cannon AFB | NM | 2008 | 10 | 13 S | 654648 | 3804405 |
| Fort Bliss AFB | NM | 2007 | 2 | 13 S | 437300 | 3583064 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 3 | 13 S | 437529 | 3582645 |
| Fort Bliss AFB | NM | 2007 | 4 | 13 S | 437503 | 3582643 |
| Fort Bliss AFB | NM | 2007 | 4 | 13 S | 437503 | 3582643 |
| Fort Bliss AFB | NM | 2007 | 4 | 13 S | 437503 | 3582643 |
| Fort Bliss AFB | NM | 2007 | 4 | 13 S | 437503 | 3582643 |
| Fort Bliss AFB | NM | 2007 | 5 | 13 S | 437949 | 3582616 |
| Fort Bliss AFB | NM | 2008 | 6 | 13 S | 437191 | 3583016 |
| Fort Bliss AFB | NM | 2008 | 7 | 13 S | 437703 | 3582979 |
| Holloman AFB | NM | 2007 | 7 | 13 S | 392098 | 3642876 |
| Holloman AFB | NM | 2007 | 7 | 13 S | 392098 | 3642876 |
| Holloman AFB | NM | 2007 | 7 | 13 S | 392098 | 3642876 |
| Holloman AFB | NM | 2007 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2007 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2007 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2007 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2007 | 33 | 13 S | 392138 | 3643693 |
| Holloman AFB | NM | 2007 | 45 | 13 S | 392718 | 3641873 |
| Holloman AFB | NM | 2007 | 45 | 13 S | 392718 | 3641873 |
| Holloman AFB | NM | 2007 | 45 | 13 S | 392718 | 3641873 |
| Holloman AFB | NM | 2007 | 45 | 13 S | 392718 | 3641873 |
| Holloman AFB | NM | 2007 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2007 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2007 | 51 | 13 S | 398546 | 3637866 |
| Holloman AFB | NM | 2007 | 52 | 13 S | 397877 | 3637907 |

| | | | | NAD 83 | | |
|---|---|---|---|---|---|---|
| **Site** | **US State** | **year** | **Nest ID** | **Zone for UTMs** | **Easting** | **Northing** |
| Holloman AFB | NM | 2008 | 5 | 13 S | 392120 | 3642006 |
| Holloman AFB | NM | 2008 | 7 | 13 S | 392098 | 3642876 |
| Holloman AFB | NM | 2008 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2008 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2008 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2008 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2008 | 37 | 13 S | 392216 | 3642985 |
| Holloman AFB | NM | 2008 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2008 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2008 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2008 | 50 | 13 S | 393009 | 3639452 |
| Holloman AFB | NM | 2008 | 61 | 13 S | 398057 | 3636381 |
| Holloman AFB | NM | 2008 | 61 | 13 S | 398057 | 3636381 |
| Holloman AFB | NM | 2008 | 62 | 13 S | 391754 | 3639122 |
| Holloman AFB | NM | 2008 | 67 | 13 S | 397910 | 3636265 |
| Holloman AFB | NM | 2008 | 67 | 13 S | 397910 | 3636265 |
| Holloman AFB | NM | 2008 | 67 | 13 S | 397910 | 3636265 |
| Holloman AFB | NM | 2008 | 68 | 13 S | 395372 | 3637174 |
| Holloman AFB | NM | 2008 | 69 | 13 S | 392419 | 3640176 |

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# APPENDIX E. Habitat, Range, and Forestry Studies

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**Plant species known to occur at NWSTF Boardman.** [1]

| Common Name | Scientific Name |
|---|---|
| **Vascular Plants** | |
| Family Asteraceae (Aster) | |
| Annual agoseris | *Agoseris heterophylla* |
| Annual bursage | *Ambrosia acanthicarpa* |
| Diffuse knapweed | *Centaurea diffusa* |
| Big sagebrush | *Artemesia tridentata* |
| Bull thistle | *Cirsium vulgare* |
| Canadian thistle | *Cirsium arvense* |
| Carey's balsamroot | *Balsamorhiza careyana* |
| Chicory | *Chichorium intybus* |
| Cluster tarweed | *Madia glomerata* |
| Common cocklebur | *Xanthium strumarium* |
| Common dandelion | *Taraxacum officinale* |
| Common rabbitleaf | *Lagophylla ramosissima* |
| Common spikeweed | *Hemizonia pungens* var. *septentrionalis* |
| Columbia cut-leaf | *Hymenopappus filifolius* var. *filifolius* |
| Columbia coreopsis | *Coreopsis atkinsoniana* |
| False-yarrow | *Chaenactis douglasii* var. *achilleaefolia* |
| Gold stars | *Crocidium multicaule* |
| Gray rabbitbrush | *Chrysothamnus nauseosus* |
| Green rabbitbrush | *Chrysothamnus viscidiflorus* |
| Hairy golden-aster | *Chrysopsis villosa* |
| Hawkweed | *Hieracium* sp. |
| Hoary aster | *Machaeranthera canascens* |
| Horseweed | *Conyza canadensis* |
| Hounds-tongue | *Hieracium cynoglossoides* |
| Long-leaf hawksbeard | *Crepis acuminata* |
| Long-leaved aster | *Aster chilensis* |
| Low pussy-toes | *Antennaria dimorpha* |
| Nodding beggar-ticks | *Bidens cernua* |
| Northern wyethia | *Wyethia amplexicaulis* |
| Northwest balsamroot | *Balsamorhiza deltoidea* |
| Pineapple weed | *Matricaria matricarioides* |
| Prickly lettuce | *Lactuca serriola* |
| Scotch thistle | *Onopordum acanthium* |
| Shaggy daisy | *Erigeron pumilis* |
| Skeleton weed | *Stephanomeria paniculata* |
| Slender hawksbeard | *Crepis atrabarba* |
| Snakeweed | *Gutierrezia sarothrae* |
| Tall pussy-toes | *Antennaria anaphaloides* |
| Thread-leaf fleabane | *Erigeron filifolius* |
| White tidy tips | *Layia glandulosa* |
| Yarrow | *Achillea millefolium* |
| Yellow desert daisy | *Erigeron linearis* |
| Yellow salsify | *Tragopogon dubius* |
| Family Boraginaceae (Borage) | |
| Common cryptantha | *Cryptantha intermedia* |
| Slender popcorn flower | *Plagiobothrys tenellus* |
| Fiddleneck tarweed | *Amsinckia lycopsoides* |
| Family Brassicaceae (Mustard) | |
| Clasping peppergrass | *Lepidium perfoliatum* |
| Flixweed | *Descurainia sophia* |
| Jim-hill mustard | *Sysimbrium altissimum* |

**Plant species known to occur at NWSTF Boardman.** [1]

| Common Name | Scientific Name |
|---|---|
| Prairie rocket | *Erysimum asperum* |
| Shepard's purse | *Capsella bursa-pastoris* |
| Whitlow-grass | *Draba verna* |
| Tall peppergrass | *Lepidium virginicum* |
| Tansy mustard | *Descurainia pinnata* |
| Tumble mustard | *Sisymbrium altissimum* |
| Family Cactaceae (Cactus) | |
| Prickly pear cactus | *Opuntia polyacantha* |
| Family Capparidaceae (Caper) | |
| Yellow bee plant | *Cleome lutea* |
| Family Carophyllaceae (Pink) | |
| Jagged chickweed | *Holosteum umbellatum* |
| Bouncing bett | *Saponaria officinalis* |
| Family Chenopodiaceae (Goosefoot) | |
| Black greasewood | *Sarcobatus vermiculatus* |
| Russian thistle | *Salsola kali* |
| Family Cupressaceae (Cypress) | |
| Western juniper | *Juniperus occidentalis* |
| Family Dipsacaceae (Teasel) | |
| Teasel | *Dipsacus sylvestris* |
| Family Euphorbiaceae (Spurge) | |
| Rattlesnake weed | *Euphorbia serpyllifolia* |
| Family Fabaceae (Pea) | |
| Alfalfa | *Medicago sativa* |
| Black locust | *Robinia pseudo-acacia* |
| Columbia milk-vetch | *Astragalus succembens* |
| Stalked-pod milk-vetch | *Astragalus sclerocarpus* |
| Hairy vetch | *Vicia villosa* |
| Lance-leaf scurf-pea | *Psoralea lanceolata* |
| Laurance's milk-vetch | *Astragalus collinus* var. *laurentii* |
| Licorice | *Glycyrrhiza leipdota* |
| Long-leaf locoweed | *Astragalus reventus* var. *reventus* |
| Lupine | *Lupinus* spp. |
| Pauper milk-vetch | *Astragalus misellus* |
| Shoestring psoralea | *Psoralea lanceolata* |
| Speckle-pod milk-vetch | *Astragalus lentiginosus* |
| Thread-stalk milk-vetch | *Astragalus filipes* |
| Tweedy's milk-vetch | *Astragulus tweedyi* |
| White clover | *Trifolium repens* |
| White sweet-clover | *Melilotus alba* |
| Pursh's milk-vetch | *Astragalus purshii* |
| Wyeth's lupine | *Lupinus wyethii* |
| Yellow deer-vetch | *Lotus corniculatus* |
| Yellow sweet-clover | *Melilotus officinalis* |
| Family Gentianaceae (Gentian) | |
| White-stemmed swertia | *Swertia albicaulis* |
| Family Geraniaceae (Geranium) | |
| Redstem filaree/storksbill | *Erodium circutarium* |
| Family Hydrophyllaceae (Waterleaf) | |
| Silver-leafed phacelia | *Phacelia hastata* |
| Thread-leaf phacelia | *Phacelia linearis* |
| Family Lamiaceae (Mint) | |
| Horehound | *Marrubium vulgare* |
| Family Liliaceae (Lily) | |

**Plant species known to occur at NWSTF Boardman.** [1]

| Common Name | Scientific Name |
|---|---|
| Douglas' brodiaea | *Brodiaea douglasii* |
| Sagebrush mariposa | *Calochortus macrocarpus* |
| Panicled death-camas | *Zigadenus venenosus* |
| Yellow bells | *Fritillaria pudica* |
| | |
| Family Linaceae (Flax) | |
| Wild flax | *Linum perenne* |
| Family Malvaceae (Mallow) | |
| Orange globe mallow | *Sphaeralcea munroana* |
| Family Nyctaginaceae (Four-o'clock) | |
| White-sand verbena | *Abronia mellifera* |
| Family Onagraceae (Evening Primrose) | |
| Common evening primrose | *Oenethera strigosa* |
| Pale evening primrose | *Oenothera pallida* |
| Parched fireweed | *Epilobium paniculatum* |
| Family Plantaginaceae (Plantain) | |
| English plantain | *Plantago lanceolata* |
| Hairy plantain | *Plantago patagonica* |
| Family Poaceae (Grass) | |
| Barren fescue | *Festuca bromoides* |
| Bluebunch wheatgrass | *Agropyron spicatum* |
| Bottlebrush squirrel tail | *Sitanion hystrix* |
| Bulbous bluegrass | *Poa bulbosa* |
| Crested wheatgrass | *Agropyron cristatum* |
| Cheatgrass | *Bromus tectorum* |
| Thickspike wheatgrass | *Agropyron dasytachyum* |
| Dune wild rye | *Elymus mollis* |
| Foxtail barley | *Hordeum murimum* |
| Giant wild rye | *Elymus flavescens* |
| Idaho fescue | *Festuca idahoensis* |
| Indian ricegrass | *Oryzopsis hymenoides* |
| Junegrass | *Koeleria cristata* |
| Nevada bluegrass | *Poa nevadensis* |
| Nuttall's fescue | *Festuca microstachys* |
| Orchard grass | *Dactylis glomerata* |
| Saltgrass | *Distichlis stricta* |
| Sandberg's bluegrass | *Poa sandbergii* |
| Six-weeks fescue | *Festuca octoflora* |
| Thurber needle grass | *Stipa thurberiana* |
| Western needle-and-thread grass | *Stipa comata* |
| Wheat | *Triticum aestivum* |
| Yellow wild rye | *Elymus cinereus* |
| Family Polemoniaceae (Phlox) | |
| Desert phlox | *Phlox austromontana* |
| Long-leaf phlox | *Phlox longifolia* |
| Microsteris | *Microsteris gracilis* |
| Small-flowered gilia | *Gilia minutiflora* |
| Family Polygonaceae (Buckwheat) | |
| Broom buckwheat | *Eriogonum vimineum* |
| Desert buckwheat | *Eriogonum compositum* |
| Snow buckwheat | *Eriogonum niveum* |
| Veiny dock | *Rumex venosus* |
| Wyeth eriogonum | *Eriogonum heracleoides* |
| Family Portulacaceae (Purslane) | |
| Common purslane | *Portulaca oleracea* |

**Plant species known to occur at NWSTF Boardman.** [1]

| Common Name | Scientific Name |
|---|---|
| Family Ranunculaceae (Buttercup) | |
| Hornseed buttercup | *Ranunculus testiculatus* |
| Upland larkspur | *Delphinium nuttallianum* |
| Water buttercup | *Ranunculus aquatilis* |
| Family Rosaceae (Rose) | |
| Antelope bitterbrush | *Purshia tridentata* |
| Family Santalaceae (Sandalwood) | |
| Bastard toad-flax | *Comandra umbelleta* |
| Family Saxifragaceae (Saxifrage) | |
| Bulbet prairie star | *Lithophragma bulbifera* |
| Family Scrophulariaceae (Figwort) | |
| Common mullein | *Verbascum thapsus* |
| Sand dune penstemon | *Penstemon acuminatus* |
| Family Solanaceae (Potato or Nightshade) | |
| Cut-leaf nightshade | *Solanum triflorum* |
| Potato | *Solanum tuberosum* |
| Family Umbelliferae (Parsley) | |
| Bicolor biscuit root | *Lomatium leptocarpum* |
| Cous biscuit root | *Lomatium cous* |
| Biscuit root | *Lomatium macrocarpum* |
| Turpentine cymopterus | *Cymopterus terebinthinus* |
| Nine-leaved desert-parsley | *Lomatium triternatum* |
| Family Verbenaceae (Verbena) | |
| Bracted verbena | *Verbena bracteata* |
| **Non-vascular Plants** | |
| (no common names) | |
| Mosses | |
| *Aloina pilifera* | |
| *Bryum* sp. | |
| *Ceratodon purpureus* | |
| *Didymodon australasii* | |
| *Didymodon brachyphyllus* | |
| *Encalypta cf. rhaptocarpa* | |
| *Funaria hygrometrica* | |
| *Grimmia montana* | |
| *Phascum cuspidatum* | |
| *Pseudocrossidium revolutum* | |
| *Pterygoneurum ovatum* | |
| *Tortula brevipes* | |
| *Tortula princeps* | |
| *Tortula ruralis* | |
| Lichens | |
| *Acarospora schleicheri* | |
| *Cladonia coniocraea* | |
| *Cladonia fimbriata* | |
| *Cladonia pyxidata* | |
| *Collema tenax* | |
| *Dermatocarpon hepaticum* | |
| *Diploschistes scruposus* | |
| *Lecanora muralis* | |
| *Leptogium californicum* | |
| *Leptogium lichenoides* | |
| *Nostoc* | |

**Plant species known to occur at NWSTF Boardman.** [1]

| Common Name | Scientific Name |
|---|---|
| *Polychidium albociliatum* | |
| *Psora luridella* | |
| Liverworts | |
| *Cephaloziella divaricata* | |

[1] Sources: McClelland and Bedell (1987), Quade (1994).

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# Changes in Vegetation on Range Monitoring Plots
## 2008-2017

# Naval Weapons Systems Training Facility Boardman
## Cooperative Agreement N44255-16-2-0008

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November 2018

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## FIGURES AND TABLES



## APPENDICES

# 1. Introduction

The Naval Weapon Systems Training Facility (NWSTF) Boardman, combined with the adjacent Boardman Conservation Area and other private lands, contains some of the best remaining grassland and shrub-steppe in the Columbia Plateau ecoregion (Oregon Department of Fish and Wildlife 2005). Grasslands and shrub-steppe at NWSTF Boardman provide important habitat for sensitive wildlife including the Washington ground squirrel, a listed species under the Oregon Endangered Species Act, as well as loggerhead shrikes, sagebrush sparrows, ferruginous hawks, burrowing owls, and northern sagebrush lizards, all species of concern under the Federal Endangered Species Act, and critical or vulnerable under the Oregon Endangered Species Act (Oregon Natural Heritage Information Center 2004).

To track changes in grassland and shrub-steppe conditions, a range monitoring program was developed at NWSTF Boardman in 1987. This monitoring program was specifically designed to inform the livestock grazing program on the site and consisted of two phases; annual interpretation of domestic livestock utilization of the plant resources in designated pastures and periodic measurement of floristic composition, canopy cover, substrate, plant vigor and forage production at permanent plots. Since 1987, several large fires have burned through the site, military training activities have been reduced, and the grazing program has ceased (Table 1). Range monitoring plots were re-surveyed in 2008 (Elseroad et al. 2009), 2010, 2011 (Elseroad et al. 2011), 2013 (Nelson et al. 2013), 2015 (Cahill 2015) and again in 2017 to document the changes in vegetation that occurred over the previous two decades. Evaluation of changes in grassland and shrub-steppe condition on the NWSTF since plot establishment in 1987 is thoroughly covered in Elseroad et al. (2011). The purpose of this report is to summarize the 2017 survey results and evaluate trends in grassland and shrub-steppe condition from 2008 to 2017.

# 2. Methods

## *2.1 Site d*escription

The 47,400-acre NWSTF Boardman is located in Morrow County, Oregon. Vegetation on the property is composed of a mosaic of grassland and shrubland plant communities. Dominant native vegetation includes bunchgrass communities composed of bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and threadgrass (*Hesperostipa comata*), and Sandberg's bluegrass (*Poa secunda*); and shrubland communities dominated by big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (both *Ericameria nauseosa* and *Chrysothamnus viscidiflorus*) and western juniper (*Juniperus occidentalis*). Large portions of NWSTF Boardman have been invaded by cheatgrass (*Bromus tectorum*), a non-native annual grass. In most areas, cheatgrass occurs within a matrix of native vegetation, but some heavily disturbed areas are dominated by cheatgrass and other non-native species. A more detailed description of plant community types at NWSTF Boardman is available in Phillips et al. 2012.

Several large-scale disturbances at NWSTF Boardman have influenced vegetation composition in recent history, including livestock grazing, military activities, and wildfires. Prior to purchase by the U.S. military, NWSTF Boardman was heavily grazed by horses and sheep, and cattle and sheep continued to graze large portions of the property until the grazing lease was terminated in 2002 (Phillips et al. 2012). From 1943 to 1996, NWSTF Boardman was actively used by the military for aerial bombing and gunnery training but since 1996 has only been used infrequently for military training (Phillips et al. 2012). Within the last ten years, several large wildfires have burned across the property, including 17,000 acres in

1998, 5,000 acres in 2002 (Phillips et al. 2012), 11,600 acres in 2008, and 14,500 acres in 2015 (Figure 1). Recent wildfire history at each range monitoring plot is shown in Table 1.

## 2.2 Vegetation sampling

In 1987, eighteen 50 ft. radius range monitoring plots were established at NWSTF Boardman (Figure 1, Table 3) and data were collected following the methods described in Anderson (1986) and Anderson (1988). The same methodology was used in 2008, 2010, 2011, 2013, 2015 and 2017. In each plot, data collection consisted of estimating the percent cover of each plant species and ground surface category (bare ground, litter, gravel and stones, and mosses and lichen), assigning a dominance rating to each plant species, estimating vigor and the number of seedlings for key species, and estimating perennial grass and forb biomass. In addition, two photographs were taken at each plot – one of the permanently marked 3-foot square subplot, and another of the permanently marked 25-foot line subplot. Detailed plot location information is provided in Table 2.

Specific methods for estimating perennial grass and forb biomass were not outlined in Anderson (1986) or Anderson (1988). Therefore, in 2008, 2010, 2011, 2013, 2015 and 2017 the field methods described in Brence and Sheley (2003) were used to collect biomass samples. Within each plot, a 92-inch circumference hoop was thrown in four random locations, and all perennial grasses and forbs within the hoop were clipped and combined into one paper bag. Samples were then air-dried for several weeks and weighed in grams. Weights for each sample were divided by four to obtain the average weight per hoop, and then multiplied by twenty to obtain pounds of perennial grass and forb forage per acre.

In 2017, plots were visited on May 23-30. Unknown plants were keyed to species using Hitchcock and Cronquist's (1973) Flora of the Pacific Northwest.

## 2.3 Data analysis

Two approaches have been used to compare changes in vegetation across all eighteen plots between 2008 and 2017. In the first method, average cover (±SE) was calculated for all species, five plant guilds, ground surface, species richness, and perennial forb and grass biomass for each year. Plant guilds included: shrubs, native perennial grasses, native perennial forbs, native annual forbs, and exotic annual forbs.

To further explore the trends observed in the summary statistics, described above, changes in cover were modeled using a repeated measures analysis for the period 2008 to 2017. A univariate split plot approach (which tests for within-plot effects and interactions involving these effects) was used to test for linear changes in cover over time across all plots for each plant guild, including *Bromus tectorum*, dominant native perennial grasses (*Pseudoroegneria spicata* ssp. *spicata*, *Hesperostipa comata*, and *Poa secunda*), dominant ground surface categories (bare ground, litter, and mosses and lichen); and species richness. JMP version 13.2.1 (SAS Institute) was used for repeated measures modeling with a defined statistical significance of $p<0.05$.

Biennial species were treated as annuals for both analyses; species nativity and duration followed USDA (2013).

# 3. Results

Evaluation of changes in grassland and shrub-steppe condition on the NWSTF since plot establishment in 1987 is thoroughly covered in Elseroad et al. (2011); therefore, this discussion is limited to the recent changes (2008 to 2017) across the monitoring plots.

In 2017, plots were visited on May 23 and 30. On average from 2008 to 2017, there was no significant change in species richness per plot ($\beta=-0.01$, $p=0.9011$) (Figure 2). Nine species were found in 2017 that were not found in 2008, and seven species were not found in 2017 that were found in 2008. Species present in 2008 but not found in 2017 were five native annual forbs, one non-native annual forb and one non-native annual grass, whereas species not present in 2008 but found in 2017 included five native perennial forbs, three native annual forbs and one non-native annual forb.

Perennial grass and forb biomass averaged 187 lbs/acre in 2017, up slightly from the lowest to date, 181 lbs/acre, in 2015, but still less than 50% of the 2008 to 2013 average of 380 ± 12 lbs./acre (Table 1). However, the biomass estimate obtained in any given year is largely dependent on the timing of the sampling (i.e. the phenology of the perennial vegetation); this measurement of domestic livestock utilization would have been considered important when the plots were established but is not particularly meaningful for tracking vegetative vigor or ecological condition.

In addition, broad speculation regarding general trends for some parameters is possible from the output of the repeated measures analysis. Table 4 summarizes the results of the 2008-2017 analysis for selected guilds and species and provides a comparison to the results of the 2008-2015 trends (see also Figures 3, 4, 5). Changes in cover of litter and mulch, *Hesperostipa comata*, *Poa secunda*, *Pseudoroegneria spicata*, native annual forbs, native perennial forbs and native shrubs are not statistically significant ($p>0.05$). There appears to be a continued significant decrease in bare ground and cover of exotic annual forbs ($p<0.05$). Mosses and lichens, combined cover and native perennial grasses may be increasing slightly ($p<0.05$).

# 4. Discussion

The Boardman NWSTF range monitoring program was developed in 1987 to inform the livestock grazing program on the site using annual interpretation of domestic livestock utilization of the plant resources in designated pastures and periodic measurement of floristic composition, canopy cover, substrate, plant vigor and forage production at 18 permanent plots. However, because of the original intention of the sampling scheme, data collected is qualitative in nature rather than quantitative and therefore does not lend itself to rigorous statistical comparison across years, nor does it prove sufficient to infer ecological condition of a broader landscape.

The Navy should consider whether the existing sampling scheme is sufficient to allow evaluation of the effects of management actions and natural events on the NWSTF. A properly planned and carefully designed sampling scheme that is appropriate for the size of the site and the variability of plant communities on the site should be implemented. The Conservancy would be happy to work with the Navy to identify potential sampling methods that would be appropriate for the site and goals of the monitoring.

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## 6. Figures and tables

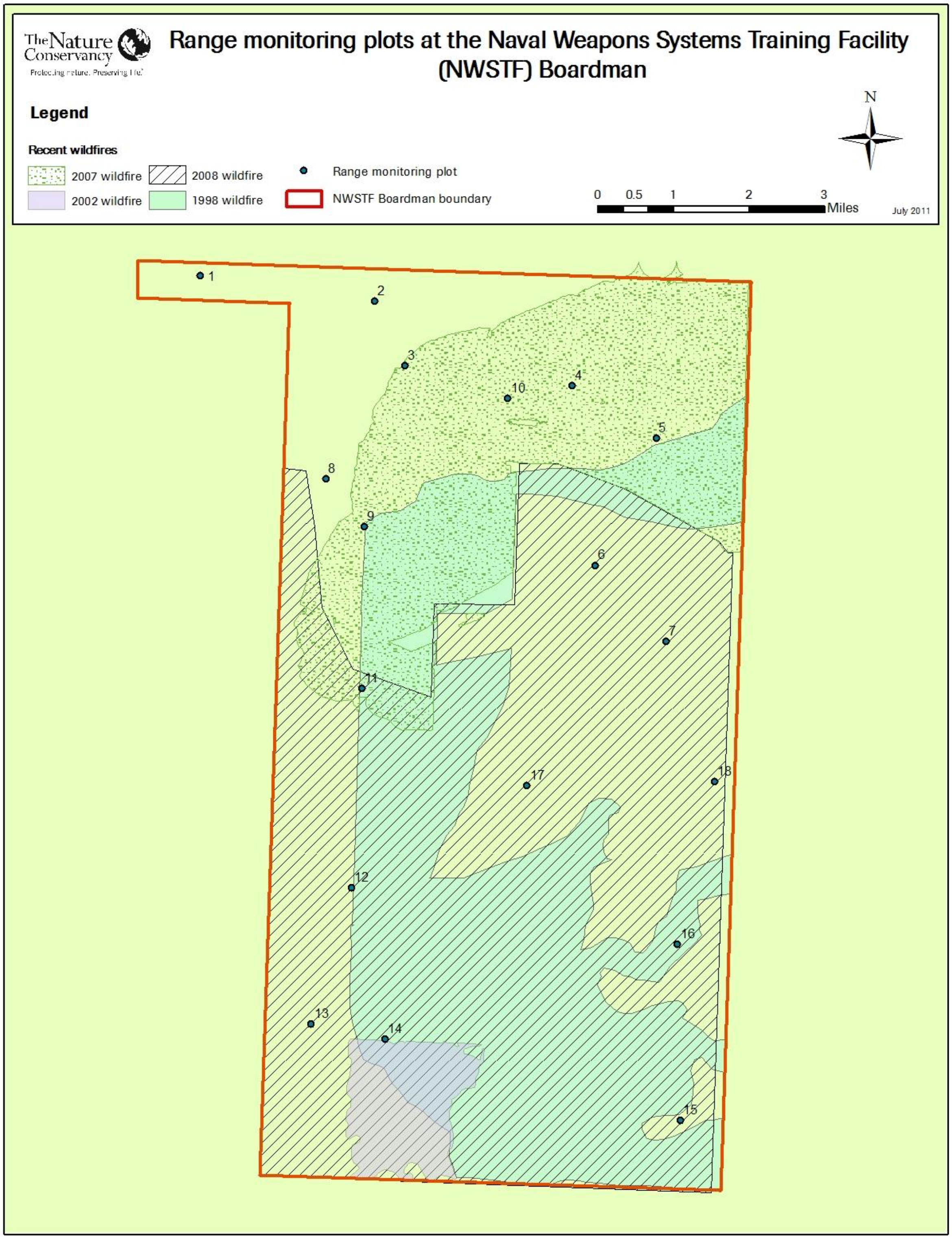



**Figure 1. Location of range monitoring plots at NWSTF Boardman.**

**Table 1. Perennial grass and forb biomass estimates (lbs/acre) for range monitoring plots at NWSTF Boardman, 2008-2017.**

| Plot | 2008 | 2010 | 2011 | 2013 | 2015 | 2017 |
|---|---|---|---|---|---|---|
| 1 | 30 | 553 | 170 | 7 | 112 | 9 |
| 2 | 55 | 71 | 44 | 1 | 10 | 25 |
| 3 | 695 | 383 | 77 | 91 | 17 | 48 |
| 4 | 185 | 482 | 339 | 805 | 223 | 198 |
| 5 | 830 | 255 | 143 | 142 | 154 | 194 |
| 6 | 300 | 553 | 265 | 386 | 312 | 408 |
| 7 | 60 | 156 | 153 | 218 | 107 | 33 |
| 8 | 540 | 496 | 374 | 469 | 220 | 313 |
| 9 | 135 | 1063 | 320 | 361 | 256 | 306 |
| 10 | 530 | 255 | 184 | 517 | 97 | 178 |
| 11 | 835 | 312 | 135 | 237 | 159 | 359 |
| 12 | 40 | 227 | 142 | 143 | 102 | 27 |
| 13 | 300 | 780 | 937 | 291 | 177 | 248 |
| 14 | 290 | 666 | 636 | 336 | 436 | 230 |
| 15 | 215 | 1191 | 780 | 921 | 431 | 90 |
| 16 | 255 | 836 | 240 | 469 | 226 | 525 |
| 17 | 165 | 340 | 395 | 397 | 159 | 60 |
| 18 | 245 | 1063 | 447 | 444 | 55 | 120 |
| **Average** | **317** | **538** | **321** | **346** | **181** | **187** |

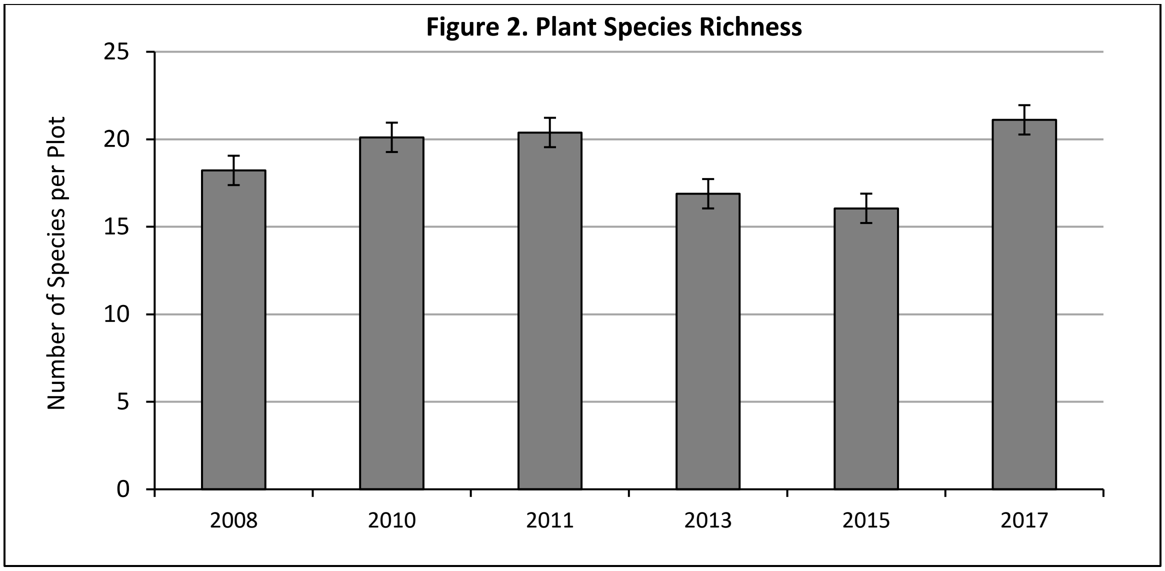



**Figure 2. Plant species richness on range monitoring plots at NWSTF Boardman, 2008-2017.** Values are averages ± SE.

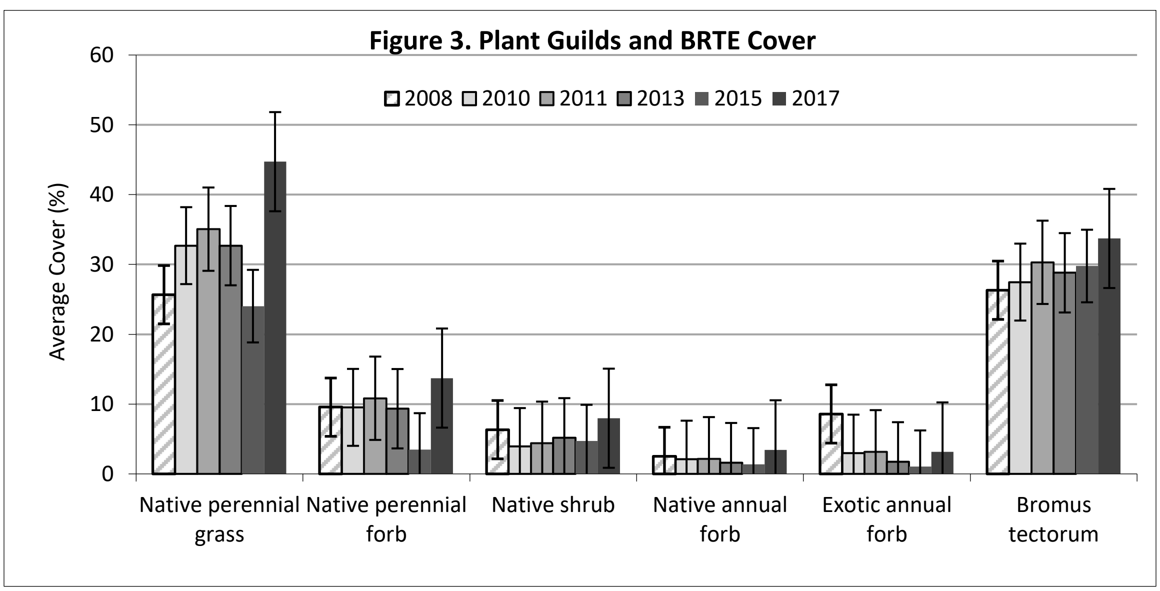



**Figure 3. Plant guilds and *Bromus tectorum* cover on range monitoring plots at NWSTF Boardman, 2008-2017.** Values are averages ± SE.

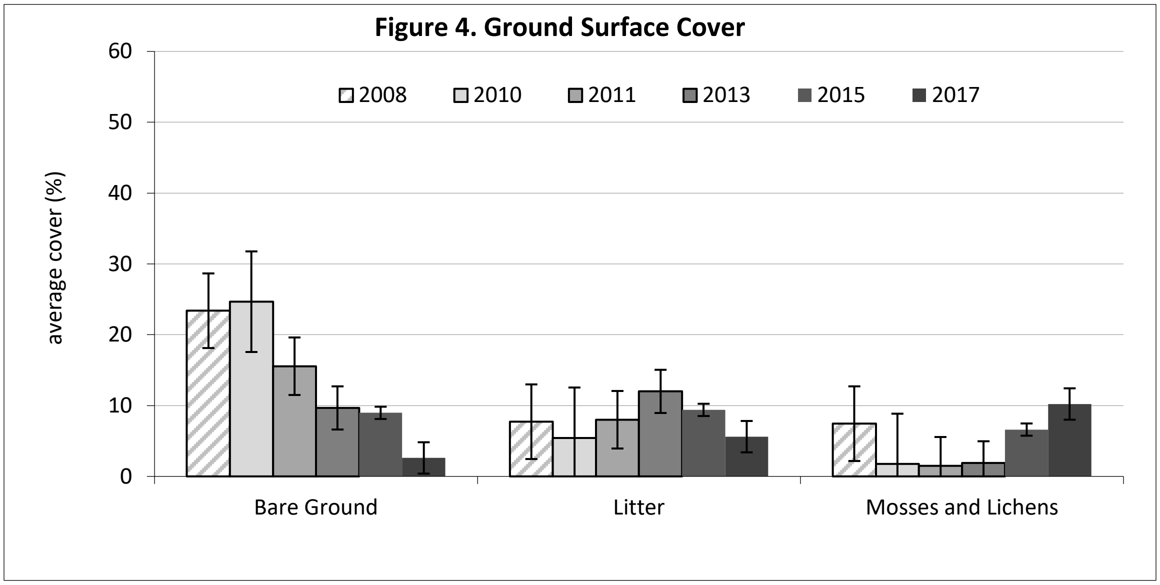



**Figure 4. Ground surface cover on range monitoring plots at NWSTF Boardman, 2008-2017.** Values are averages ± SE.

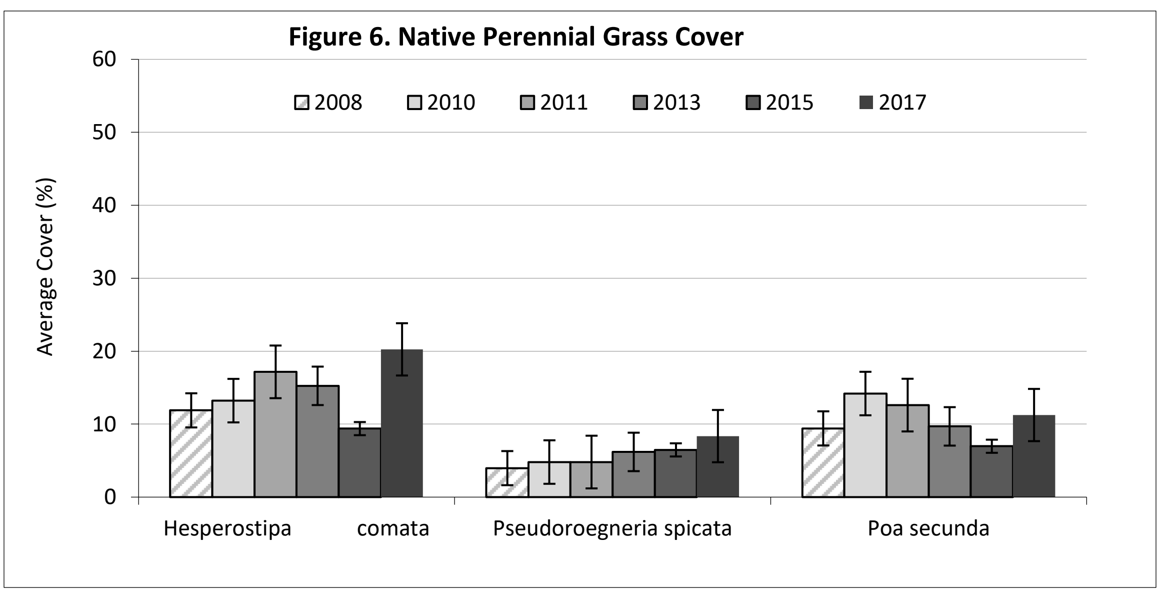



**Figure 5. Native perennial grass cover on range monitoring plots at NWSTF Boardman, 2008-2017.** Values are averages ± SE

**Table 2. Recent wildfire history at NWSTF Boardman range monitoring plots.** "X" indicates that the plot burned in the wildfire. Data obtained from NWSTF Boardman fire extent GIS shapefiles.

| | Wildfire | | | | |
|---|---|---|---|---|---|
| **Plot** | **1998** | **2002** | **2007** | **2008** | **2015** |
| 1 | - | - | - | - | - |
| 2 | - | - | - | - | - |
| 3 | - | - | X | - | - |
| 4 | - | - | X | - | - |
| 5 | - | - | X | - | - |
| 6 | X* | - | - | X | - |
| 7 | - | - | - | X | - |
| 8 | - | - | - | - | - |
| 9 | - | - | X | - | - |
| 10 | - | - | X* | - | - |
| 11 | X[1] | - | X | - | - |
| 12 | - | - | - | X | X |
| 13 | - | - | - | X | X |
| 14 | X | - | - | X | X |
| 15 | X* | - | - | X | - |
| 16 | X[1] | - | - | X | X |
| 17 | - | - | - | X | - |
| 18 | - | - | - | X | X |

**Table 3. Location of range monitoring plots at NWSTF Boardman.** GPS datum are in NAD 1983, UTM zone 11.

| Plot | Northing | Easting | Plot marker information |
|---|---|---|---|
| 1 | 284459.5212 | 5076010.6508 | |
| 2 | 288813.1238 | 5074094.9413 | Center of photoplot is 180° from the center of the monument (railroad tie). |
| 3 | 288384.1736 | 5059783.7060 | |
| 4 | 292851.9509 | 5069848.2526 | |
| 5 | 291406.2497 | 5065169.6690 | |
| 6 | 294603.4683 | 5061802.5544 | 25-foot line plot rebar is 34' 6" and 172° from the monument center (railroad tie). |
| 7 | 294665.4984 | 5058057.9713 | |
| 8 | 286815.4557 | 5060111.3088 | |
| 9 | 287893.7427 | 5067235.6898 | 25-foot line plot rebar is 32' 3" and 155° from the monument center (railroad tie). |
| 10 | 287941.0083 | 5070676.7667 | |
| 11 | 295392.9575 | 5065255.1156 | |
| 12 | 288162.1390 | 5075457.7114 | |
| 13 | 290996.3173 | 5073397.6448 | |
| 14 | 292368.0480 | 5073671.3042 | |
| 15 | 294151.7775 | 5072550.8612 | |
| 16 | 294368.6810 | 5068237.2113 | 25-foot line plot rebar is 30' 9" and 167° from the monument center (railroad tie). |
| 17 | 287126.7000 | 5071688.7052 | 25-foot line plot rebar is 39' 6" and 156° from the monument center (railroad tie). |
| 18 | 287668.9405 | 5063004.3892 | 25-foot line plot rebar is 32' and 166° from the monument center (railroad tie). |

**Table 4. Results of the repeated measures analysis (2008-2017) for selected guilds and species with comparison to results of 2008-2015 trends.**

Modeled in JMP 12 (SAS Institute)

| **Guild / Species** | **β** | **SE(β)** | ***d.f.*** | ***F*** | ***p*** | ***r2*** | **2015 -> 2017** |
|---|---|---|---|---|---|---|---|
| Bare ground | -2.47 | 0.45 | 1,17 | 30.791 | <.0001 | 0.688 | Same |
| Litter and mulch | 0.04 | 0.14 | 1,17 | 0.089 | 0.7691 | 0.400 | Same |
| Mosses and lichens | 0.51 | 0.19 | 1,17 | 7.065 | 0.0166 | 0.430 | NS Dec -> S Inc |
| | | | | | | | |
| Combined cover | 1.87 | 0.54 | 1,17 | 12.111 | 0.0029 | -0.019 | NS Dec -> S Inc |
| *Bromus tectorum* | 1.06 | 0.52 | 1,17 | 4.134 | 0.0579 | 0.924 | Same |
| *Hesperostipa comata* | 0.75 | 0.44 | 1,17 | 2.980 | 0.1024 | 0.748 | NS Dec -> NS Inc |
| *Poa secunda* | -0.17 | 0.23 | 1,17 | 0.541 | 0.4720 | 0.714 | Same |
| *Pseudoroegneria spicata* | 0.46 | 0.24 | 1,17 | 3.851 | 0.0663 | 0.972 | Same |
| | | | | | | | |
| Exotic Annual Forb | -0.54 | 0.25 | 1,17 | 4.557 | 0.0476 | 0.395 | Same |
| Native Annual Forb | -0.02 | 0.06 | 1,17 | 0.132 | 0.7210 | 0.165 | S Dec -> NS NC |
| Native Perennial Forb | 0.00 | 0.20 | 1,17 | 0.000 | 0.9941 | 0.545 | S Dec -> NS NC |
| Native Perennial Grass | 1.26 | 0.45 | 1,17 | 7.827 | 0.0124 | 0.808 | NS Dec -> S Inc |
| Shrub | 0.21 | 0.18 | 1,17 | 1.309 | 0.2685 | 0.741 | NS Dec -> NS Inc |
| | | | | | | | |
| Species Richness | -0.01 | 0.11 | 1,17 | 0.016 | 0.9011 | 0.542 | S Dec -> NS NC |
| | | | | | | | |

***Notes:***

NS Dec. – Non-significant Decrease
S Dec. – Significant Decrease
NC – No Change
NS Inc. – Non-significant Increase
S. Inc. – Significant Increase
Same – Same as in 2015

| |
|---|
| Significant Results (p<0.05) |
| Marginally Sig. Results (0.05<p<0.1) |
| Change in Significance or Trend Since 2015 |

## Table 5. Plant species found on NWSTF Boardman range monitoring plots, 1987-2017

(N=native, I=introduced, P=perennial, A=annual, B=biennial).

| Scientific name* | Common name* | Family | Origin | Duration | Form | 1987 | 2008 | 2010 | 2011 | 2013 | 2015 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abronia mellifera | sandverbena, white | Nyctaginaceae | N | P | forb | x | | | | | | |
| Achillea millefolium | yarrow | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Achnatherum hymenoides | ricegrass, Indian | Poaceae | N | P | grass | x | x | x | x | x | X | x |
| Agoseris heterophylla | agoseris, annual | Asteraceae | N | A | forb | x | x | x | x | x | x | x |
| Agropyron cristatum | wheatgrass, crested | Poaceae | I | P | grass | x | x | x | x | x | x | x |
| Alyssum alyssoides | pale madwort | Brassicaceae | I | A | forb | | x | x | x | | | |
| Ambrosia sp. | bursage | Asteraceae | N | A | forb | | x | x | x | x | x | |
| Amsinkia sp. | fiddleneck | Boraginaceae | N | P | forb | x | x | x | x | x | x | x |
| Antennaria dimorpha | pussytoes | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Artemisia tridentata | sagebrush, basin big | Asteraceae | N | P | shrub | x | x | x | x | x | x | x |
| Aster sp. / Asteraceae sp. | Aster? | Asteraceae | | | forb | x | | | | | x | |
| Astragalus purshii | loco, woolly pod | Fabaceae | N | P | forb | x | | | x | x | | x |
| Astralagus sclerocarpus | milkvetch, stalked pod | Fabaceae | N | P | forb | x | x | x | x | x | x | x |
| Astralagus succumbens | milkvetch, Columbia | Fabaceae | N | P | forb | x | x | x | x | x | x | x |
| Balsamorhiza careyana | balsamroot, Carey | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Bromus tectorum | cheatgrass | Poaceae | I | A | grass | x | x | x | x | x | x | x |
| Calochortus macrocarpus | mariposa lily | Liliaceae | N | P | forb | x | x | x | x | x | x | x |
| Camissonia contorta | plains evening primrose | Onagraceae | N | P | forb | | x | | x | | | x |
| Centaurea diffusa | diffuse knapweed | Asteraceae | I | A | forb | | x | x | x | x | x | x |
| Chaenactis douglasii var. achilleifolia | false yarrow | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Chondrilla juncea | rush skeletonweed | Asteraceae | I | P | forb | | | | x | x | x | |
| Chrysothamnus viscidiflorus | rabbitbrush, Douglas green | Asteraceae | N | P | shrub | x | x | x | x | x | x | x |
| Conyza canadensis | Canadian horseweed | Asteraceae | N | A | Forb | | | | | x | | |
| Crepis atribarba | slender hawksbeard | Asteraceae | N | P | forb | | x | | | x | x | x |
| Cryptantha flaccida | weakstem cryptantha | Boraginaceae | N | A | forb | | x | x | x | x | | |
| Cryptantha sp. | | Boraginaceae | | | forb | | | | | | x | |
| Descurania pinnata | western tansymustard | Brassicaceae | N | A | forb | | | x | x | x | x | x |
| Elymus elymoides | squirreltail | Poaceae | N | P | grass | x | x | x | x | x | x | x |
| Elymus lanceolatus | wheatgrass, thickspike | Poaceae | N | P | grass | x | x | x | x | x | x | x |
| Epilobium brachycarpum | tall annual willowherb | Onagraceae | N | A | forb | | x | x | x | x | | x |
| Ericameria nauseosa | rabbitbrush, rubber | Asteraceae | N | P | shrub | x | x | x | x | x | x | x |
| Erigeron filifolius | fleabane, cushion | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Erigeron pumilus | fleabane, shaggy | Asteraceae | N | P | forb | x | x | x | x | x | x | x |
| Eriogonum niveum | buckwheat, snow | Polygonaceae | N | P | forb | x | x | x | x | x | x | x |
| Erodium cicutarium | filaree | Geraniaceae | I | A | forb | x | x | x | x | x | | x |
| Erysimum capitatum | wallflower | Brassicaceae | N | P | forb | x | | | | | | x |
| Fritillaria pudica | yellow bells | Liliaceae | N | P | forb | | | | x | | | |
| Gutierrezia sarothrae | snakeweed | Asteraceae | N | P | shrub | x | x | x | x | x | x | x |
| Hesperostipa comata | needle-and-thread | Poaceae | N | P | grass | x | x | x | x | x | x | x |
| Heterotheca villosa var. villosa | hairy false golden aster | Asteraceae | N | P | forb | | x | x | x | x | x | x |

| Scientific name* | Common Name | Family | Origin | Duration | Form | 1987 | 2008 | 2010 | 2011 | 2013 | 2015 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Holosteum umbellatum | chickweed, jagged | Caryophyllaceae | I | A | forb | x | x | x | x | | | |
| Hordeum murinum | mouse barley | Poaceae | I | P | grass | | x | | | | | |
| Hymenopappus filifolius | hymenopappus, fineleaf | Asteraceae | N | P | forb | | x | x | x | x | | x |
| Lactuca serriola | lettuce, prickly | Asteraceae | I | A | forb | x | x | x | x | x | x | x |
| Layia glandulosa | white tidy-tips | Asteraceae | N | A | forb | | x | x | x | | x | |
| Lepidium sp. | stoneseed | Brassicaceae | | | forb | | | | | | x | x |
| Linum lewisii | blue flax | Linaceae | N | P | forb | | | | | | | x |
| Lithospermum ruderale | Gorman's biscuitroot | Boraginaceae | N | P | forb | x | | | | | | |
| Lomatium gormanii | lomatium (gray carrot leaf) | Apiaceae | N | P | Forb | | | | | x | x | |
| Lomatium macrocarpum | bigseed biscuitroot | Apiaceae | N | P | forb | | x | x | x | x | | x |
| Machaeranthera canescens | hoary aster | Asteraceae | N | P | forb | x | x | x | x | x | | x |
| Madia glomerata | cluster tarweed | Asteraceae | N | A | forb | | x | x | x | x | | **x** |
| Microsteris gracilis | microsteris | Polemoniaceae | N | A | forb | | x | x | x | x | | |
| Oenothera pallida | pale evening primrose | Onagraceae | N | P | forb | | x | x | x | x | x | x |
| Opuntia polyacantha | prickly pear | Cactaceae | N | P | forb | x | x | x | x | x | x | x |
| Penstemon acuminatus | penstemon | Scrophulariaceae | N | P | forb | x | | | | | | |
| Phacelia hastata | silver-leafed phacelia | Hydrophyllaceae | N | P | forb | | | | x | | | |
| Phacelia linearis | threadleaf phacelia | Hydrophyllaceae | N | A | forb | x | x | x | x | | x | x |
| Phlox longifolia | longleaf phlox | Poleminiaceae | N | P | forb | x | x | x | x | x | x | x |
| Plagiobothrys tenellus | slender popcorn flower | Boraginaceae | N | A | forb | x | | | x | | | x |
| Plantago patagonica | wooly indianwheat | Plantaginaceae | N | A | forb | x | x | x | x | x | x | x |
| Plectritis macrocera | longhorn plectritis | Valerianaceae | N | A | forb | | | x | x | | x | x |
| Poa bulbosa | bulbous bluegrass | Poaceae | I | P | grass | | x | x | x | | x | x |
| Poa secunda | Sandberg's bluegrass | Poaceae | N | P | grass | x | x | x | x | x | x | x |
| Pseudoroegneria spicata | bluebunch wheatgrass | Poaceae | N | P | grass | x | x | x | x | x | x | x |
| Psoralidium lanceolatum | scurfpea | Fabaceae | N | P | forb | x | x | x | x | x | x | x |
| Pteryxia terebinthina var. terebinthina | desert parsley, chimaya | Apiaceae | N | P | forb | x | x | x | x | x | x | x |
| Purshia tridentata | bitterbrush | Rosaceae | N | P | shrub | x | x | x | x | x | x | x |
| Salsola kali | Russian thistle | Chenopodiaceae | I | A | forb | | x | x | x | | x | x |
| Sisymbrium altissimum | mustard, Jim Hill | Brassicaceae | I | A | forb | x | x | x | x | x | x | x |
| Stephanomeria paniculata | skeleton weed | Asteraceae | N | A/P | forb | | x | | | x | | |
| Tragopogon dubius | salsify | Asteraceae | I | A/B | forb | x | x | x | x | x | x | x |
| Triteleia grandiflora | largeflower triteleia | Liliaceae | N | A | forb | | x | x | x | | x | x |
| Vulpia microstachys | fescue pacific | Poaceae | N | A | grass | x | | | | | | |
| Vulpia octoflora | fescue, six weeks | Poaceae | N | A | grass | x | | | | | | |
| Vulpia sp. | fescue sp. | Poaceae | N | A | grass | | x | x | x | x | x | x |

# Appendix A
# Range monitoring plot datasheets at NWSTF Boardman
# 1987, 2008, 2010, 2011, 2013, 2015 and 2017

| Plot 1 | Substrates | Date: 5/4/87 Dominance | Canopy Cover | Date: 5/13/08 Dominance | Canopy Cover | Date: 5/4/10 Dominance | Canopy Cover | Date: 5/16/11 Dominance | Canopy Cover | Date: 5/29/13 Dominance | Canopy Cover | Date: 4/27/15 Dominance | Canopy Cover | Date: 5/23/2017 Dominance | Canopy Cover |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bare Ground | xxx | 50 | xxx | 15 | xxx | 10 | xxx | 3 | xxx | 3 | xxx | 3 | xxx | 1 |
| | Gravel / Stones | xxx | 3 | xxx | 0 | xxx | 1 | xxx | 1 | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 1 | xxx | 8 | xxx | 10 | xxx | 20 | xxx | 20 | xxx | 10 | xxx | 7 |
| | Mosses / Lichens | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | xxx | T | xxx | 3 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 4 | 35 | 5 | 40 | 5 | 40 | 5 | 40 | 5 | 50 | 4 | 50 | 5 | 65 |
| Poa bulbosa | bulbous bluegrass | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sandverbena | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agoseris heterophylla | annual agoseris | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Amsinkia sp. | fiddleneck | 1 | T | 3 | 2 | 3 | 5 | 2 | 1 | 3 | 1 | 3 | T | 3 | 1 |
| Astralagus succumbens | Columbia milk-vetch | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Astralagus sp. | milkvetch sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Chaenactis douglasii | false yarrow | 1 | T | 0 | 0 | 2 | T | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Crepis atribarba | slender hawksbeard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Epilobium brachycarpum | tall anual willowherb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Eriogonum niveum | snow buckwheat | 3 | 1 | 3 | 3 | 3 | 5 | 3 | 2 | 3 | 2 | 1 | T | 2 | 1 |
| Erodium cicutarium | filaree | 3□ | 10 | 2 | 2 | 1 | T | 1 | 1 | 1 | T | 0 | 0 | 2 | 1 |
| Holosteum umbellatum | jagged chickweed | 3 | 10 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 1 | T |
| Madia glomerata | cluster tarweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Oenothera pallida | pale evening primrose | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 3 | T | 2 | T | 3 | T | 3 | T | 0 | 0 | 1 | T | 3 | 1 |
| Plantago patagonica | hairy plantain | 0 | 0 | 1 | T | 1 | T | 1 | 1 | 1 | T | 1 | T | 2 | 1 |
| Plectritis macrocera | longlorn plectritis | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T |
| Pteryxia terebinthina | turpentine cymopterus | 3- | 1 | 3 | 2 | 3 | 2 | 3 | 1 | 2 | T | 1 | T | 2 | 1 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Sisymbrium altissimum | mustard, Jim hill | 2 | T | 3 | 3 | 3 | 8 | 3 | 3 | 3 | 1 | 2 | T | 3 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T | 2 | 1 |
| Triteleia grandiflora | largeflower triteleia | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | 1 | 1 | 1 | 3 | 2 | 3 | T | 2 | T | 3 | 3 | 3 | 10 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 5 | 0 | 0 | 3 | T | 3 | 2 | 3 | 2 | 2 | T | 3 | 2 |
| Purshia tridentata | bitterbrush | 5 | 10 | 4 | 25 | 4 | 20 | 4 | 25 | 4 | 20 | 5 | T | 5 | 35 |
| | Combined cover: | 76 | | 81 | | 88 | | 80 | | 79.5 | | 93 | | 120 | |
| | Perennial cover: | 19.5 | | 33 | | 32 | | 32 | | 25 | | 2 | | 49 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 0 | | 30 | | 553 | | 170 | | 7 | | 111.5 | | 8.5 | |

| Plot 2 | Substrates | Date: 5/4/87 | | Date: 5/20/08 | | Date: 5/4/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/23/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 80 | xxx | 30 | xxx | 30 | xxx | 15 | xxx | 15 | xxx | 20 | xxx | 2 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 20 | xxx | 7 | xxx | 10 | xxx | 15 | xxx | 15 | xxx | 20 | xxx | 15 |
| | Mosses / Lichens | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | xxx | T | xxx | 4 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 1 | T | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bromus tectorum | cheatgrass | 3□ | 15 | 4 | 40 | 5 | 45 | 5 | 45 | 5 | 40 | 5 | 45 | 5 | 60 |
| Elymus elymoides | squirreltail | 3- | 1 | 1 | T | 2 | T | 2 | T | 2 | 1 | 1 | T | 3 | 2 |
| Elymus lanceolatus | thickspike wheatgrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 2 | 2 |
| Hesperostipa comata | needle and thread grass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Poa secunda | Sandberg's bluegrass | 0 | 0 | 0 | 0 | 3 | T | 3 | T | 1 | T | 1 | T | 3 | 2 |
| Vulpia sp. | fescue sp. | | | | | | | | | | | | | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sandverbena | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Achillea millefolium | yarrow | 1 | T | 1 | T | 2 | T | 2 | T | 3 | T | 1 | T | 3 | 1 |
| Ambrosia sp. | bursage | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T | 0 | 0 |
| Amsinkia sp. | fiddleneck | 1 | T | 1 | T | 2 | T | 2 | T | 2 | T | 1 | T | 3 | 1 |
| Astralagus sclerocarpus | stalk-pod milk-vetch | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 1 | 3 | T | 1 | T | 0 | 0 |
| Astralagus succumbens | Columbia milk-vetch | 1 | T | 3 | 3 | 2 | 1 | 2 | 2 | 3 | 1 | 2 | 1 | 2 | 1 |
| Calochortus macrocarpus | mariposa lily | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Crepis atribarba | slender hawksbeard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Chaenactis douglasii | false yarrow | 0 | 0 | 2 | T | 3 | 1 | 3 | T | 2 | T | 1 | T | 2 | 1 |
| Cryptantha flaccida | weak stemmed cryptantha | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Descurania pinnata | western tansy mustard | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 1 | T | 1 | T |
| Eriogonum niveum | snow buckwheat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Hymenopappus filifolius | fineleaf hymenopappus | 2 | T | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 0 | 0 |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 3 | 1 | 1 | T | 3 | 2 |
| Linum lewisii | prairie flax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 2 | T |
| Madia glomerata | cluster tarweed | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 3 | T | 0 | 0 | 1 | T | 3 | 1 | 0 | 0 | 1 | T |
| Pteryxia terebinthina | turpentine cymopterus | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Sisymbrium altissimum | Jim Hill mustard | 3- | 1 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | 1 | 3 | T | 3 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T | 3 | 1 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3□ | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | T | 4 | 10 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 15 | 4 | 5 | 3 | 6 | 3 | 5 | 3 | 1 | 3 | 1 | 4 | 15 |
| Purshia tridentata | antelope bitterbrush | 5 | 3 | 5 | 10 | 4 | 15 | 1 | 15 | 3 | 1 | 3 | T | 3 | 9 |
| | Combined cover: | 47 | | 70 | | 82 | | 78.5 | | 54 | | 55 | | 109 | |
| | Perennial cover: | 30.5 | | 26 | | 30 | | 29 | | 8.5 | | 5 | | 44 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 10 | | 55 | | 71 | | 44 | | 1 | | 10 | | 25 | |

| **Plot 3** | | Date: 5/4/87 | | Date: 5/20/08 | | Date: 5/4/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/23/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 30 | xxx | 35 | xxx | 15 | xxx | 5 | xxx | 1 | xxx | T | xxx | 2 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 20 | xxx | 10 | xxx | 8 | xxx | 20 | xxx | 20 | xxx | 20 | xxx | 15 |
| | Mosses / Lichens | 3 | 1 | xxx | | xxx | T | xxx | T | xxx | 2 | xxx | T | xxx | 4 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 5 | 50 | 4 | 30 | 5 | 40 | 5 | 45 | 5 | 45 | 5 | 60 | 5 | 70 |
| Elymus lanceolata | thickspike wheatgrass | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 2 | T | 1 | T | 3 | 3 |
| Hesperostipa comata | needle-and-thread grass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 2 | 1 |
| Poa secunda | Sandberg's bluegrass | 3- | T | 3 | 15 | 4 | 15 | 4 | 15 | 3 | 15 | 3 | 1 | 3 | 20 |
| Vulpia sp. | fescue sp. | 0 | 0 | 3 | 7 | 4 | 20 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sandverbena | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Achillea millefolium | yarrow | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| Amsinkia sp. | fiddleneck | 1 | T | 3 | 1 | 2 | 1 | 2 | T | 3 | 3 | 1 | T | 3 | 2 |
| Astralagus sp. | milkvetch sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Astralagus succumbens | Columbia milkvetch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Calochortus macrocarpus | mariposa lily | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chaenactis douglasii | false yarrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Eriogonum niveum | snow buckwheat | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 3 | 7 | 5 | 50 | 1 | T | 1 | 1 | 1 | T | 0 | 0 | 1 | T |
| Gutierrezia sarothrae | matchbrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | T | 1 | T | 0 | 0 |
| Lactuca serriola | prickly lettuce | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Machaeranthera canescens | hoary aster | 1 | T | 0 | 0 | 2 | T | 0 | T | 1 | T | 0 | 0 | 1 | T |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Opuntia polyacantha | prickly pear | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 0 | 0 | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 1 | T |
| Psoralidium lanceolatum | scurfpea | 3 | 5 | 3 | 18 | 4 | 12 | 4 | 12 | 3 | 10 | 1 | T | 3 | 6 |
| Pteryxia terebinthina | turpentine cymopterus | 1 | T | 3 | T | 3 | T | 3 | T | 1 | T | 1 | T | 1 | T |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 1 | T | 1 | 1 | 0 | 0 | 0 | 0 | 1 | T |
| Sisymbrium altissimum | Jim Hill mustard | 3 | T | 3 | 1 | 3 | T | 3 | T | 1 | T | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 1 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| Triteleia grandiflora | Douglas' brodiaea | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | T | 1 | T | 3 | T | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 |
| Ericameria nauseosa | gray rabbitbrush | 3 | 2 | 0 | 0 | 0 | 0 | 3 | T | 3 | T | 2 | T | 2 | 2 |
| | Combined cover: | 69.5 | | 124.5 | | 93.5 | | 85 | | 79.5 | | 67.5 | | 112 | |
| | Perennial cover: | 11 | | 35 | | 30.5 | | 31.5 | | 30.5 | | 3 | | 40 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 0 | | 695 | | 383 | | 77 | | 91 | | 17 | | 47.5 | |

| Plot 4 | Substrates | Date: 5/5/87 | | Date: 5/12/08 | | Date: 5/4/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/23/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 70 | xxx | 45 | xxx | 35 | xxx | 22 | xxx | 20 | xxx | 20 | xxx | 4 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 1 | xxx | 1 | xxx | T | xxx | 2 |
| | Litter / Mulch | xxx | 25 | xxx | 1 | xxx | 5 | xxx | 10 | xxx | 20 | xxx | 15 | xxx | 7 |
| | Mosses / Lichens | xxx | T | xxx | T | xxx | T | xxx | T | xxx | T | xxx | T | xxx | 5 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 3 | 7 | 4 | 25 | 5 | 30 | 5 | 40 | 4 | 25 | 5 | 45 | 5 | 50 |
| Hesperostipa comata | needle-and-thread grass | 3 | 1 | 4 | 12 | 4 | 18 | 4 | 22 | 4 | 20 | 3 | 10 | 4 | 35 |
| Poa secunda | Sandberg's bluegrass | 3 | 1 | 3 | 8 | 4 | 8 | 4 | 3 | 3 | 12 | 3 | 10 | 2 | 7 |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sand verbena | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Achillea millefolium | yarrow | 1 | T | 1 | T | 2 | T | 2 | T | 3 | T | 2 | T | 2 | 1 |
| Ambrosia sp. | bursage | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 0 | 0 | 2 | T | 2 | T | 2 | T | 3 | T | 1 | T | 2 | 1 |
| Astragalus sclerocarpus | stalk-pod milk-vetch | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 0 | 0 |
| Calochortus macrocarpus | sagebrush mariposa | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| Chaenactis douglasii | false-yarrow | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 1 | T |
| Descurainia pinnata | western tansymustard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Chondrilla juncea | rush skeletonweed | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 1 | T | 1 | T | 0 | 0 |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Erodium cicutarium | filaree | 3 | 3 | 5 | 20 | 1 | T | 1 | T | 2 | T | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 2 | T | 2 | T | 2 | 1 | 3 | 1 | 3 | T | 1 | 2 |
| Lactuca serriola | prickly lettuce | 2 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 2 | T | 0 | 0 | 1 | T |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 3 | 3 | 2 | T | 2 | T | 2 | T | 1 | T | 2 | 1 |
| Opuntia polyacantha | prickly pear | 2 | T | 1 | T | 2 | T | 2 | T | 1 | T | 1 | T | 1 | T |
| Phacelia hastata | silver-leafed phacelia | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Phacelia linearis | threadleaf phacelia | 1 | T | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| Phlox longifolia | long-leaf phlox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Plagiobithrys tenellus | slender popcorn flower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Psoralidium lanceolatum | scurfpea | 3- | 1 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 7 | 3 | 1 | 3 | 3 |
| Pteryxia terebinthina | turpentine cymopterus | 1 | T | 3 | 2 | 3 | T | 3 | 1 | 0 | 1 | 3 | 1 | 3 | 2 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 1 |
| Sisymbrium altissimum | Jim Hill mustard | 3- | T | 3 | 1 | 3 | T | 3 | T | 3 | T | 2 | T | 1 | T |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Triteleia grandiflora | largeflower triteleia | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Ericameria nauseosa | gray rabbitbrush | 5 | 20 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| | Combined cover: | 37 | | 78 | | 64.5 | | 79.5 | | 71.5 | | 73 | | 104 | |
| | Perennial cover: | 24 | | 30 | | 31.5 | | 33.5 | | 43.5 | | 26 | | 53 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 50 | | 185 | | 482 | | 339 | | 805 | | 222.5 | | 197.5 | |

| Plot 5 | | Date: 5/5/87 | | Date: 5/12/08 | | Date: 5/4/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/23/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare ground | xxx | 30 | xxx | 15 | xxx | 20 | xxx | 20 | xxx | T | xxx | 15 | xxx | 4 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 8 | xxx | 8 | xxx | 8 | xxx | 20 | xxx | 10 | xxx | 7 |
| | Mosses / Lichens | | 10 | | 1 | 1 | 1 | | T | | T | xxx | T | xxx | 4 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 5 | 20 | 5 | 38 | 5 | 40 | 5 | 40 | 5 | 40 | 4 | 35 | 4 | 40 |
| Hesperostipa comata | needle-and-thread grass | | | | | | | | | | | 1 | T | 3 | 2 |
| Poa secunda | Sandberg's bluegrass | 3 | 2 | 3 | 12 | 4 | 15 | 4 | 18 | 3 | 22 | 4 | 35 | 4 | 30 |
| **Forbs** | | | | | | | | | | | | | | | |
| Amsinkia sp. | fiddleneck | 0 | 0 | 1 | T | 2 | T | 2 | T | 3 | T | 1 | T | 1 | T |
| Chaenactis douglasii | false yarrow | 1 | T | 0 | 0 | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 3 | 2 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Descurainia pinnata | western tansymustard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 3□ | 10 | 3 | 10 | 1 | T | 1 | 1 | 2 | T | 0 | 0 | 2 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 1 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Lomatium macrocarpum | biscuit root | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Opuntia polyacantha | prickly pear | 3□ | 3 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phacelia linearis | threadleaf phacelia | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Phlox longifolia | longleaf phlox | 1 | T | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 0 | 0 |
| Plagiobithrys tenellus | slender popcornflower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Psoralidium lanceolatum | scurfpea | 4 | 30 | 4 | 35 | 4 | 25 | 4 | 20 | 3 | 15 | 3 | 1 | 3 | 25 |
| Pteryxia terebinthina | turpentine cymopterus | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 2 | T | 3 | 1 | 3 | 3 |
| Salsola kali | Russina thistle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | T | 1 | T |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 3 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | T | 1 | T | 3 | T | 3 | T | 3 | 1 | 1 | T | 3 | 1 |
| Ericameria nauseosa | gray rabbitbrush | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Combined cover: | 69.5 | | 99.5 | | 85 | | 85.5 | | 79.5 | | 76 | | 105 | |
| | Perennial cover: | 38 | | 50 | | 42.5 | | 41 | | 38.5 | | 38 | | 63 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 20 | | 830 | | 255 | | 143 | | 142 | | 153.5 | | 194 | |

| Plot 6 | | Date: 5/5/87 | | Date: 5/14/08 | | Date: 5/4/10 | | Date: 5/17/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/23/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare ground | xxx | 75 | xxx | 12 | xxx | 10 | xxx | 10 | xxx | 10 | xxx | 15 | | 1 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | | 2 |
| | Litter / Mulch | xxx | 15 | xxx | 15 | xxx | 2 | xxx | 5 | xxx | 5 | xxx | 7 | | 10 |
| | Mosses / Lichens | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 1 | | 14 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 3 | 7 | 4 | 40 | 4 | 30 | 4 | 30 | 4 | 30 | 4 | 30 | 3 | 20 |
| Elymus lanceolata | thickspike wheatgrass | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Hesperostipa comata | needle-and-thread grass | 5 | 7 | 4 | 35 | 5 | 40 | 5 | 30 | 4 | 35 | 4 | 30 | 5 | 45 |
| Poa secunda | Sandberg's bluegrass | 3 | 2 | 2 | 1 | 4 | 20 | 4 | 15 | 3 | 12 | 3 | 4 | 3 | 8 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 2 | T | 3 | T | 3 | 1 | 3 | 2 | 3 | 2 | 1 | T | 3 | 2 |
| Agroseris heterophylla | annual agroseris | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ambrosia sp. | bursage | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 1 | T | 2 | T | 2 | T | 2 | T | 2 | T | 1 | T | 2 | 1 |
| Antennaria dimorpha | pussytoes | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Astralagus sclerocarpus | stalk-pod milk-vetch | 1 | T | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 1 | T |
| Balsamorhiza careyana | Carey's balsamroot | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 1 | T | 0 | 0 |
| Chaenactis douglasii | false yarrow | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 1 | T |
| Eriogonum niveum | snow buckwheat | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T |
| Erodium cicutarium | filaree | 0 | 0 | 2 | T | 1 | T | 1 | 1 | 2 | T | 0 | 0 | 0 | 0 |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T | 2 | 1 |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | 1 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Opuntia polyacantha | prickly pear | 2 | T | 1 | T | 2 | T | 0 | 0 | 1 | T | 1 | T | 1 | T |
| Phlox longifolia | longleaf phlox | 3 | T | 3 | 2 | 3 | 7 | 3 | 8 | 3 | 1 | 3 | 1 | 3 | 6 |
| Plagiobithrys tenellus | slender popcornflower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Plantago patagonica | hairy plantain | 0 | 0 | 1 | T | 2 | T | 2 | 1 | 0 | 0 | 1 | T | 1 | T |
| Psoralidium lanceolatum | scurfpea | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 3 | 5 | 2 | T | 3 | 7 |
| Pteryxia terebinthina | turpentine cymopterus | 2 | T | 3 | 1 | 2 | T | 2 | T | 2 | T | 2 | T | 0 | 0 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 3 | 2 |
| Sisymbrium altissimum | Jim Hill mustard | 1 | T | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 0 | 0 |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 0 | 0 | 0 | 0 |
| Triteleia grandiflora | largeflower triteleia | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 2 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 3 | 1 | T | 2 | T | 2 | T | 3 | T | 0 | 0 | 3 | 2 |
| | Combined cover: | 26.5 | | 87.5 | | 108 | | 94.5 | | 89.5 | | 72.5 | | 97 | |
| | Perennial cover: | 17.5 | | 44.5 | | 73.5 | | 58.5 | | 57.5 | | 40 | | 76 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 250 | | 300 | | 553 | | 265 | | 386 | | 311.5 | | 408 | |

| Plot 7 | Substrates | Date: 5/5/87 | | Date: 5/12/08 | | Date: 5/5/10 | | Date: 5/17/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 80 | xxx | 5 | xxx | 20 | xxx | 15 | xxx | 2 | xxx | 3 | xxx | 1 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 20 | xxx | 13 | xxx | 5 | xxx | 10 | xxx | 15 | xxx | 25 | xxx | 8 |
| | Mosses / Lichens | 2 | 2 | 1 | T | 1 | T | 1 | T | 1 | T | xxx | T | xxx | 6 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Bromus tectorum | cheatgrass | 4 | 15 | 5 | 60 | 5 | 60 | 5 | 60 | 5 | 50 | 5 | 50 | 4 | 55 |
| Elymus elymoides | squirreltail | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 0 | 0 | 2 | T | 0 | 0 |
| Hesperostipa comata | needle-and-thread grass | 2 | T | 1 | T | 2 | 1 | 2 | 1 | 3 | 2 | 3 | 3 | 4 | 45 |
| Poa secunda | Sandberg's bluegrass | 2 | T | 3 | 1 | 2 | T | 2 | T | 2 | T | 2 | T | 3 | 12 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | 2 | 1 | T | 1 | T | 0 | 0 | | | | |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 0 | 0 | 0 | 0 | 2 | T | 2 | 1 | 3 | T | 3 | T | 3 | 2 |
| Achnatherum hymenoides | indian ricegrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Agroseris heterophylla | annual agroseris | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ambrosia sp. | bursage | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 2 | T | 3 | 1 | 2 | T | 2 | T | 2 | T | 1 | T | 2 | 2 |
| Aster sp. | aster sp. | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astralagus succumbens | Columbia milkvetch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 2 | T | 1 | T |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 3 | 5 | 4 | 15 | 4 | 15 | 3 | 10 | 2 | T | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 1 | T | 1 | T | 1 | 1 | 3 | 1 | 2 | 1 | 2 | 2 |
| Lactuca serriola | prickly lettuce | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 1 | T |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 2 | T | 1 | T |
| Plantago patagonica | hairy plantain | 1 | T | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Psoralidium lanceolatum | scurfpea | 3 | 2 | 3 | 2 | 4 | 8 | 4 | 10 | 3 | 8 | 3 | 2 | 3 | 10 |
| Sisymbrium altissimum | Jim Hill mustard | 3 | T | 3 | T | 2 | 1 | 2 | T | 2 | T | 2 | T | 1 | T |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T |
| Triteleia grandiflora | douglas' brodiaea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 4 | 6 | 3 | 1 | 2 | T | 2 | T | 3 | T | 3 | 3 | 3 | 4 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 5 | 3 | 1 | 2 | T | 2 | T | 3 | T | 3 | 2 | 3 | 2 |
| | Combined cover: | 38.5 | | 86.5 | | 91.5 | | 88.5 | | 67 | | 67 | | 135 | |
| | Perennial cover: | 16 | | 7.5 | | 13 | | 15.5 | | 13.5 | | 5 | | 78 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 10 | | 60 | | 156 | | 153 | | 218 | | 107 | | 33 | |

| Plot 8 | | Date: 5/5/87 | | Date: 5/13/08 | | Date: 5/5/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/29/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 70 | xxx | 10 | xxx | 2 | xxx | 5 | xxx | 5 | xxx | 2 | xxx | 1 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 15 | xxx | 10 | xxx | 5 | xxx | 5 | xxx | 10 | xxx | 8 | xxx | 5 |
| | Mosses / Lichens | 1 | T | | 4 | 3 | 5 | 1 | T | 1 | T | xxx | T | xxx | 4 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 2 | 1 |
| Bromus tectorum | cheatgrass | 5 | 15 | 5 | 55 | 5 | 55 | 5 | 45 | 5 | 40 | 5 | 35 | 4 | 30 |
| Elymus lanceolatus | thickspike wheatgrass | 0 | 0 | 3 | 2 | 1 | T | 1 | T | 3 | 20 | 3 | 15 | 3 | 13 |
| Hesperostipa comata | needle-and-thread grass | 3 | 15 | 4 | 30 | 4 | 40 | 4 | 45 | 3 | 5 | 3 | 15 | 4 | 40 |
| Poa secunda | Sandberg's bluegrass | 1 | T | 2 | 1 | 3 | 1 | 3 | 1 | 2 | T | 2 | T | 3 | 3 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vulpia sp. | fescue sp. | 2 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 2 | T | 3 | 1 | 2 | T | 2 | T | 2 | T | 2 | T | 3 | 1 |
| Agroseris heterophylla | annual agroseris | 1 | T | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Amsinkia sp. | fiddleneck | 1 | T | 3 | 2 | 2 | T | 2 | T | 3 | 1 | 2 | T | 3 | 1 |
| Aster sp. | aster sp. | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astragalus sclerocarpus | stalk-pod milk-vetch | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Balsamorhiza careyana | Carey's balsamroot | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Centauria diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 1 | T |
| Chaenactis douglasii | false yarrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 2 | T | 2 | 5 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Opuntia polyacantha | prickly pear cactus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Phacelia linearis | threadleaf phacelia | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 1 | T |
| Plagiobithrys tenellus | slender popcorn flower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Plantago patagonica | hairy plantain | 3- | T | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Psoralidium lanceolatum | scurfpea | 3 | 3 | 3 | 8 | 3 | 5 | 3 | 10 | 3 | 15 | 3 | 1 | 3 | 25 |
| Pteryxia terebinthina | turpentine cymopterus | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 2 | 2 |
| Sisymbrium altissimum | Jim Hill mustard | 1 | T | 1 | T | 2 | T | 2 | T | 2 | T | 2 | T | 3 | 2 |
| Stephanomeria paniculata | skeleton weed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | T | 3 | 1 | 3 | 1 | 3 | 1 | 3 | T | 3 | T | 3 | 4 |
| Ericameria nauseosa | gray rabbitbrush | 3 | 1 | 3 | 1 | 2 | T | 2 | 1 | 3 | T | 3 | T | 3 | 2 |
| | Combined cover: | 41 | | 109.5 | | 108 | | 109 | | 87.5 | | 71.5 | | 124 | |
| | Perennial cover: | 22 | | 45 | | 49.5 | | 60.5 | | 43 | | 33.5 | | 91 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 350 | | 540 | | 496 | | 374 | | 469 | | 220 | | 312.5 | |

| Plot 9 | | Date: 5/5/87 | | Date: 5/15/08 | | Date: 5/5/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/29/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 80 | xxx | 68 | xxx | 40 | xxx | 25 | xxx | T | xxx | 7 | xxx | 1 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 2 | xxx | 5 | xxx | 3 | xxx | 15 | xxx | 3 | xxx | 1 |
| | Mosses / Lichens | 1 | T | 1 | 0 | 1 | T | 1 | T | 1 | T | xxx | 3 | xxx | 10 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Agropyron cristatum | crested wheatgrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | T | 1 | T | 2 | 3 |
| Bromus tectorum | cheatgrass | 3 | 10 | 5 | 15 | 5 | 40 | 5 | 35 | 4 | 30 | 4 | 15 | 4 | 25 |
| Elymus lanceolatus | thickspike wheatgrass | 3 | 10 | 1 | T | 1 | T | 1 | 1 | 3 | 2 | 1 | T | 1 | T |
| Hesperostipa comata | needle-and-thread grass | 5 | 7 | 4 | 2 | 4 | 10 | 4 | 30 | 4 | 30 | 4 | 20 | 5 | 60 |
| Poa secunda | Sandberg's bluegrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Pseudoroegneria spicata | bluebunch wheatgrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 |
| Vulpia sp. | fescue sp. | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sandverbena | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Achillea millefolium | yarrow | 2 | T | 3 | 1 | 2 | T | 0 | 3 | 3 | 1 | 3 | 5 | 3 | 5 |
| Agroseris heterophylla | annual agroseris | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 1 | T | 3 | 1 | 2 | T | 0 | 0 | 2 | T | 2 | T | 2 | 2 |
| Aster sp. | aster sp. | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astragalus sclerocarpus | stalk-pod milk-vetch | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| Astralagus succumbens | Columbia milk-vetch | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Camissonia contorta | pale evening primrose | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Chaenactis douglasii | false yarrow | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 1 | T |
| Crepis atribarba | slender hawksbeard | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T |
| Descurainia pinnata | western tansy mustard | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Erodium cicutarium | filaree | 0 | 0 | 2 | 3 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 2 | T | 2 | T | 2 | 1 | 3 | 2 | 1 | T | 2 | 4 |
| Holosteum umbellatum | jagged chickweed | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | 1 | 0 | 0 | 0 | 0 | 1 | T |
| Microsteris gracilis | microsteris | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 3 | 2 | 1 | 1 | 1 | T | 2 | T | 1 | T | 1 | T |
| Phacelia linearis | threadleaf phacelia | 1 | T | 2 | T | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T |
| Phlox longifolia | longleaf phlox | 1 | T | 3 | 2 | 3 | 5 | 3 | 8 | 3 | 1 | 3 | 3 | 1 | T |
| Plagiobithrys tenellus | slender popcorn flower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Plantago patagonica | hairy plantain | 3 | 7 | 1 | T | 1 | T | 1 | 1 | 1 | T | 1 | T | 0 | 0 |
| Psoralidium lanceolatum | scurfpea | 3 | 5 | 3 | 1 | 3 | 1 | 1 | 1 | 3 | 3 | 0 | 0 | 3 | 3 |
| Pteryxia terebinthina | turpentine cymopterus | 0 | 0 | 3 | 1 | 2 | T | 2 | 2 | 2 | T | 3 | T | 1 | T |
| Salsola kali | Russian thistle | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 3 | 1 | 2 | T | 2 | 1 | 2 | T | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | 1 | 2 | T | 2 | T | 2 | T | 3 | T | 3 | 1 | 3 | 7 |
| Ericameria nauseosa | gray rabbitbrush | 1 | T | 2 | T | 2 | T | 2 | T | 3 | 1 | 3 | T | 2 | 2 |
| | Combined cover: | 45 | | 37 | | 66.5 | | 91 | | 75 | | 51 | | 114 | |
| | Perennial cover: | 25.5 | | 13 | | 21.5 | | 49.5 | | 42.5 | | 32 | | 86 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 300 | | 135 | | 1063 | | 320 | | 361 | | 256 | | 306 | |

| Plot 10 | Substrates | Date: 5/6/87 | | Date: 5/15/08 | | Date: 5/4/10 | | Date: 5/16/11 | | Date: 5/29/13 | | Date: 4/27/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 80 | xxx | 55 | xxx | 50 | xxx | 3 | xxx | 15 | xxx | 20 | xxx | 2 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 1 | xxx | 5 | xxx | 10 | xxx | 15 | xxx | 15 | xxx | 12 |
| | Mosses / Lichens | 2 | 2 | 1 | 0 | 1 | T | 1 | T | 1 | T | xxx | T | xxx | 5 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 1 | T | 0 | 0 | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T |
| Bromus tectorum | cheatgrass | 4 | 15 | 4 | 15 | 5 | 25 | 5 | 40 | 5 | 30 | 5 | 40 | 5 | 70 |
| Elymus lanceolatus | thickspike wheatgrass | 1 | T | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 1 | T |
| Hesperostipa comata | needle-and-thread grass | 3 | T | 1 | T | 3 | 2 | 3 | 10 | 3 | 10 | 3 | 4 | 4 | 20 |
| Poa secunda | Sandberg's bluegrass | 2 | T | 1 | T | 3 | T | 3 | 1 | 3 | T | 3 | 1 | 1 | 2 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | T | 0 | 0 |
| Vulpia sp. | fescue sp. | 0 | 0 | 0 | 0 | 0 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sandverbena | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Achillea millefolium | yarrow | 3 | 1 | 3 | T | 3 | T | 3 | 5 | 3 | 3 | 1 | T | 3 | 2 |
| Ambrosia sp. | bursage | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 3 | T | 1 | T | 2 | T | 2 | T | 3 | T | 1 | T | 1 | T |
| Astralagus sclerocarpus | stalk-pod milk-vetch | 1 | T | 1 | T | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Balsamorhiza careyana | Carey's balsamroot | 3 | T | 2 | T | 3 | T | 3 | T | 1 | T | 2 | T | 1 | T |
| Camissonia contorta | pale evening primrose | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Chaenactis douglasii | false yarrow | 0 | 0 | 1 | T | 2 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Eriogonum niveum | snow buckwheat | 1 | T | 1 | T | 3 | 1 | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 3 |
| Erodium cicutarium | filaree | 3 | 5 | 5 | 22 | 1 | 1 | 1 | 2 | 2 | T | 0 | 0 | 1 | T |
| Erysium capitatum | wallflower | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Lactuca serriola | prickly lettuce | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Layia glandulosa | white tidy-tips | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Macaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 0 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Microsteris gracilis | microsteris | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 2 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Opuntia polyacantha | prickly pear | 3 | 1 | 1 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T |
| Phacelia linearis | threadleaf phacelia | 3 | 1 | 0 | 0 | 3 | T | 3 | T | 0 | 0 | 1 | T | 1 | T |
| Phlox longifolia | longleaf phlox | 2 | T | 3 | 1 | 2 | 1 | 3 | 5 | 2 | T | 3 | T | 2 | 2 |
| Plagiobithrys tenellus | slender popcorn flower | 2 | T | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Psoralidium lanceolatum | scurfpea | 3 | 2 | 3 | 10 | 4 | 7 | 4 | 10 | 3 | 20 | 2 | T | 3 | 4 |
| Pteryxia terebinthina | turpentine cymopterus | 3 | 5 | 4 | T | 3 | T | 3 | 5 | 2 | T | 3 | 1 | 2 | 2 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 1 | T | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sisymbrium altissimum | Jim Hill mustard | 2 | T | 2 | T | 3 | T | 3 | T | 2 | T | 1 | T | 1 | T |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Triteleia grandiflora | largeflower triteleia | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | T | 1 | T | 3 | T | 3 | 1 | 3 | T | 3 | T | 3 | 2 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 2 | 1 | T | 3 | T | 3 | T | 0 | 0 | 0 | 0 | 1 | T |
| Purshia tridentata | antelope bitterbrush | 1 | T | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Combined cover: | 40.5 | | 57.5 | | 47 | | 95 | | 75 | | 56 | | 108 | |
| | Perennial cover: | 17.5 | | 17.5 | | 17 | | 44.5 | | 43.5 | | 14 | | 37 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 10 | | 530 | | 255 | | 184 | | 517 | | 97 | | 177.5 | |

| Plot 11 | | Date: 5□6□87 | | Date: 5□15□08 | | Date: 5□4□10 | | Date: 5□16□11 | | Date: 6□1□13 | | Date: 4□29□15 | | Date: 5□30□2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 60 | xxx | 55 | xxx | 45 | xxx | 25 | xxx | 15 | xxx | 3 | xxx | 8 |
| | Gravel □ Stones | xxx | T | xxx | T | xxx | T | xxx | T | xxx | T | xxx | T | xxx | 3 |
| | Litter □ Mulch | xxx | 15 | xxx | 1 | xxx | 2 | xxx | 2 | xxx | 3 | xxx | 3 | xxx | 1 |
| | Mosses □ Lichens | 3 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | xxx | 10 | xxx | 20 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 3 | 2 |
| Agropyron cristatum | crested wheatgrass | 2 | T | 4 | 8 | 3 | 8 | 3 | 6 | 3 | 7 | 4 | 10 | 3 | 10 |
| Bromus tectorum | cheatgrass | 3□ | 20 | 3 | 6 | 3 | 5 | 3 | 20 | 4 | 25 | 3 | 20 | 4 | 35 |
| Elymus lanceolatus | thickspike wheatgrass | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | T | 0 | 0 | 2 | 2 |
| Hesperostipa comata | needle-and-thread grass | 5 | 15 | 3 | 4 | 4 | 12 | 5 | 30 | 4 | 25 | 5 | 20 | 5 | 50 |
| Poa bulbosa | bulbous bluegrass | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 2 | 3 |
| Poa secunda | Sandberg's bluegrass | 3□ | 10 | 5 | 20 | 5 | 25 | 4 | 12 | 3 | 10 | 3 | 3 | 3 | 8 |
| Vulpia sp. | fescue sp. | 0 | 0 | 2 | 2 | 1 | T | 1 | 1 | 3 | 1 | 3 | 1 | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 1 | T | 2 | T | 2 | T | 2 | T | 3 | T | 1 | T | 2 | 2 |
| Agroseris heterophylla | annual agroseris | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T | 1 | T |
| Antennaria dimorpha | pussytoes | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astragalus sclerocarpus | stalk-pod milk-vetch | 0 | 0 | 1 | T | 1 | T | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astragalus succumbens | Columbia milk-vetch | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Balsamorhiza careyana | Carey's balsamroot | 1 | T | 2 | T | 3 | T | 3 | T | 2 | T | 1 | T | 2 | 2 |
| Calochortus macrocarpus | mariposa lily | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 2 | T | 0 | 0 | 1 | T |
| Chaenactis douglasii | false yarrow | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 1 | T | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Erodium cicutarium | filaree | 0 | 0 | 1 | 3 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Lithospermum ruderale | stoneseed | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 3 | 1 | 3 | 10 | 3 | 10 | 3 | 10 | 3 | 10 | 3 | 1 | 1 | T |
| Plantago patagonica | hairy plantain | 3 | 1 | T | T | 1 | T | 1 | 1 | 2 | T | 2 | T | 1 | T |
| Psoralidium lanceolatum | scurfpea | 3 | 3 | 3 | 2 | 2 | T | 2 | T | 3 | 3 | 1 | T | 1 | T |
| Pteryxia terebinthina | turpentine cymopterus | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | 2 |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 1 | T |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | 2 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3- | T | 2 | T | 2 | T | 2 | 1 | 3 | 1 | 3 | 1 | 2 | 2 |
| Ericameria nauseosa | gray rabbitbrush | 4 | 5 | 2 | T | 2 | T | 2 | T | 3 | T | 3 | T | 2 | 3 |
| | Combined cover: | 59 | | 62 | | 69.5 | | 89 | | 88.5 | | 60.5 | | 123 | |
| | Perennial cover: | 37.5 | | 49 | | 60.5 | | 64 | | 59.5 | | 36.5 | | 84 | |
| | Est. lbs□acre air dry; perennial grass □ forbs: | 250 | | 835 | | 312 | | 135 | | 237 | | 158.5 | | 358.5 | |

| Plot 12 | | Date: 5/6/87 | | Date: 5/19/08 | | Date: 5/5/10 | | Date: 5/16/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Substrates | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 50 | xxx | 8 | xxx | 12 | xxx | 10 | xxx | 5 | xxx | 5 | xxx | 2 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 20 | xxx | 8 | xxx | 10 | xxx | 10 | xxx | 15 | xxx | 8 | xxx | 1 |
| | Mosses / Lichens | 3 | 10 | 1 | 1 | 2 | 1 | 1 | T | 1 | T | xxx | 2 | xxx | 15 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Bromus tectorum | cheatgrass | 4 | 25 | 5 | 50 | 5 | 40 | 5 | 45 | 5 | 40 | 4 | 40 | 5 | 45 |
| Elymus lanceolatus | thickspike wheatgrass | 1 | T | 1 | T | 1 | 1 | 1 | 2 | 2 | 1 | 1 | T | 3 | 7 |
| Hesperostipa comata | needle-and-thread grass | 4 | 5 | 4 | 25 | 4 | 25 | 4 | 25 | 4 | 30 | 3 | 15 | 4 | 25 |
| Hordeum murinum | mouse barley | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Poa bulbosa | bulbous bluegrass | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 3 | 5 |
| Poa secunda | Sandberg's bluegrass | 2 | T | 1 | 1 | 3 | 10 | 3 | 8 | 3 | 10 | 3 | 3 | 2 | 3 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 |
| Alyssum alyssoides | pale madwort | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Ambrosia spp. | bursage | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 0 | 0 | 3 | T | 3 | 1 | 3 | T | 3 | T | 3 | T | 3 | 10 |
| Asterace sp. | aster sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Astragalus succumbens | Columbia milk-vetch | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 2 | 1 |
| Calochortus macrocarpus | mariposa lily | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 2 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 2 | 1 |
| Cryptantha flaccida | weakstem cryptantha | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Cryptantha sp. | cryptantha | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 3 | 1 |
| Erigeron pumilis | shaggy daisy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T |
| Lactuca serriola | prickly lettuce | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 |
| lepidium perfoliatum | clasping peppergrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | 1 | 0 | T | 0 | 0 | 3 | 12 |
| Microsteris gracilis | microsteris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | T | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 1 | T | 1 | T | 2 | T | 2 | T | 0 | T | 0 | 0 | 1 | T |
| Plantago patagonica | hairy plantain | 1 | T | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T | 0 | 0 |
| Sisymbrium altissimum | Jim Hill mustard | 1 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T | 3 | 1 |
| Tragopogon dubius | salsify | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 0 | 0 | 3 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | 2 |
| Ericameria nauseosa | gray rabbitbrush | 0 | 0 | 3 | T | 2 | T | 2 | T | 2 | T | 3 | T | 1 | T |
| Artemisia tridentata | basin big sagebrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| | Combined cover: | 35 | | 83.5 | | 85 | | 88.5 | | 88.5 | | 65.5 | | 115 | |
| | Perennial cover: | 7.5 | | 29 | | 39.5 | | 39 | | 43.5 | | 20 | | 57 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 100 | | 40 | | 227 | | 142 | | 143 | | 101.5 | | 26.5 | |

| Plot 13 | Substrates | Date: 5/6/87 | | Date: 5/15/08 | | Date: 5/5/10 | | Date: 5/16/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 15 | xxx | 5 | xxx | 35 | xxx | 27 | xxx | 15 | xxx | 6 | xxx | 1 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 8 | xxx | 1 | xxx | 2 | xxx | 1 | xxx | 3 | xxx | 1 |
| | Mosses / Lichens | | 40 | 3 | 20 | 3 | 5 | 2 | 5 | 2 | 15 | xxx | 25 | xxx | 25 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 1 | T | 2 | T | 2 | T | 2 | T | 3 | T | 3 | 2 | 3 | 10 |
| Hesperostipa comata | needle-and-thread grass | 2 | T | 4 | 15 | 3 | 10 | 3 | 18 | 4 | 22 | 4 | 16 | 4 | 20 |
| Poa secunda | Sandberg's bluegrass | 3 | 20 | 3 | 20 | 5 | 30 | 5 | 25 | 3 | 10 | 3 | 3 | 4 | 40 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 5 | 15 | 4 | 20 | 4 | 20 | 4 | 20 | 4 | 15 | 5 | 25 | 5 | 30 |
| Vulpia sp. | fescue sp. | 0 | 0 | 3 | 15 | 1 | T | 1 | T | 2 | T | 3 | 5 | 2 | 1 |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T |
| Antennaria dimorpha | pussytoes | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Calochortus macrocarpus | sagebrush mariposa | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Cirsium undulatum | wavy leaved thistle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T |
| Lomatium macrocarpum | biscuit root | 2 | T | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T |
| Machaeranthera canescens | hoary aster | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 3 | 3 | 3 | 2 | 3 | 1 | 3 | 1 | 1 | T | 1 | T | 1 | T |
| Plantago patagonica | hairy plantain | 3- | 1 | 2 | 1 | 1 | T | 1 | 4 | 3 | 5 | 3 | 1 | 3 | 4 |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 1 | T | 1 | T | 2 | 1 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Ericameria nauseosa | gray rabbitbrush | 0 | 0 | 3 | T | 2 | T | 2 | T | 3 | T | 3 | T | 3 | 3 |
| Gutierrezia sarothrae | matchbrush | 3 | 1 | 3 | T | 0 | 0 | 2 | T | 3 | T | 3 | T | 2 | 2 |
| | Combined cover: | 43 | | 78 | | 66.5 | | 74.5 | | 58 | | 56 | | 112 | |
| | Perennial cover: | 41.5 | | 59 | | 63.5 | | 66.5 | | 50 | | 45.5 | | 96 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 300 | | 300 | | 780 | | 937 | | 291 | | 176.5 | | 247.5 | |

| Plot 14 | | Date: 5/6/87 | | Date: 5/13/08 | | Date: 5/5/10 | | Date: 5/23/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Substrates** | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 40 | xxx | 10 | xxx | 30 | xxx | 25 | xxx | 10 | xxx | 12 | xxx | 4 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 5 | xxx | 1 | xxx | 1 | xxx | 2 | xxx | 3 | xxx | 3 |
| | Mosses / Lichens | 3□ | 30 | 3 | 40 | 3 | 10 | 3 | 10 | 3 | 5 | xxx | 25 | xxx | 8 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 3 | 2 | 2 | 3 | 2 | T | 2 | 5 | 3 | 5 | 3 | 10 | 4 | 40 |
| Elymus elymoides | squirreltail | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Hesperostipa comata | needle-and-thread grass | 4 | 5 | 4 | 15 | 4 | 15 | 4 | 15 | 4 | 25 | 3 | 12 | 3 | 2 |
| Poa bulbosa | bulbous bluegrass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Poa secunda | Sandberg's bluegrass | 4 | 20 | 4 | 20 | 5 | 30 | 5 | 30 | 3 | 10 | 4 | 20 | 3 | 12 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 3 | 1 | 5 | 8 | 3 | 10 | 3 | 10 | 1 | 30 | 4 | 20 | 4 | 40 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Antenarria dimorpha | pussytoes | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Calochortus macrocarpus | sagebrushmariposa | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 1 | T | 2 | 1 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 3 | 1 |
| Conyza canadensis | horseweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Erigeron filifolius | cushion fleabane | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erigeron pumilis | shaggy fleabane | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 3 | 7 |
| Erodium cicutarium | filaree | 3 | 2 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 3 | 2 |
| Lactuca serriola | prickly lettuce | 2 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Linum lewisii | prairie flax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Lomatium macrocarpum | biscuit root | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 2 | 2 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 1 | T |
| Phlox longifolia | longleaf phlox | 3 | 1 | 2 | 1 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | T |
| Plantago patagonica | hairy plantain | 3□ | 10 | 3 | 10 | 1 | T | 1 | 1 | 3 | 1 | 3 | 3 | 3 | 3 |
| Sisimbriam altissima | tumble mustard | 0 | 0 | 0 | 0 | 2 | T | 2 | T | 1 | T | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 3 | 1 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | T | 2 | 1 |
| Ericameria nauseosa | gray rabbitbrush | 3 | T | 3 | 5 | 3 | 3 | 2 | 3 | 3 | 7 | 3 | 5 | 4 | 1 |
| Gutierrezia sarothrae | matchbrush | 3 | 1 | 3 | 10 | 2 | T | 3 | T | 3 | 8 | 3 | 2 | 0 | 0 |
| | Combined cover: | 44.5 | | 77 | | 67.5 | | 72 | | 92 | | 77 | | 113 | |
| | Perennial cover: | 29 | | 62 | | 64 | | 63.5 | | 84 | | 55.5 | | 66 | |
| | Est. lbs/acre air dry; perennial grass + forbs: | 80 | | 290 | | 666 | | 636 | | 336 | | 436 | | 230 | |

| Plot 15 | | Date: 5/7/87 | | Date: 5/14/08 | | Date: 5/5/10 | | Date: 5/23/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Substrates | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 10 | xxx | 10 | xxx | 30 | xxx | 30 | xxx | 20 | xxx | 15 | xxx | 2 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 7 | xxx | 8 | xxx | 1 | xxx | 1 | xxx | 2 | xxx | 2 | xxx | 2 |
| | Mosses / Lichens | 3□ | 35 | 2 | 30 | 2 | 1 | 2 | 2 | 2 | 3 | xxx | 25 | xxx | 22 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 3 | 6 | 3 | 3 | 2 | T | 2 | 2 | 3 | 5 | 3 | 4 | 3 | 15 |
| Elymus elymoides | squirreltail | 1 | T | 2 | 1 | 2 | 1 | 1 | T | 2 | T | 0 | 0 | 2 | 1 |
| Poa bulbosa | bulbous bluegrass | | | | | | | | | | | 1 | T | | |
| Poa secunda | Sandberg's bluegrass | 4 | 20 | 4 | 25 | 4 | 30 | 4 | 30 | 3 | 30 | 3 | 15 | 4 | 30 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 4 | 3 | 5 | 28 | 5 | 35 | 5 | 35 | 5 | 35 | 5 | 45 | 4 | 50 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 2 |
| **Forbs** | | | | | | | | | | | | | | | |
| Antennaria dimorpha | pussytoes | 1 | T | 2 | T | 1 | T | 1 | T | 1 | T | 2 | T | 1 | T |
| Calochortus macrocarpus | sagebrush mariposa | 0 | 0 | 1 | T | 1 | T | 1 | T | 3 | 1 | 2 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 2 | 1 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Erigeron filifolius | cushion fleabane | 1 | T | 2 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Erigeron pumilus | shaggy fleabane | 1 | T | 2 | T | 1 | T | 1 | T | 1 | T | 1 | T | 2 | 1 |
| Erodium cicutarium | filaree | 3 | 15 | 1 | T | 1 | T | 1 | T | 2 | T | 0 | 0 | 2 | 1 |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 |
| Lactuca serriola | prickly lettuce | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T | 2 | 1 |
| Lomatium macrocarpum | biscuit root | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Madia glomerata | cluster tarweed | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 0 | 0 | 2 | 1 |
| Plantago patagonica | hairy plantain | 0 | 0 | 1 | T | 2 | T | 1 | T | 0 | 0 | 2 | T | 3 | 2 |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 2 | T | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 3 | 1 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Artemisia tridentata | basin big sagebrush | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chrysothamnus viscidiflorus | green rabbitbrush | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Ericameria nauseosa | gray rabbitbrush | 3 | 7 | 3 | 10 | 2 | 5 | 3 | 5 | 3 | 10 | 2 | T | 3 | 2 |
| Gutierrezia sarothrae | matchbrush | 0 | 0 | 3 | 2 | 2 | T | 2 | T | 3 | T | 1 | T | 2 | 1 |
| | Combined cover: | 58.5 | | 74.5 | | 78 | | 79 | | 87.5 | | 69.5 | | 109 | |
| | Perennial cover: | 37.5 | | 68.5 | | 74 | | 74 | | 80 | | 61 | | 85 | |
| | Est. lbs/acre air dry; perennial grass □ forbs: | 200 | | 215 | | 1191 | | 780 | | 921 | | 430.5 | | 89.5 | |

| Plot 16 | | Date: 5/7/87 | | Date: 5/14/08 | | Date: 5/5/10 | | Date: 5/17/11 | | Date: 5/30/13 | | Date: 4/28/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Substrates | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover | Dom-inance | Canopy Cover |
| | Bare Ground | xxx | 7 | xxx | 15 | xxx | 20 | xxx | 15 | xxx | 15 | xxx | 5 | xxx | 3 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | 0.5 | xxx | 1 |
| | Litter / Mulch | xxx | 10 | xxx | 12 | xxx | 5 | xxx | 5 | xxx | 5 | xxx | 3 | xxx | 5 |
| | Mosses / Lichens | | 30 | 2 | 25 | 2 | 1 | 2 | 1 | 1 | 1 | xxx | 10 | xxx | 20 |
| **Scientifc name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Bromus tectorum | cheatgrass | 3 | 10 | 3 | 8 | 3 | 3 | 3 | 5 | 3 | 8 | 4 | 15 | 3 | 8 |
| Elymus elymoides | squirreltail | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Hesperostipa comata | needle-and-thread grass | 5 | 7 | 5 | 15 | 4 | 20 | 4 | 25 | 4 | 30 | 2 | 1 | 4 | 30 |
| Poa secunda | Sandberg's bluegrass | 3 | 30 | 3 | 20 | 5 | 30 | 5 | 30 | 3 | 20 | 3 | 4 | 4 | 20 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 3 | 2 | 4 | 10 | 4 | 20 | 4 | 20 | 4 | 25 | 5 | 20 | 4 | 30 |
| Vulpia sp. | fescue sp. | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T |
| **Forbs** | | | | | | | | | | | | | | | |
| Amsinkia sp. | fiddleneck | 0 | 0 | 1 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T |
| Antennaria dimorpha | pussytoes | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Balsamorhiza careyana | Carey's balsamroot | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Calochortus macrocarpus | sagebrush mariposa | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | TT | 0 | 0 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 2 | 1 |
| Descurania pinnata | western tansy mustard | 0 | 0 | 0 | 0 | 1 | T | 0 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 0 | 0 | 2 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Erigeron filifolius | cushion fleabane | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Erigeron pumilus | woolly fleabane | 1 | T | 1 | T | 0 | 0 | 1 | 0 | 2 | T | 0 | 0 | 3 | 2 |
| Erodium cicutarium | filaree | 3 | 3 | 2 | 1 | 3 | 2 | 2 | 2 | 1 | T | 0 | 0 | 3 | 1 |
| Lactuca serriola | prickly lettuce | 1 | T | 0 | 0 | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Lomatium macrocarpum | biscuit root | 2 | T | 1 | T | 2 | 1 | 2 | 1 | 2 | T | 1 | T | 3 | 2 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 1 | T | 2 | T | 2 | T | 1 | T | 0 | 0 | 2 | 1 |
| Penstemon acuminatus | penstemon | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phlox longifolia | longleaf phlox | 3 | 5 | 3 | 6 | 3 | 5 | 3 | 5 | 3 | 2 | 2 | T | 3 | 4 |
| Plantago patagonica | hairy plantain | 3- | 1 | 3 | 2 | 2 | T | 2 | T | 3 | 2 | 3 | 3 | 1 | T |
| Sisymbrium altissimum | Jim Hill mustard | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 2 | 1 |
| Tragopogon dubius | salsify | 0 | 0 | 0 | 0 | 2 | T | 1 | T | 1 | T | 1 | T | 2 | 1 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Artemisia tridentata | basin big sagebrush | 3 | T | 4 | 18 | 2 | T | 0 | 0 | 2 | T | 3 | T | 0 | 0 |
| Chrysothamnus viscidiflorus | green rabbitbrush | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gutierrezia sarothrae | matchbrush | 2 | T | 3 | 1 | 2 | T | 2 | T | 3 | 1 | 2 | T | 2 | 1 |
| | Combined cover: | 62 | | 85.5 | | 87 | | 94 | | 93 | | 48 | | 103 | |
| | Perennial cover: | 47.5 | | 73 | | 78 | | 83 | | 80.5 | | 26.5 | | 91 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 150 | | 255 | | 836 | | 240 | | 469 | | 226 | | 524.5 | |

| Plot 17 | | Date: 5/7/87 | | Date: 5/14/08 | | Date: 5/5/10 | | Date: 5/17/11 | | Date: 5/30/13 | | Date: 4/29/15 | | Date: 5/30/2017 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dom- | Canopy | Dom- | Canopy | Dom- | Canopy | Dom- | Canopy | Dom- | Canopy | Dom- | Canopy | Dom- | Canopy |
| | **Substrates** | inance | Cover | inance | Cover | inance | Cover | inance | Cover | inance | Cover | inance | Cover | inance | Cover |
| | Bare Ground | xxx | 75 | xxx | 20 | xxx | 25 | xxx | 15 | xxx | 12 | xxx | 5 | xxx | 3 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 2 |
| | Litter / Mulch | xxx | 10 | xxx | 10 | xxx | 5 | xxx | 5 | xxx | 3 | xxx | 10 | xxx | 5 |
| | Mosses / Lichens | 1 | T | xxx | 1 | 2 | 1 | 1 | 1 | 1 | 1 | xxx | 2 | xxx | 5 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian ricegrass | 1 | T | 2 | T | 2 | T | 2 | T | 0 | 0 | 2 | T | 3 | 6 |
| Bromus tectorum | cheatgrass | 3 | 3 | 4 | 30 | 5 | 35 | 5 | 35 | 5 | 40 | 4 | 20 | 3 | 20 |
| Elymus lanceolata | thickspike wheatgrass | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hesperostipa comata | needle-and-thread grass | 5 | 15 | 5 | 25 | 4 | 20 | 4 | 25 | 3 | 20 | 3 | 7 | 5 | 35 |
| Poa secunda | Sandberg's bluegrass | 3 | 3 | 3 | 10 | 3 | 10 | 3 | 8 | 3 | 10 | 4 | 15 | 3 | 5 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 3- | 1 | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T | 0 | 0 |
| Vulpia sp. | fescue sp. | 3 | 2 | 3 | 5 | 1 | T | 1 | T | 2 | T | 1 | T | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Abronia mellifera | white sand verbena | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Achillea millifolium | yarrow | 0 | 0 | 1 | T | 2 | T | 2 | T | 3 | T | 1 | T | 2 | 1 |
| Agoseris heterophylla | annual agoseris | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ambrosia sp. | bursage | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amsinkia sp. | fiddleneck | 2 | T | 3 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T |
| Antennaria dimorpha | pussytoes | 2 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T | 1 | T |
| Aster sp. | aster sp. | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astralagus sclerocarpus | stalk-pod milk-vetch | 1 | T | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astralagus succumbens | Columbia milk-vetch | 1 | T | 0 | 0 | 2 | T | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Balsamorhiza careyana | Carey's balsamroot | 0 | 0 | 3 | T | 2 | T | 2 | T | 1 | T | 2 | T | 1 | T |
| Calochortus macrocarpus | sagebrush mariposa | 2 | T | 1 | T | 1 | T | 1 | T | 1 | T | 2 | T | 2 | 1 |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 1 | T | 2 | T | 2 | 1 | 0 | 0 | 0 | 0 | 1 | T |
| Chaenactis douglasii | false yarrow | 0 | 0 | 1 | T | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Epilobium brachycarpum | tall annual willowherb | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erigeron filifolius | cushion fleabane | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T | 1 | T | 2 | 3 |
| Erodium cicutarium | filaree | 0 | 0 | 2 | 1 | 1 | T | 1 | T | 1 | T | 0 | 0 | 1 | T |
| Fritillaria pudica | yellow bells | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 3 | 1 | 1 | T | 1 | T | 1 | T | 1 | T | 2 | 1 |
| Lactuca serriola | prickly lettuce | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lomatium macrocarpum | biscuit root | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oenothera pallida | pale evening primrose | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Opuntia polyacantha | prickly pear | 2 | T | 2 | T | 2 | T | 2 | T | 1 | T | 2 | T | 2 | 1 |
| Phacelia linearis | threadleaf phacelia | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 |
| Phlox longifolia | longleaf phlox | 3 | 2 | 3 | 1 | 2 | T | 2 | 1 | 1 | T | 1 | T | 1 | T |
| Plantago patagonica | hairy plantain | 3 | 1 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | T | 1 | T |
| Psoralidium lanceolatum | scurfpea | 2 | T | 3 | 1 | 3 | 10 | 3 | 10 | 3 | 10 | 2 | 1 | 3 | 8 |
| Pteryxia terebinthina | turpentine cymopterus | 2 | T | 1 | T | 2 | T | 2 | T | 0 | 0 | 2 | T | 1 | 1 |
| Sisymbrium altissimum | Jim Hill mustard | 2 | T | 2 | T | 2 | T | 2 | T | 1 | T | 1 | T | 0 | 0 |
| Tragopogon dubius | salsify | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 1 | T | 1 | T | 0 | 0 | 2 | T | 2 | T | 1 | T | 2 | 1 |
| Ericameria nauseosa | gray rabbitbrush | 1 | T | 3 | T | 3 | T | 3 | T | 3 | T | 3 | T | 2 | 1 |
| Gutierrezia sarothrae | matchbrush | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Combined cover: | 35 | | 85.5 | | 89 | | 91.5 | | 89.5 | | 52 | | 84 | |
| | Perennial cover: | 27.5 | | 44 | | 48.5 | | 50.5 | | 45.5 | | 28.5 | | 64 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 250 | | 165 | | 340 | | 395 | | 397 | | 159 | | 60 | |

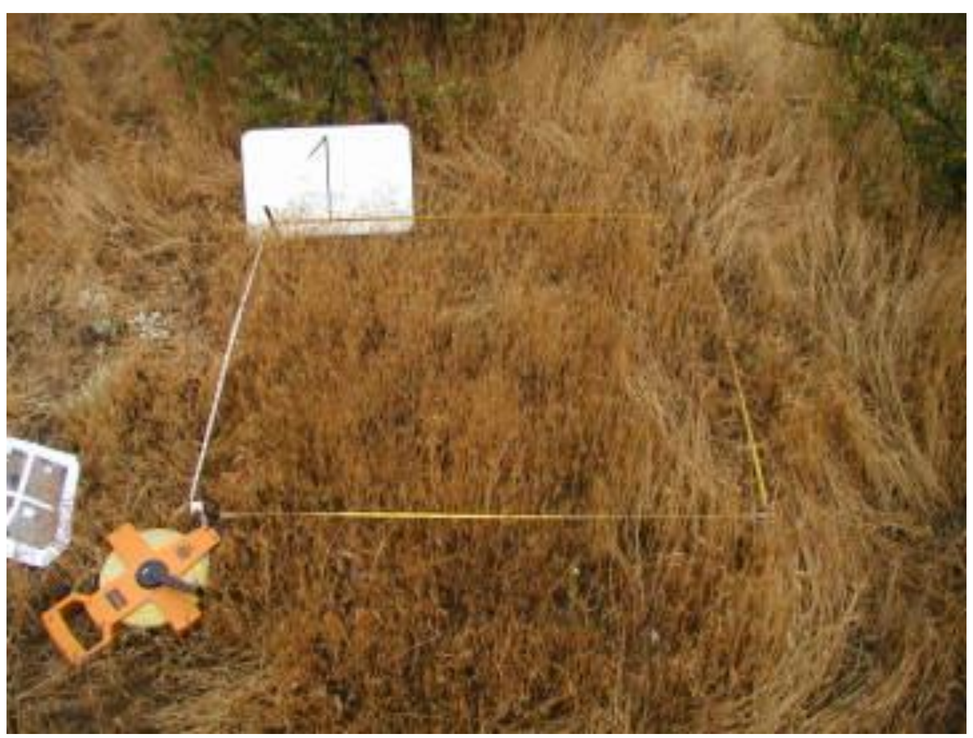
| Plot 18 | Substrates | Date: 5/7/87 Dom-inance | Canopy Cover | Date: 5/15/08 Dom-inance | Canopy Cover | Date: 5/18/10 Dom-inance | Canopy Cover | Date: 5/17/11 Dom-inance | Canopy Cover | Date: 5/30/13 Dom-inance | Canopy Cover | Date: 4/28/15 Dom-inance | Canopy Cover | Date: 5/23/2017 Dom-inance | Canopy Cover |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bare Ground | xxx | 40 | xxx | 8 | xxx | 15 | xxx | 15 | xxx | 12 | xxx | 5 | xxx | 4 |
| | Gravel / Stones | xxx | 0 | xxx | 0 | xxx | 0 | xxx | T | xxx | T | xxx | T | xxx | 1 |
| | Litter / Mulch | xxx | 20 | xxx | 12 | xxx | 10 | xxx | 5 | xxx | 3 | xxx | 4 | xxx | 7 |
| | Mosses / Lichens | 2 | 3 | 1 | 8 | 2 | 1 | 1 | 1 | 1 | 1 | xxx | 12 | xxx | 12 |
| **Scientific name** | **Common name** | | | | | | | | | | | | | | |
| **Grasses** | | | | | | | | | | | | | | | |
| Achnatherum hymenoides | Indian rice grass | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Bromus tectorum | cheatgrass | 4 | 10 | 3 | 15 | 3 | 5 | 3 | 8 | 4 | 15 | 4 | 20 | 4 | 30 |
| Elymus elymoides | squirreltail | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 |
| Hesperostipa comata | needle-and-thread grass | 5 | 15 | 5 | 35 | 4 | 25 | 5 | 33 | 4 | 20 | 3 | 15 | 4 | 20 |
| Poa secunda | Sandberg's bluegrass | 3 | 15 | 3 | 15 | 5 | 30 | 4 | 30 | 3 | 10 | 3 | 10 | 3 | 14 |
| Pseudoroegneria spicata | bluebunch wheatgrass | 3- | T | 3 | 5 | 2 | 1 | 2 | 1 | 3 | 5 | 3 | 4 | 1 | T |
| Vulpia sp. | fescue sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 0 | 0 |
| **Forbs** | | | | | | | | | | | | | | | |
| Achillea millefolium | yarrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Agoseris heterophylla | annual agoseris | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 0 | 0 | 1 | T | 1 | T |
| Amsinkia sp. | fiddleneck | 0 | 0 | 1 | T | 2 | T | 1 | T | 0 | 0 | 1 | T | 1 | 2 |
| Aster sp. | aster sp. | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Astragalus purshii | Pursh's milk-vetch | 1 | T | 0 | 0 | 0 | 0 | 0 | T | 1 | T | 0 | 0 | 1 | T |
| Astralagus succumbens | Columbia milk-vetch | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Calochortus macrocarpus | sagebrush mariposa | 1 | T | 0 | 0 | 1 | T | 1 | T | 2 | T | 2 | T | 1 | T |
| Centaurea diffusa | diffuse knapweed | 0 | 0 | 0 | 0 | 2 | T | 0 | 0 | 1 | T | 0 | 0 | 1 | T |
| Chaenactis douglasii | false yarrow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Cryptantha flaccida | weakstem cryptantha | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Erigeron filifolius | cushion fleabane | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 1 | T |
| Erigeron pumilis | shaggy daisy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Erodium cicutarium | filaree | 1 | T | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Heterotheca villosa | hairy golden-aster | 0 | 0 | 1 | T | 2 | T | 2 | T | 2 | T | 0 | 0 | 1 | T |
| Lactuca serriola | prickly lettuce | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Lomatium macrocarpum | biscuit root | 0 | 0 | 1 | T | 2 | T | 2 | T | 0 | 0 | 1 | T | 2 | 3 |
| Machaeranthera canescens | hoary aster | 0 | 0 | 2 | 1 | 1 | T | 2 | 2 | 1 | T | 0 | 0 | 3 | 3 |
| Madia glomerata | cluster tarweed | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 0 | 0 | 1 | T |
| Phlox longifolia | longleaf phlox | 1 | T | 2 | T | 2 | 1 | 2 | 1 | 2 | T | 2 | T | 1 | T |
| Plantago patagonica | hairy plantain | 3 | 1 | 1 | T | 2 | T | 2 | 1 | 2 | T | 1 | T | 2 | 1 |
| Salsola kali | Russian thistle | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | T |
| Sisymbrium altissimum | Jim Hill mustard | 1 | T | 2 | T | 2 | 1 | 2 | T | 0 | 0 | 2 | T | 3 | 1 |
| Stephanomeria paniculata | skeleton weed | 0 | 0 | 1 | T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tragopogon dubius | salisfy | 1 | T | 0 | 0 | 0 | 0 | 1 | T | 1 | T | 0 | 0 | 1 | T |
| **Shrubs** | | | | | | | | | | | | | | | |
| Chrysothamnus viscidiflorus | green rabbitbrush | 3 | T | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 7 | 4 | 12 | 3 | 5 |
| Ericameria nauseosa | gray rabbitbrush | 3 | 2 | 4 | 8 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 | 3 | 1 |
| | Combined cover: | 48.5 | | 86.5 | | 73.5 | | 86.5 | | 65 | | 71.5 | | 79 | |
| | Perennial cover: | 35.5 | | 69 | | 64.5 | | 74 | | 48.5 | | 31 | | 46 | |
| | Est. lbs/acre air dry; perennial grass / forbs: | 150 | | 245 | | 1063 | | 447 | | 444 | | 54.5 | | 120 | |

# Appendix B
# Range monitoring plot photos at NWSTF Boardman
# 1987, 2008, 2011, 2013, 2015 and 2017


1987


2008


2011



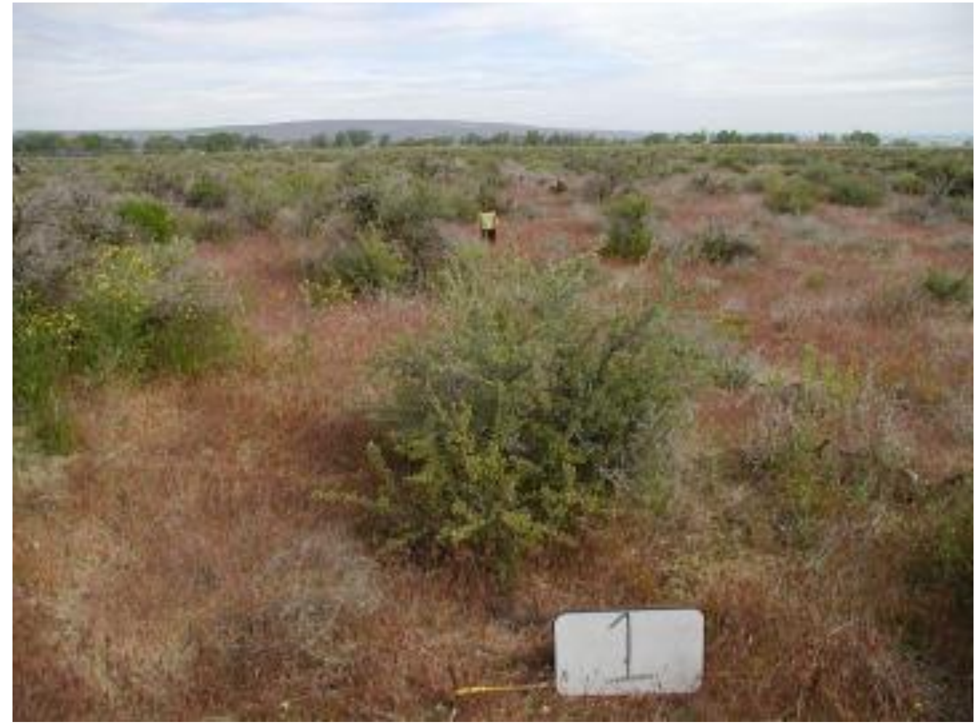

2013


2015


2017

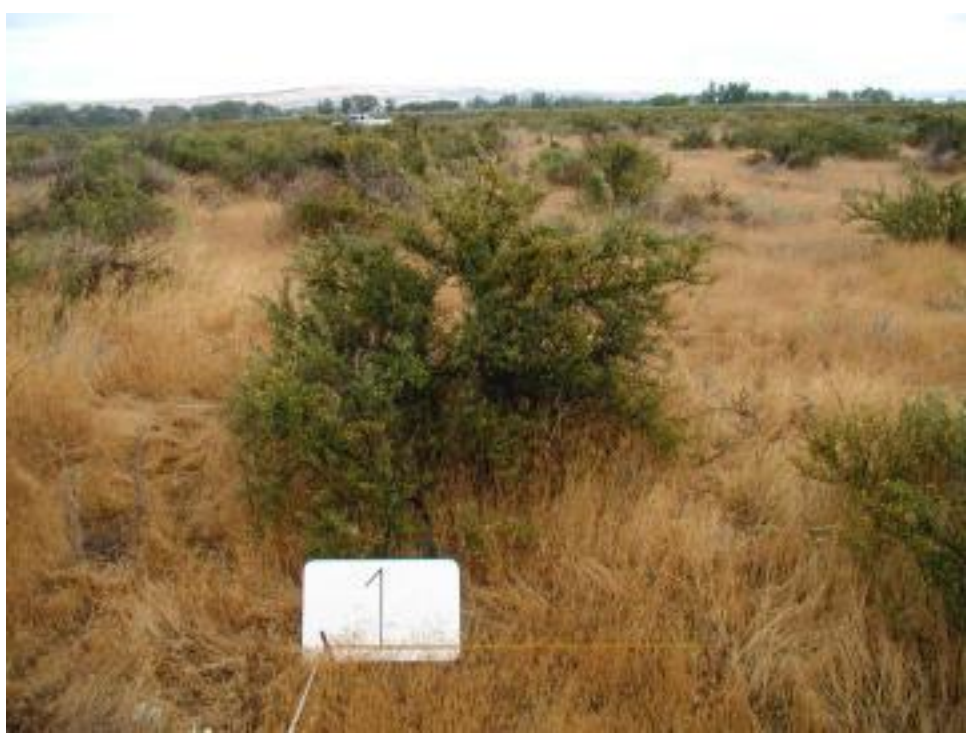
Figure B1a. Range monitoring plot at NWSTF Boardman – close-up photo


1987




2008


2011




2013

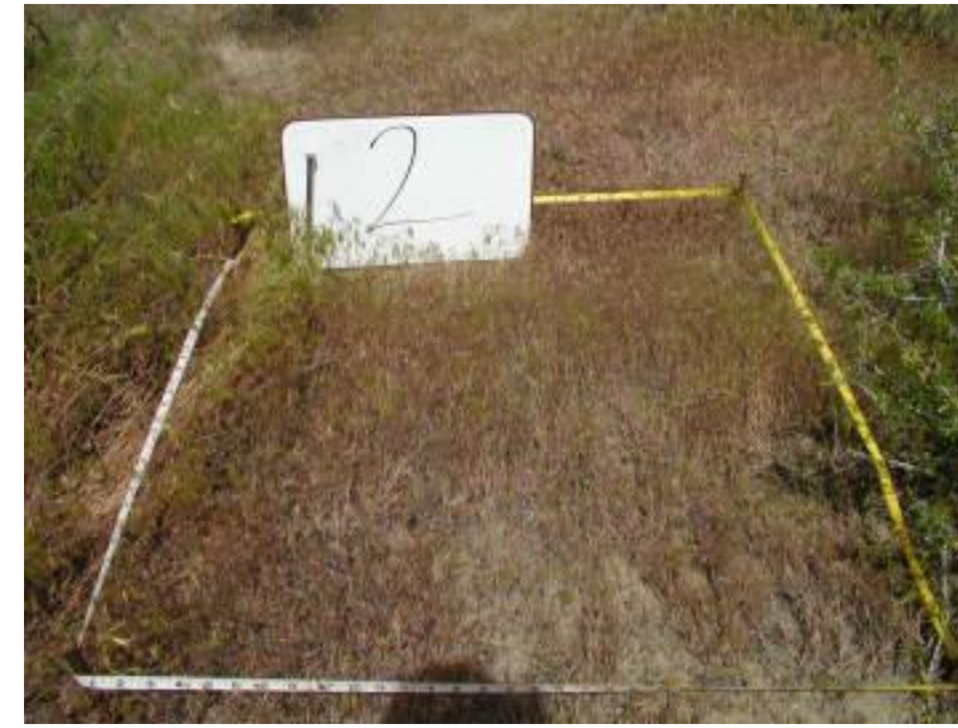

2015


2017

Figure B1b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008




2011

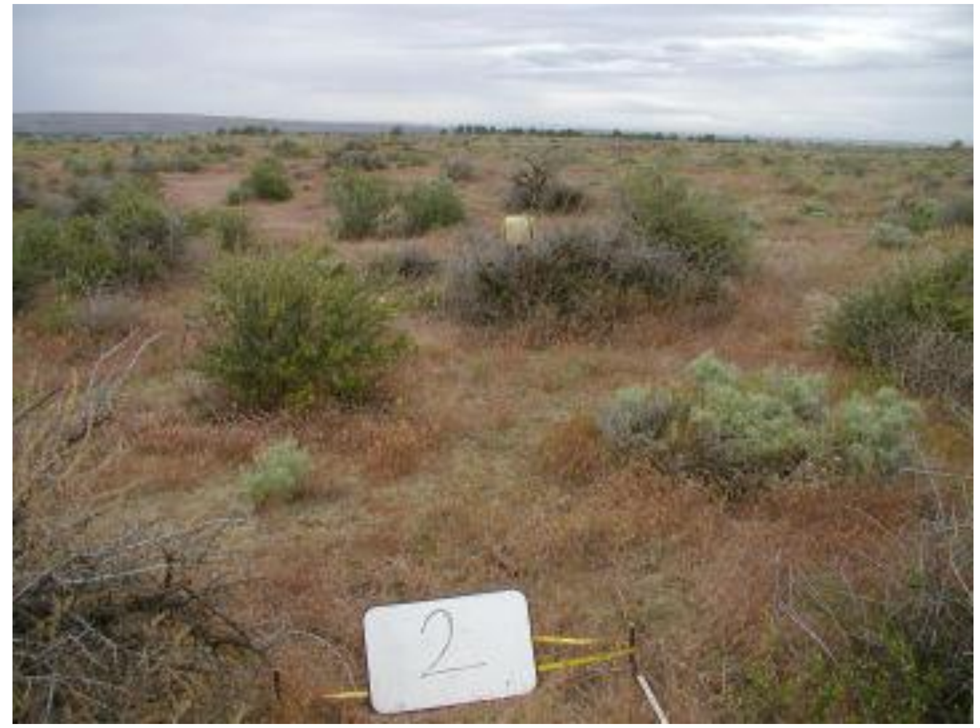
2013

2015

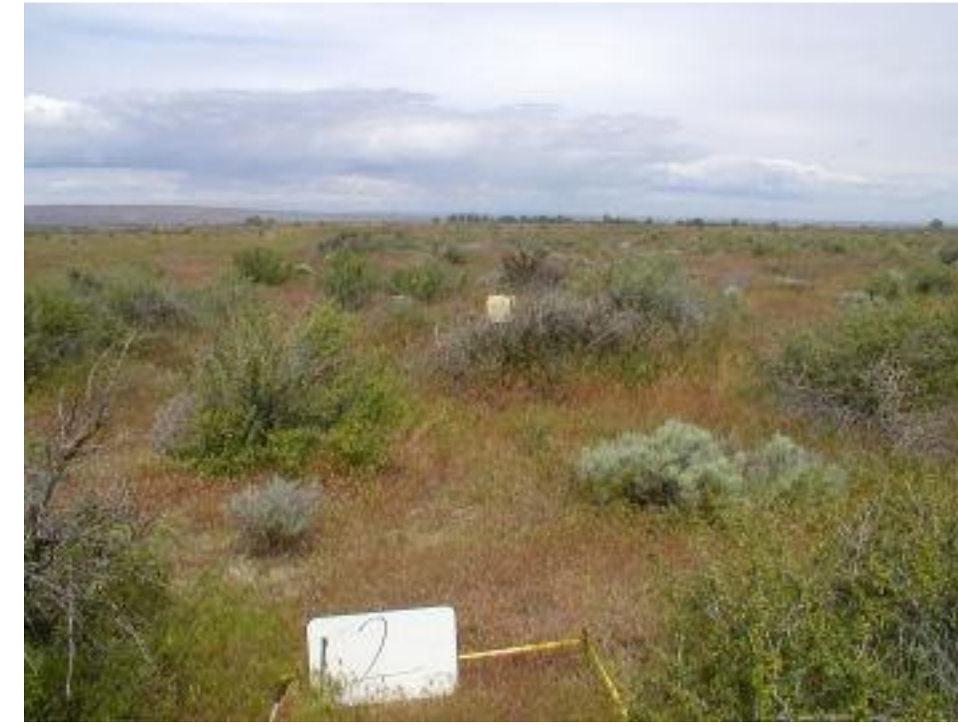
2017

Figure B2a. Range monitoring plot at NWSTF Boardman – close-up photo

1987



2008



2011

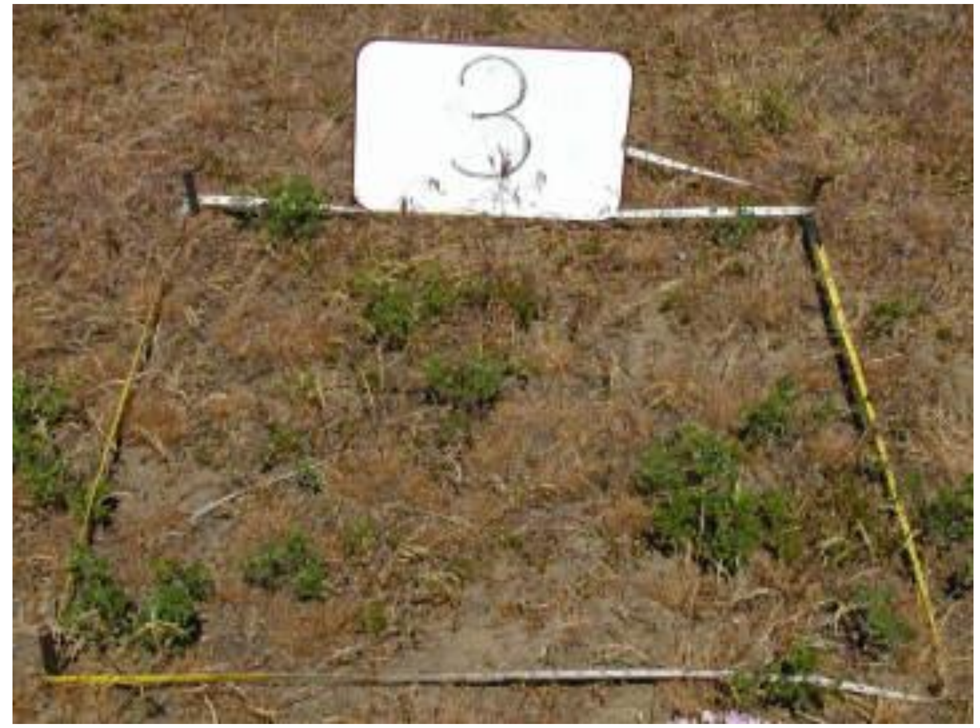
2013

2015

2017

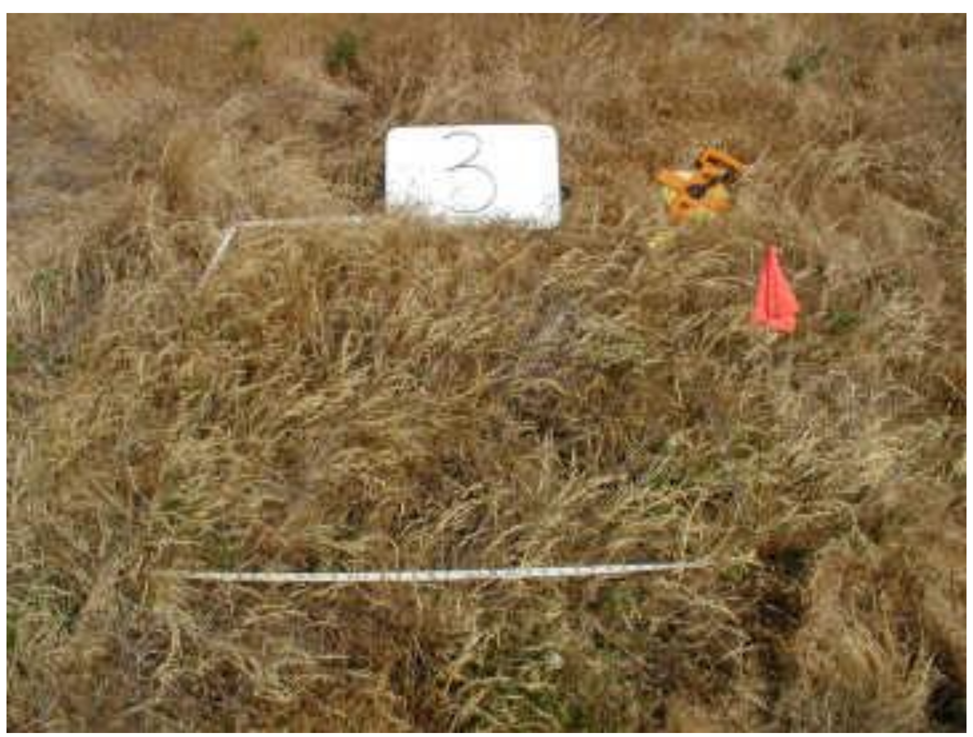
Figure B2b. Range monitoring plot at NWSTF Boardman – aspect photo


1987




2008


2011



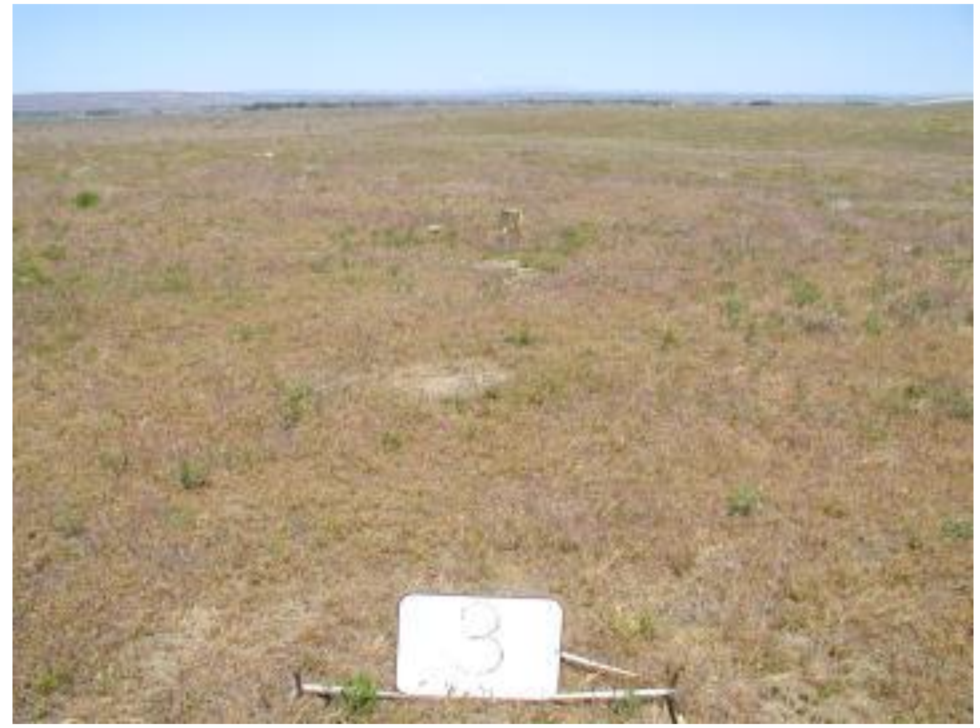

2013


2015


2017

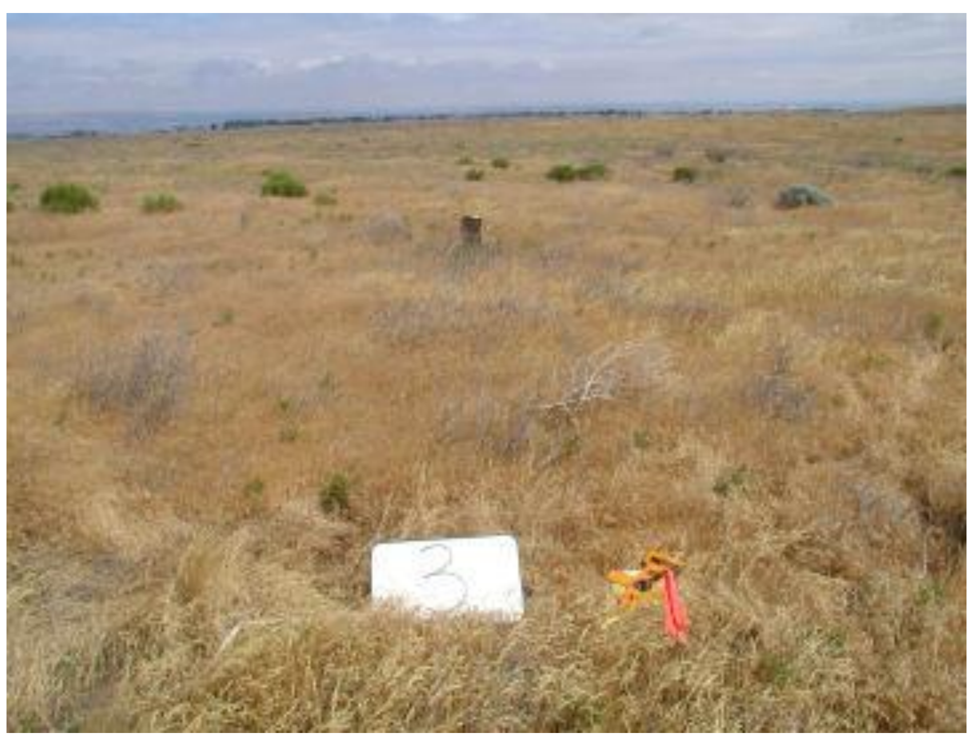
Figure B3a. Range monitoring plot at NWSTF Boardman – close-up photo


1987




2008


2011




2013


2015


2017

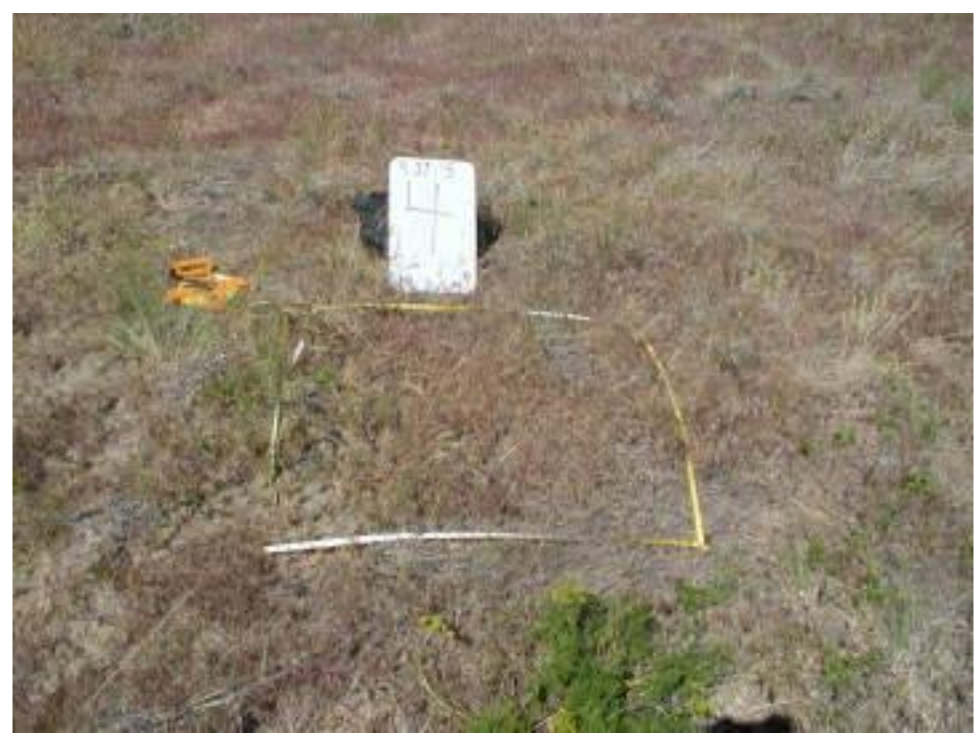
Figure B3b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011


2013



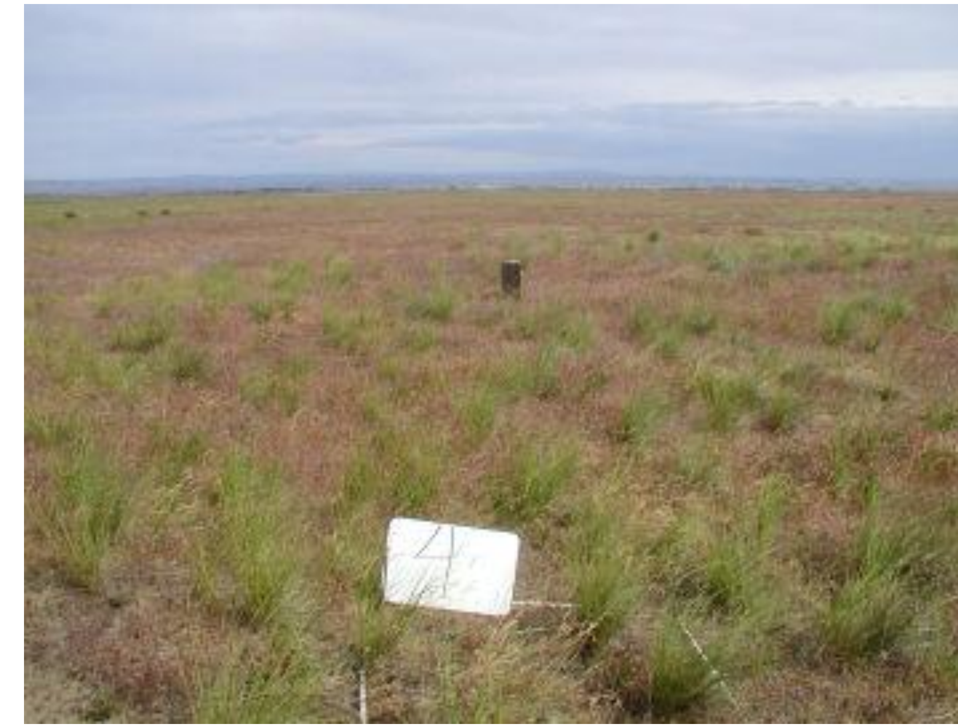

2015


2017

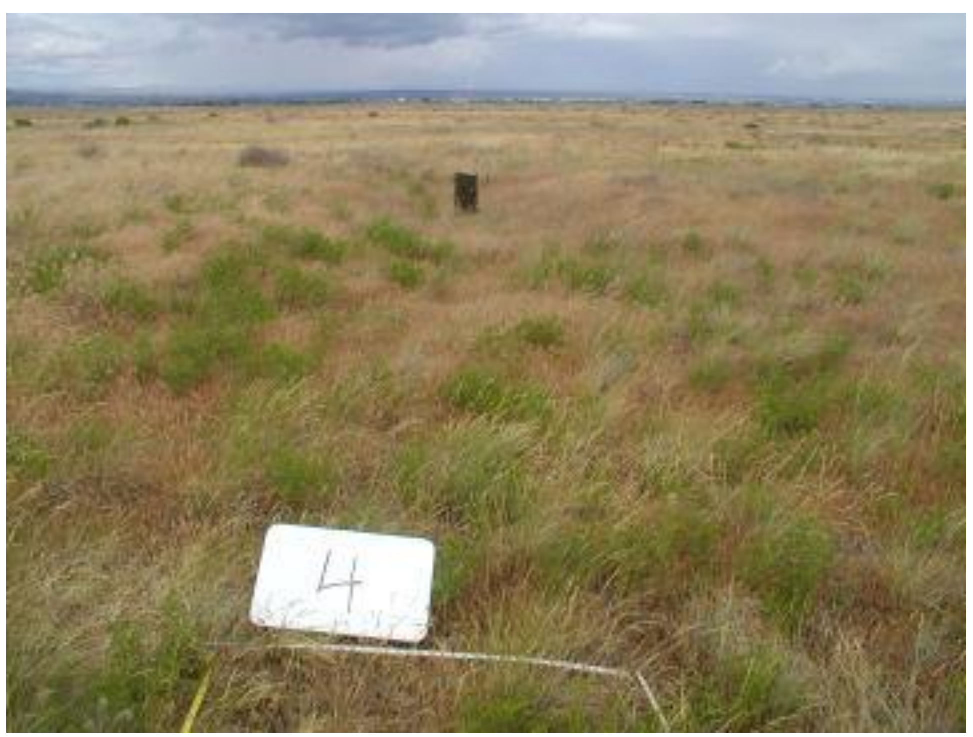
Figure B4a. Range monitoring plot at NWSTF Boardman – close-up photo


1987


2008




2011




2013


2015

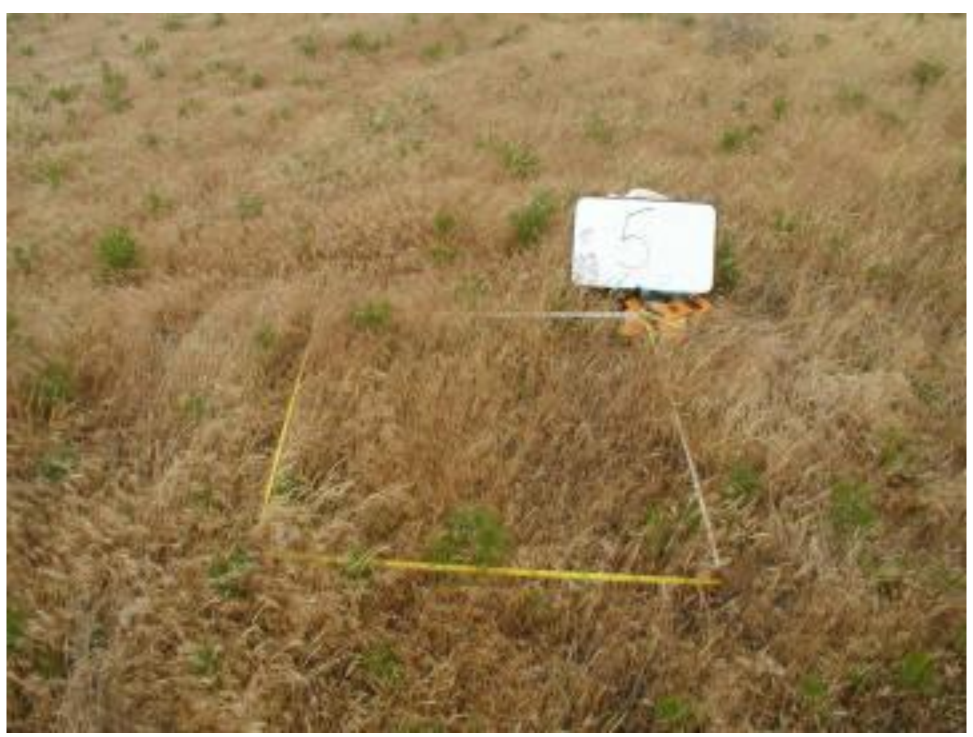

2017

Figure B4b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011



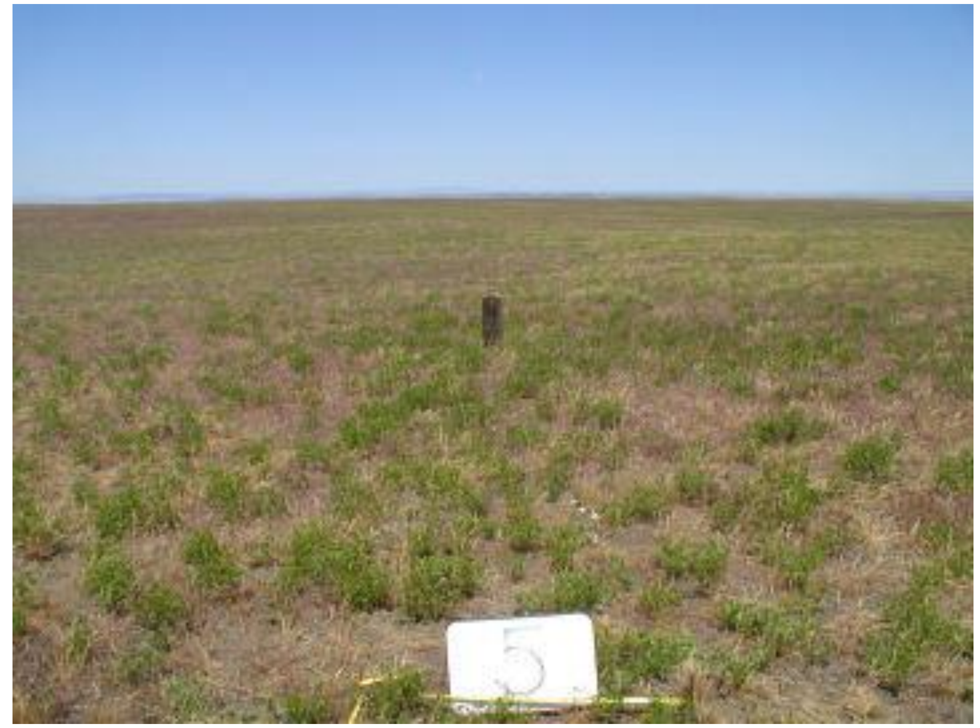

2013

2015

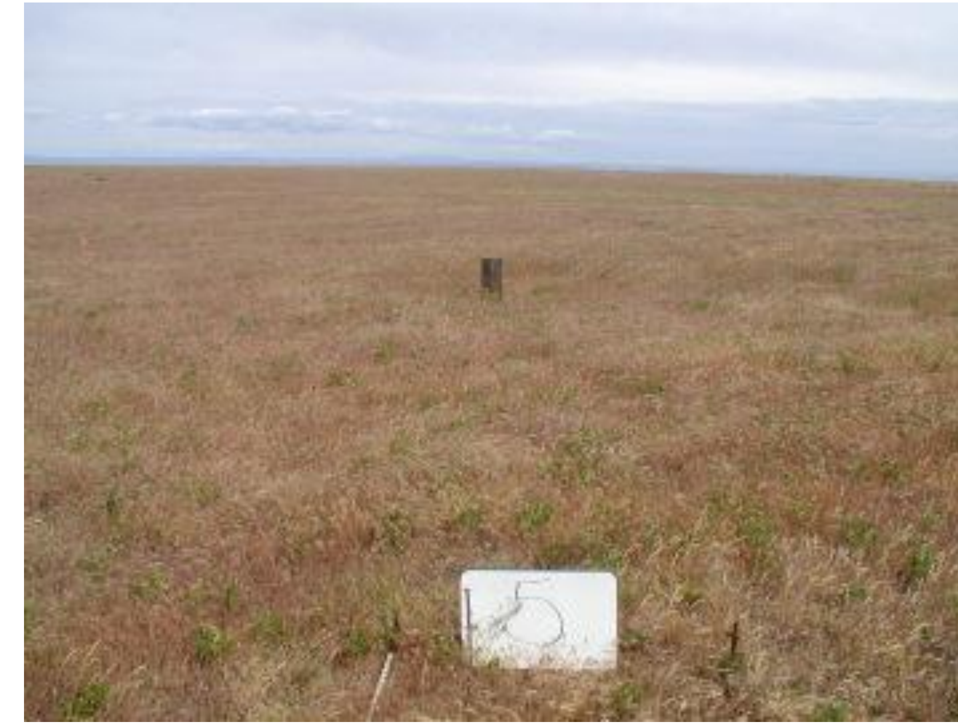

2017

Figure B5a. Range monitoring plot at NWSTF Boardman – close-up photo

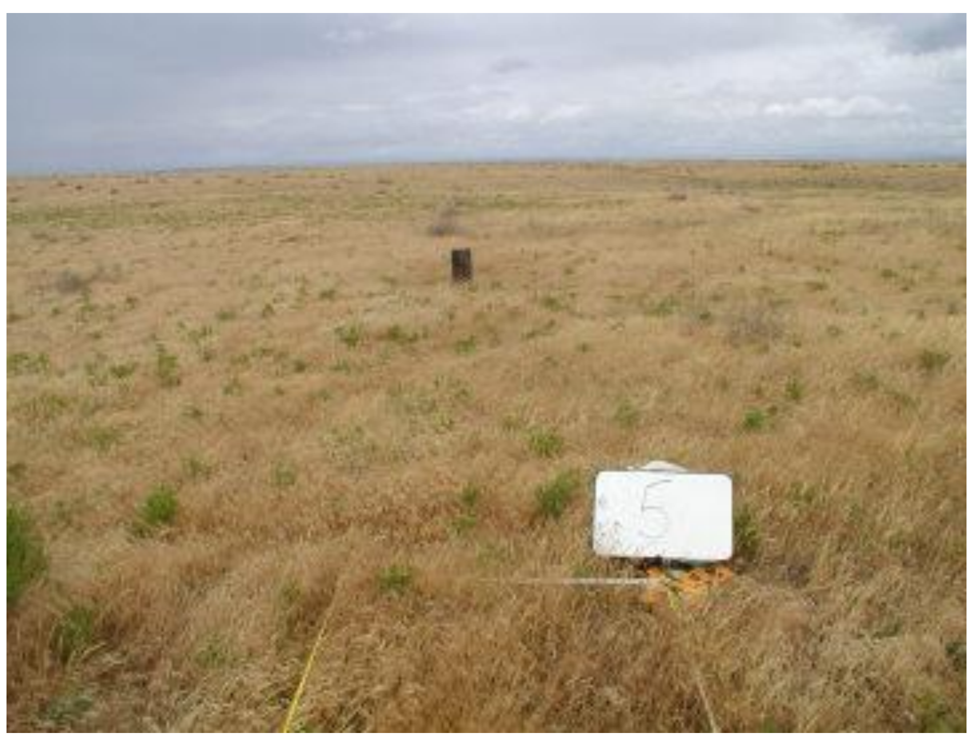

1987




2008




2011



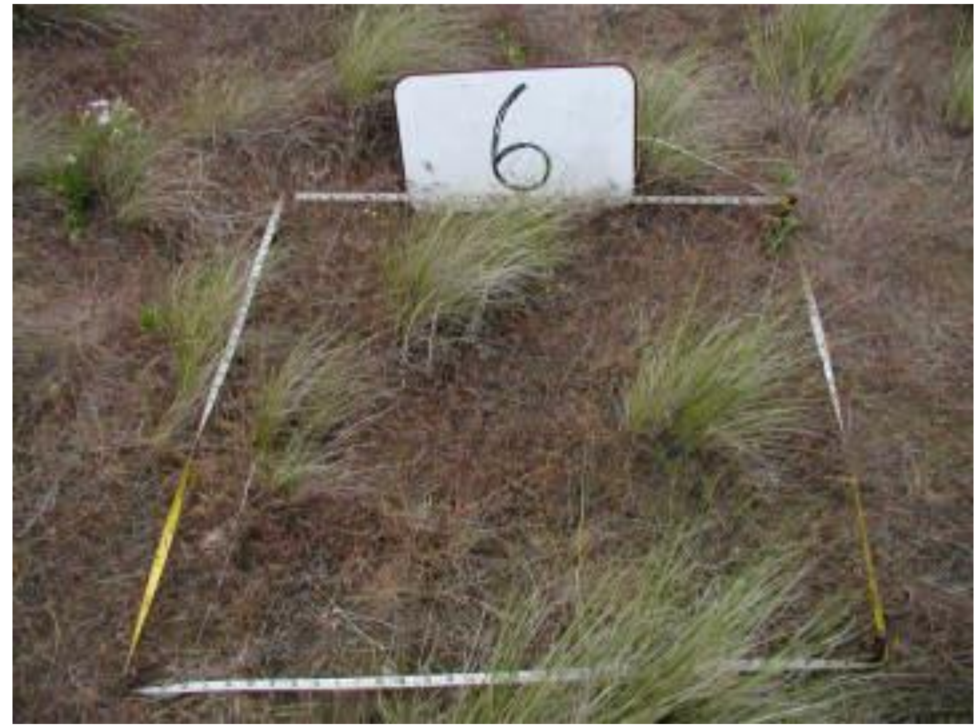

2013

2015


2017

Figure B5b. Range monitoring plot at NWSTF Boardman – aspect photo

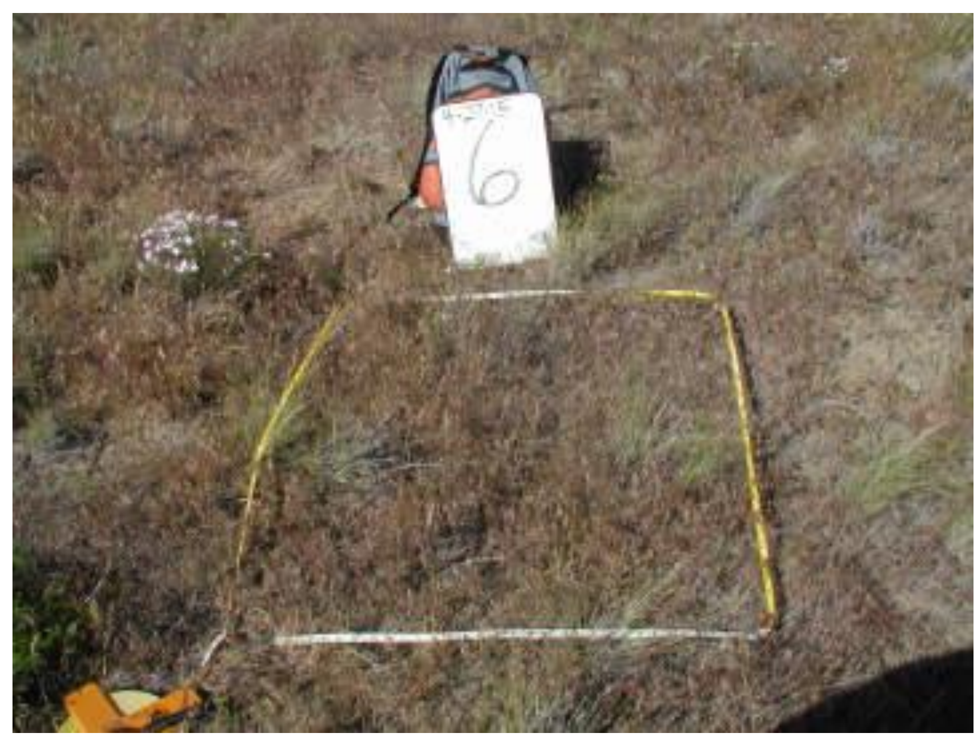

1987



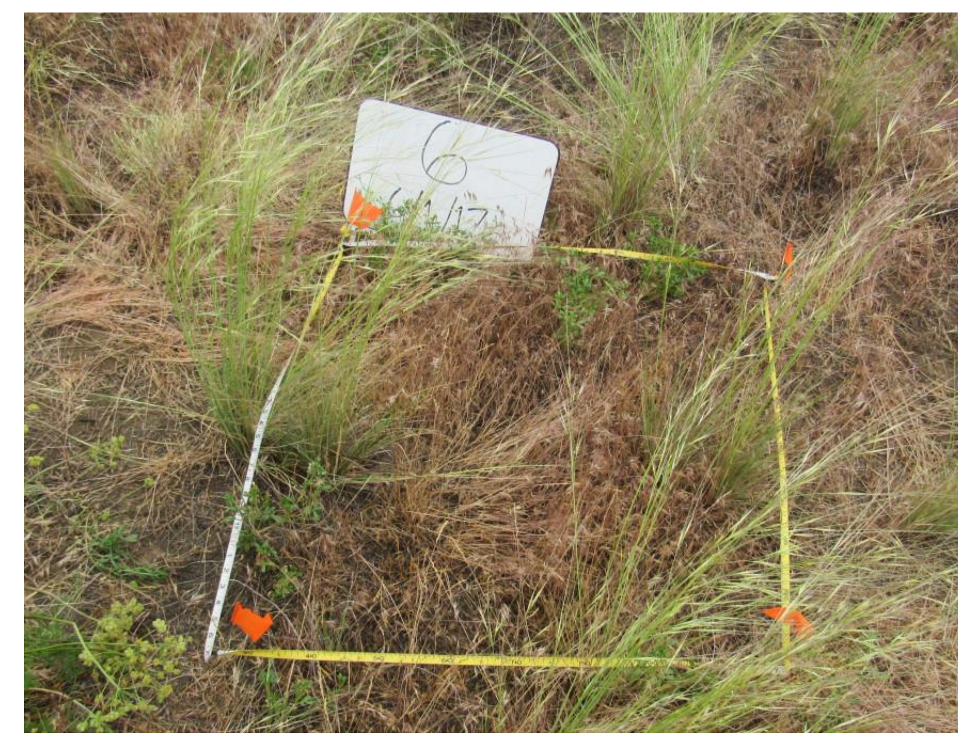

2008


2011


2013

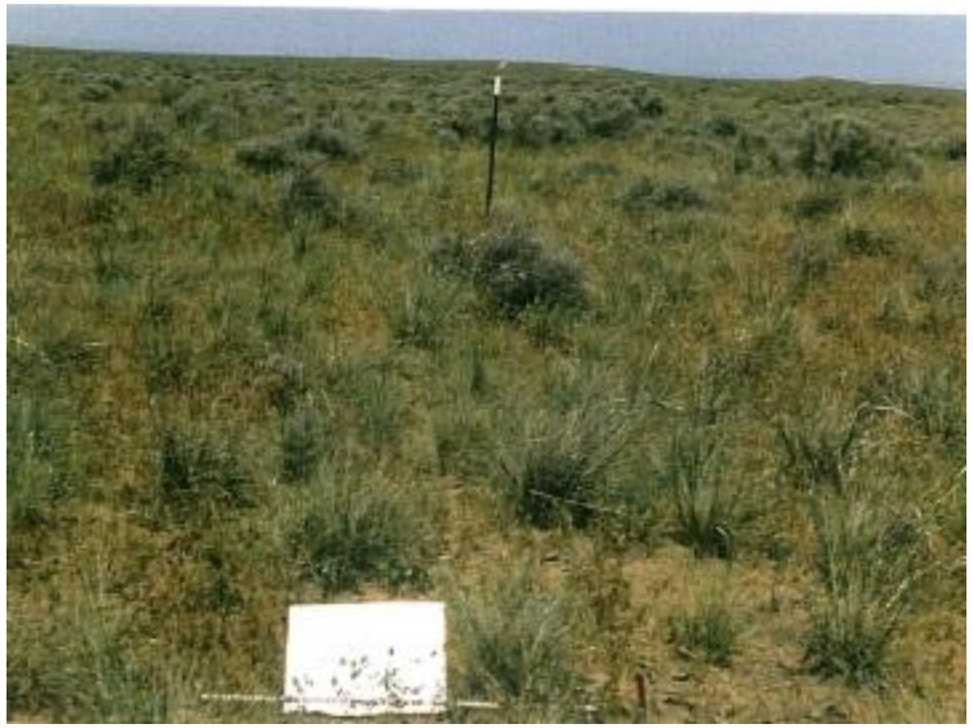



2015

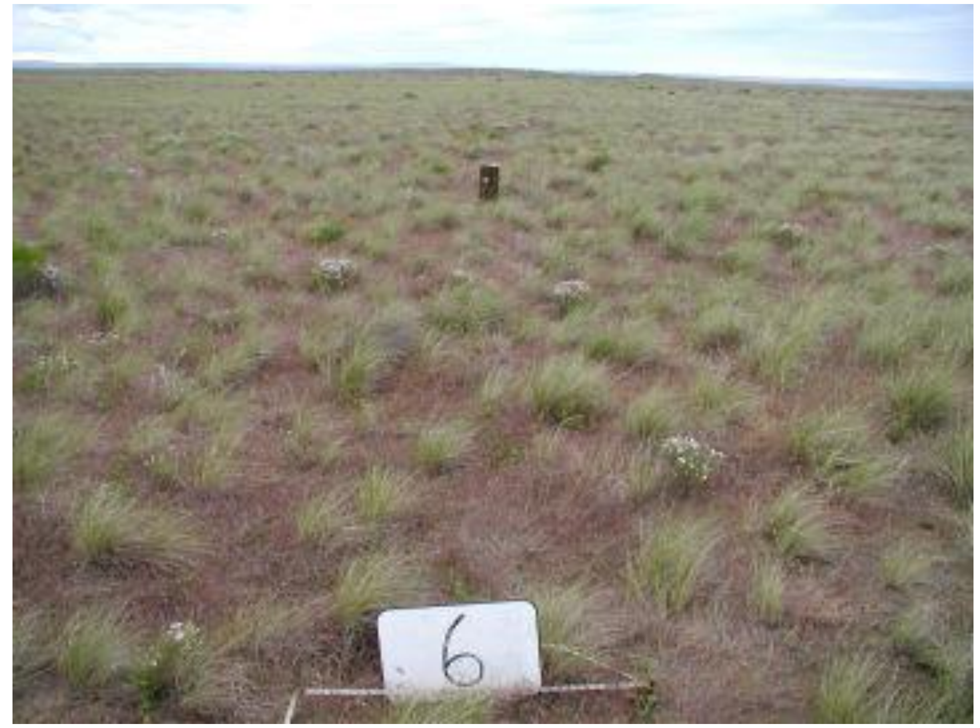



2017

Figure B6a. Range monitoring plot at NWSTF Boardman – close-up photo

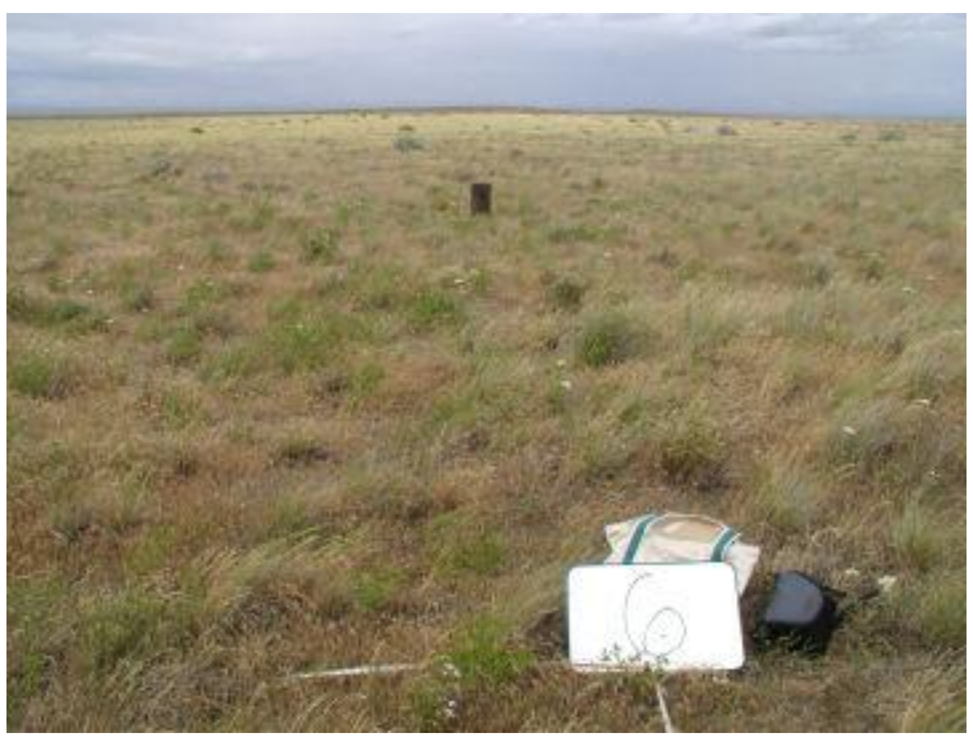


1987

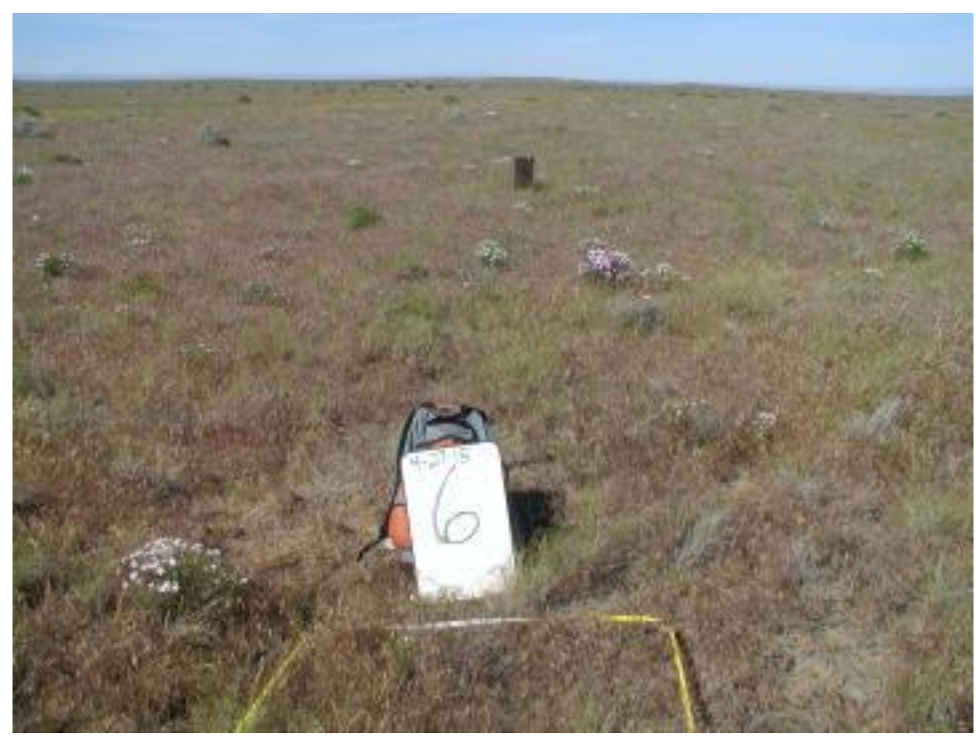



2008


2011




2013



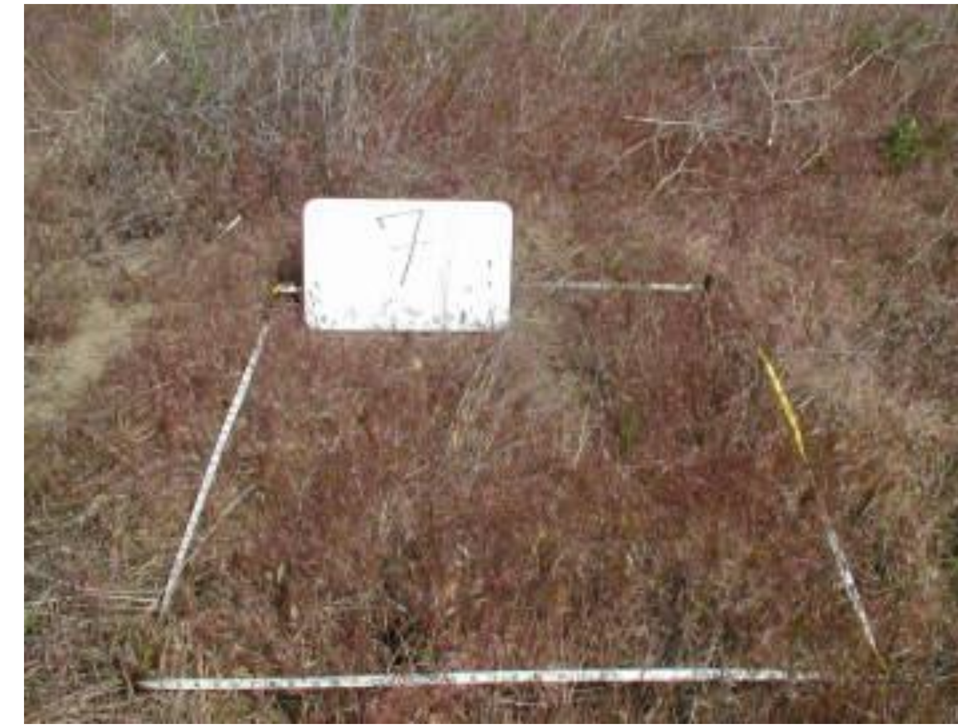

2015


2017

Figure B6b. Range monitoring plot at NWSTF Boardman – aspect photo

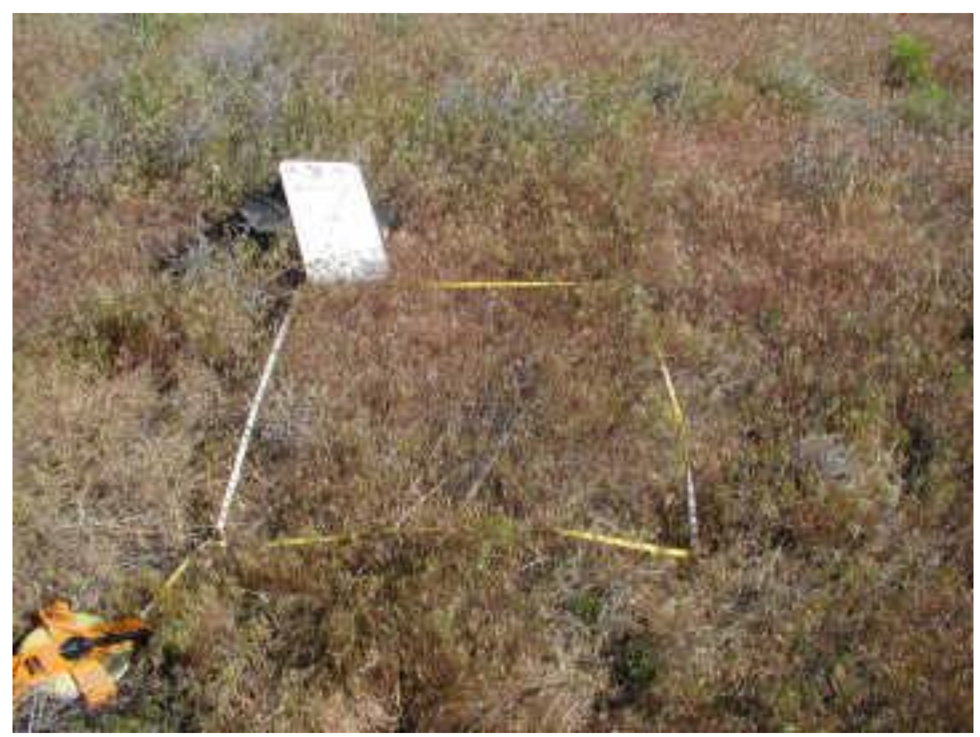

1987


2008

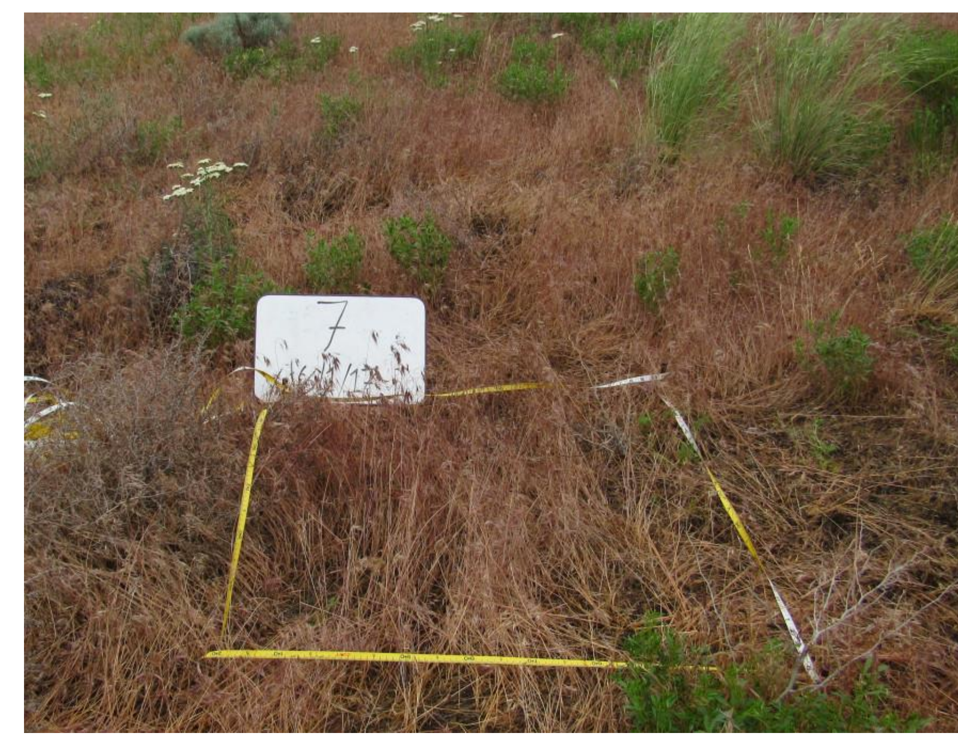



2011

2013

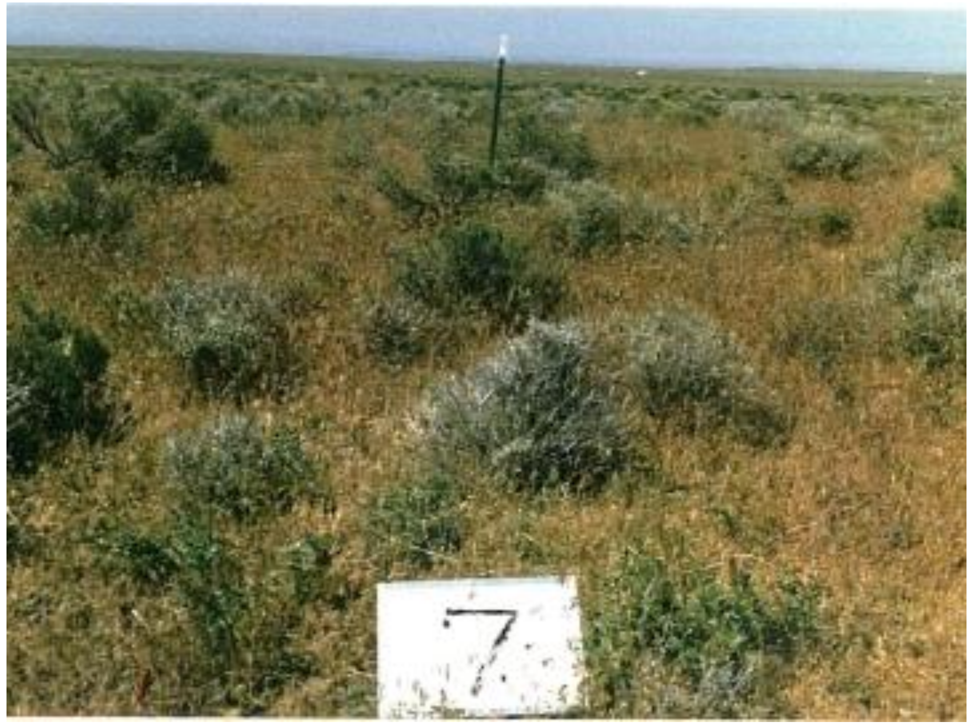


2015

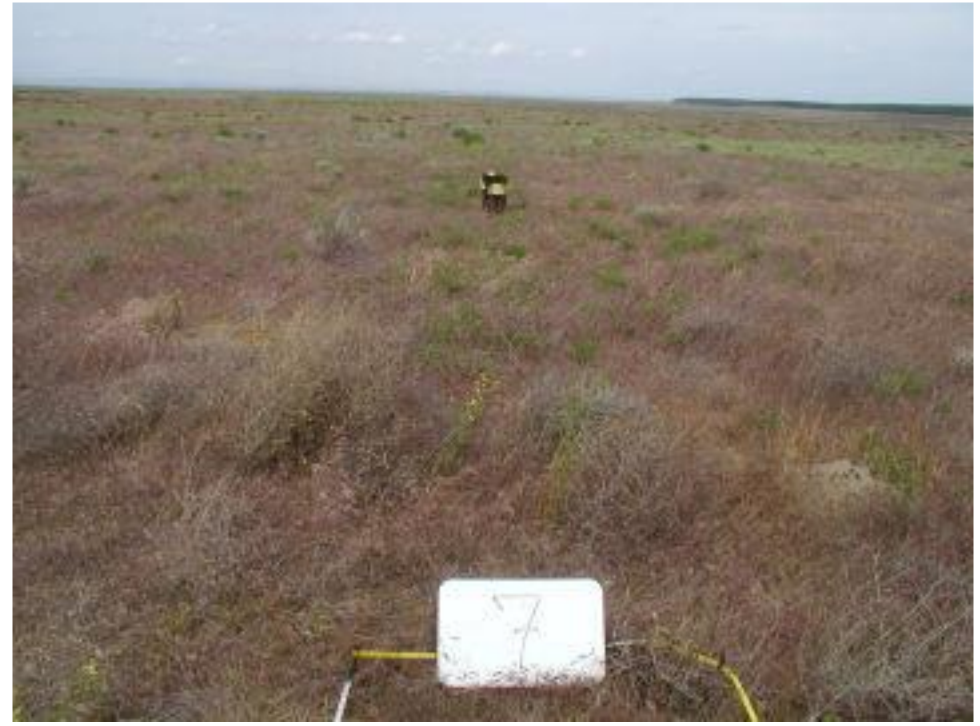



2017

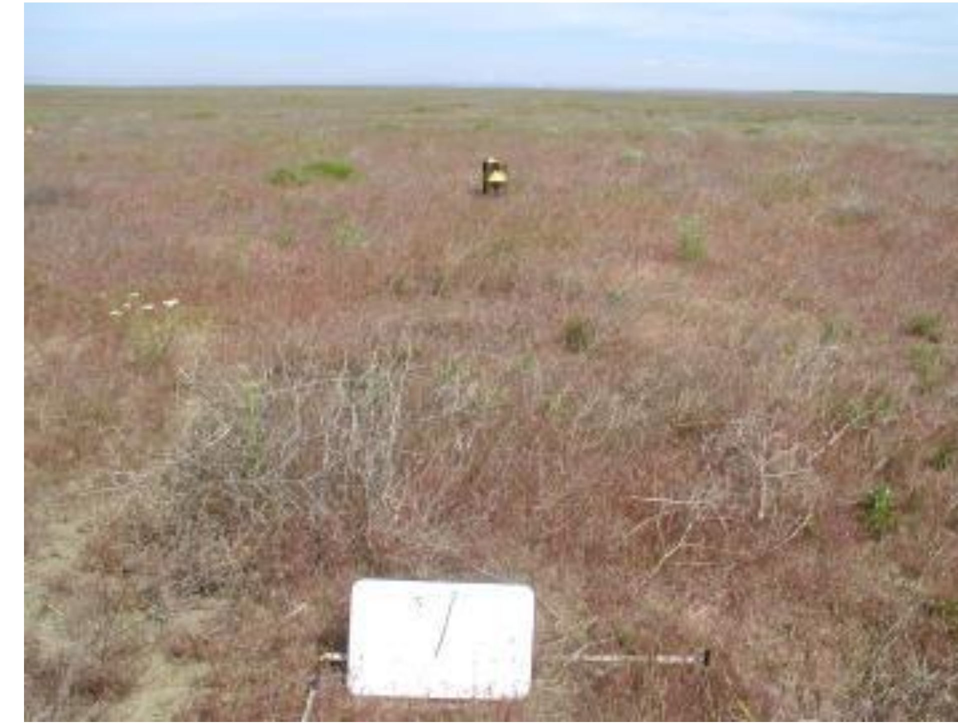
Figure B7a. Range monitoring plot at NWSTF Boardman – close-up photo




1987

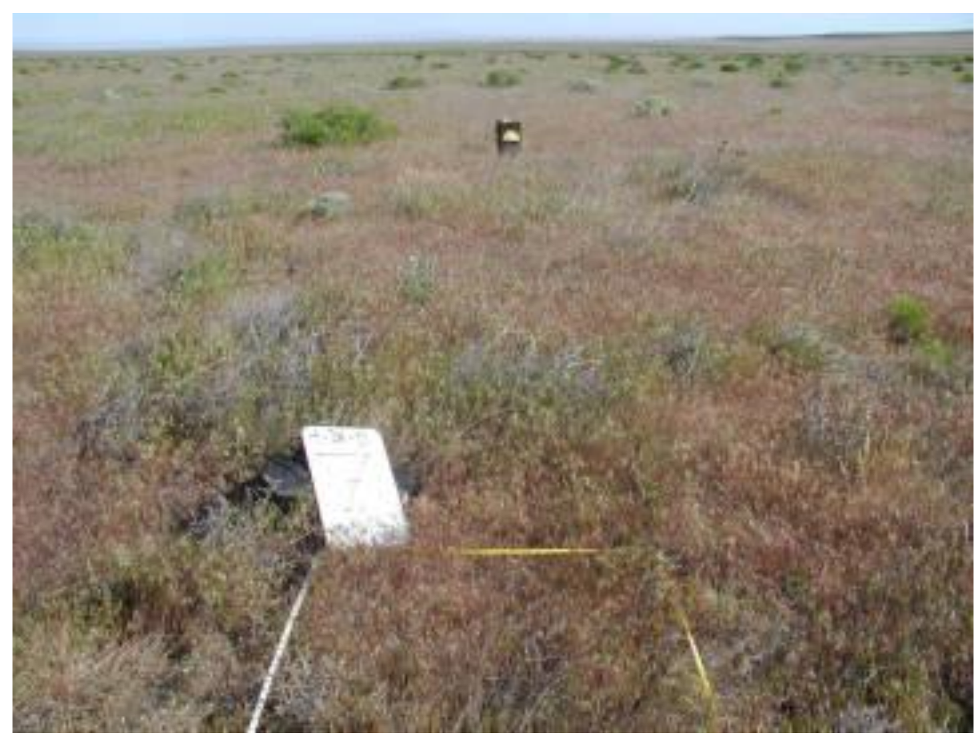



2008



2011


2013



2015


2017

Figure B7b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

2013

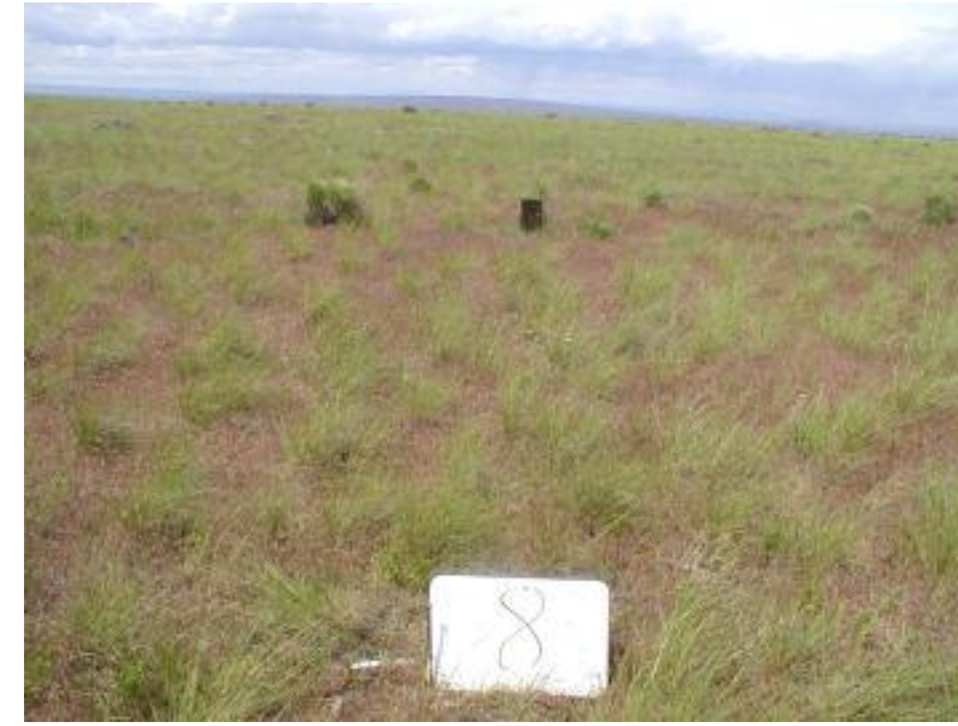

2015

2017

Figure B8a. Range monitoring plot at NWSTF Boardman – close-up photo


1987


2008




2011

2013


2015

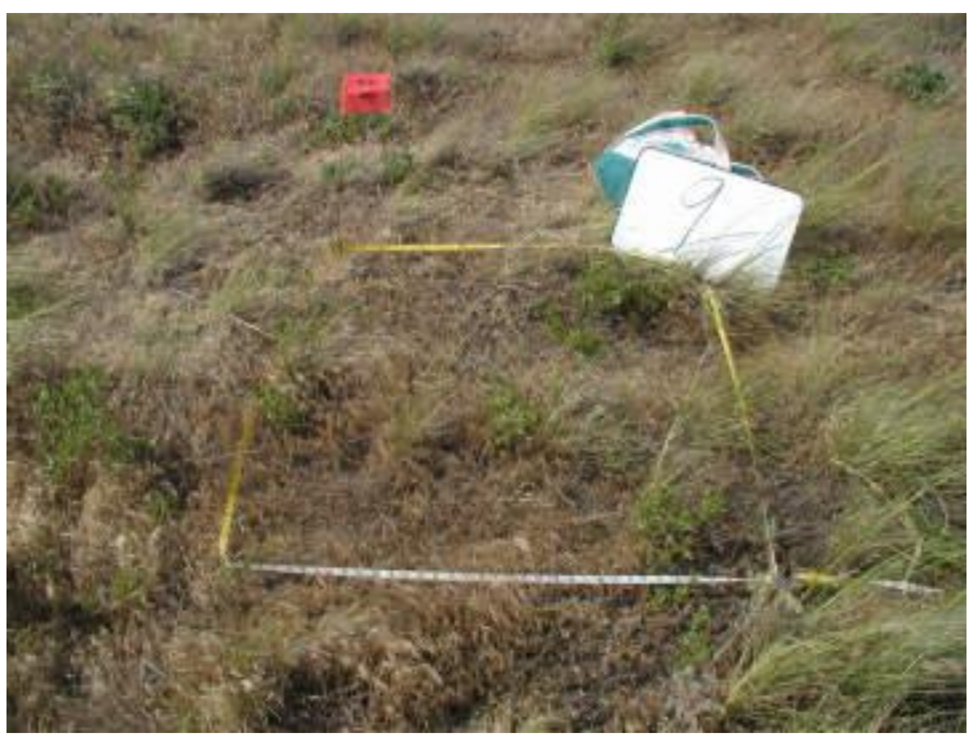

2017

Figure B8b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

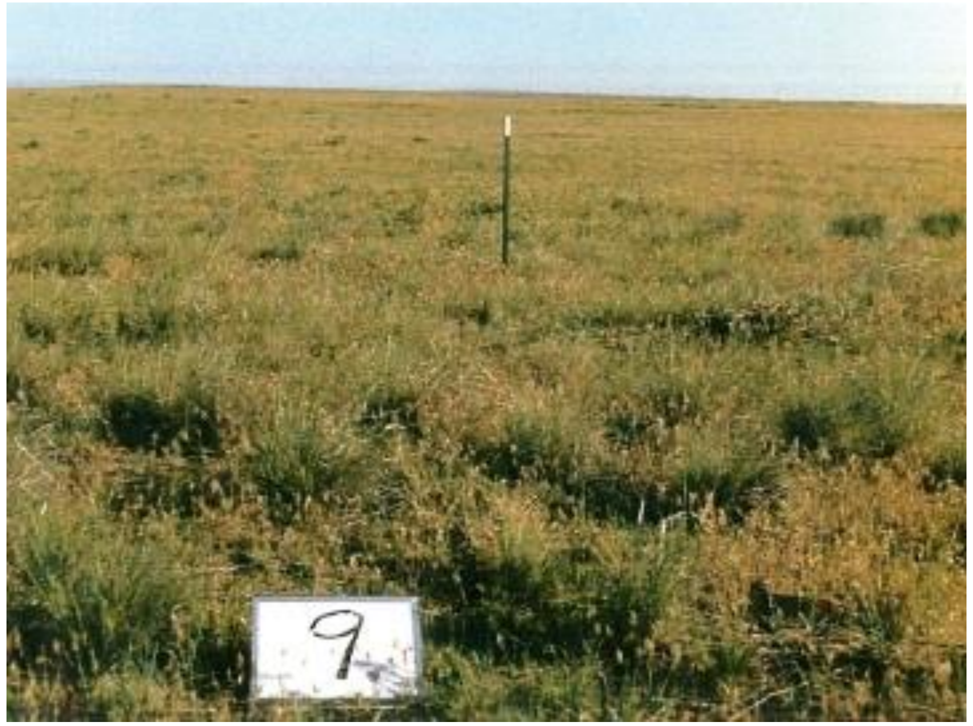


2013

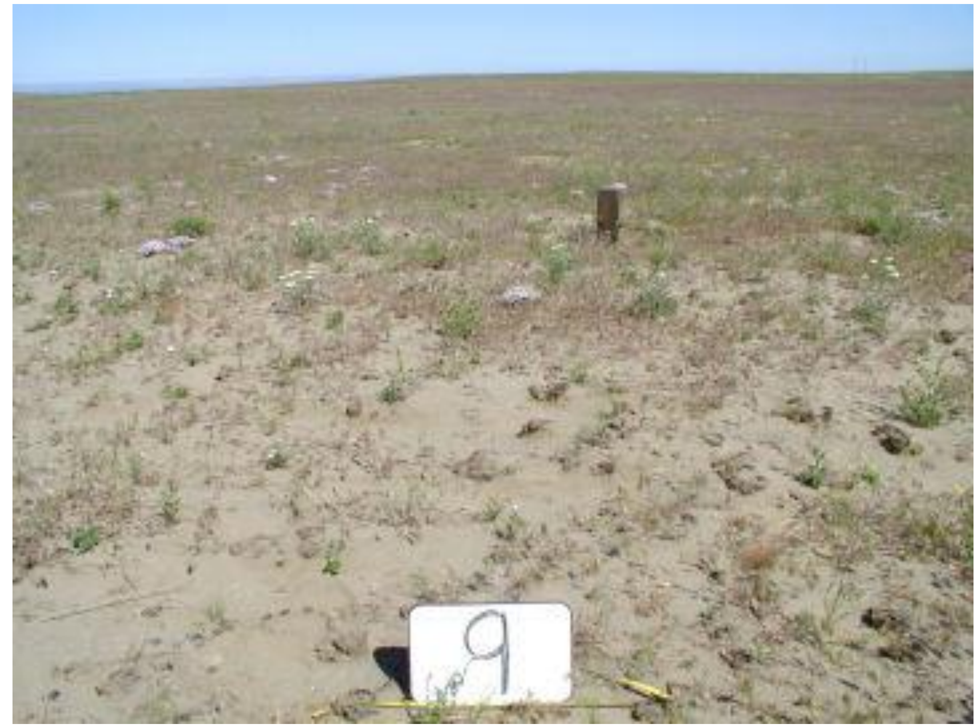

2015


2017

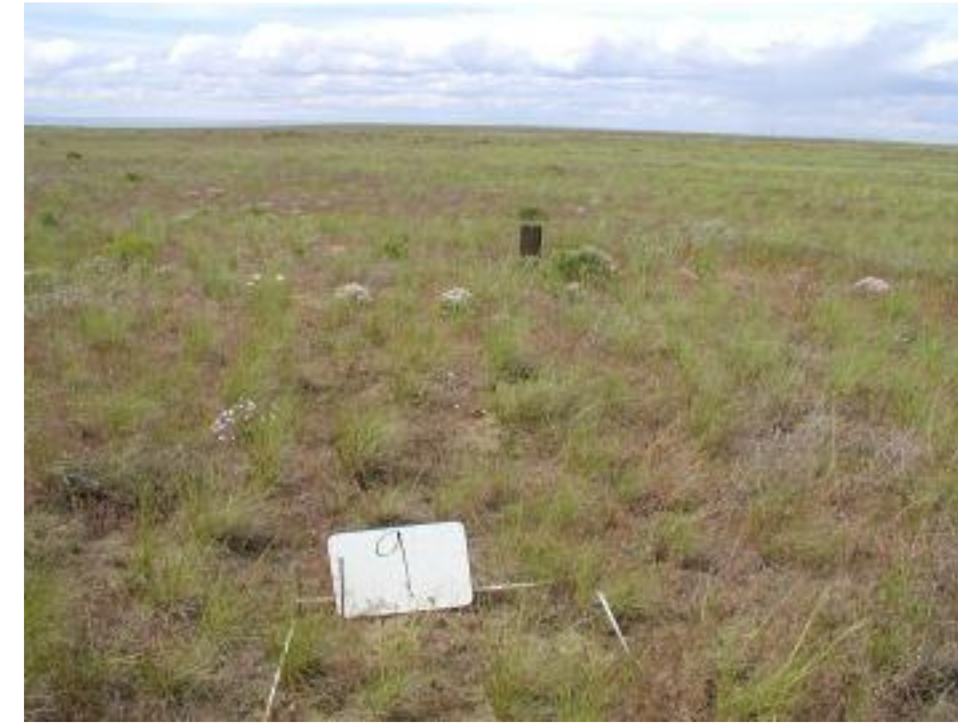
Figure B9a. Range monitoring plot at NWSTF Boardman – close-up photo



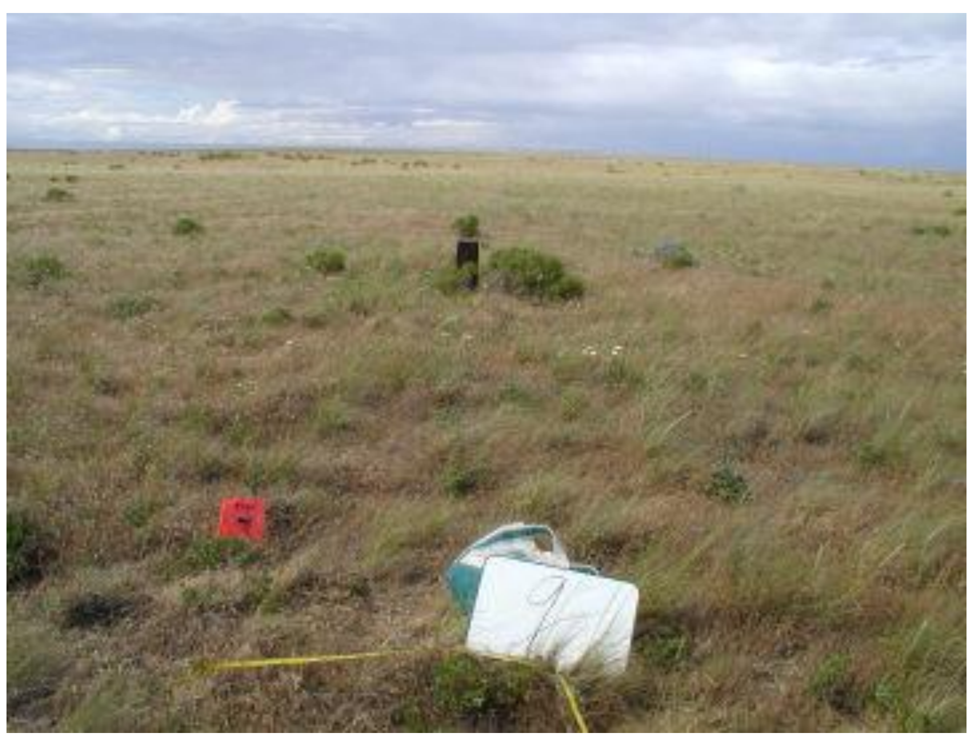

1987




2008




2011



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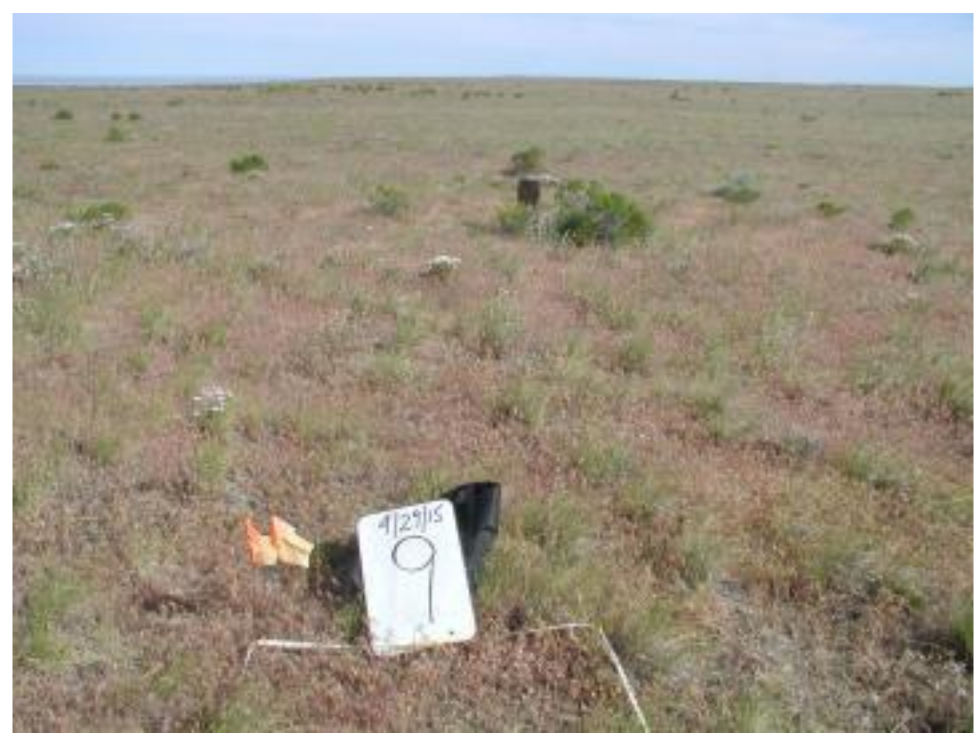



2015


2017

Figure B9b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011


2013

2015

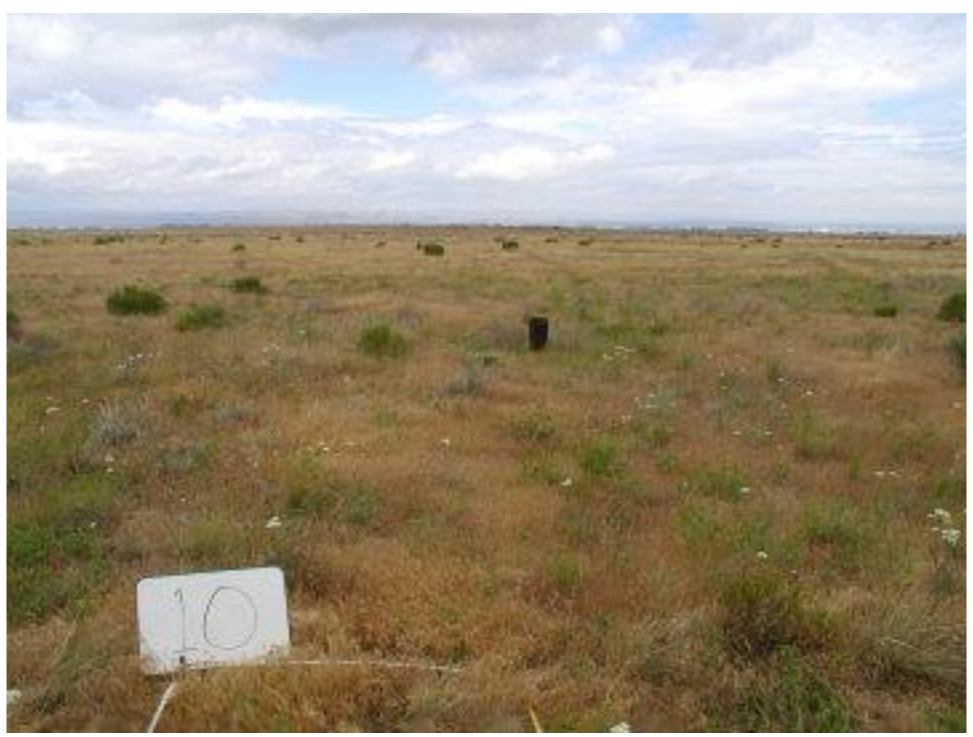

2017

Figure B10a. Range monitoring plot at NWSTF Boardman – close-up photo


1987


2008


2011

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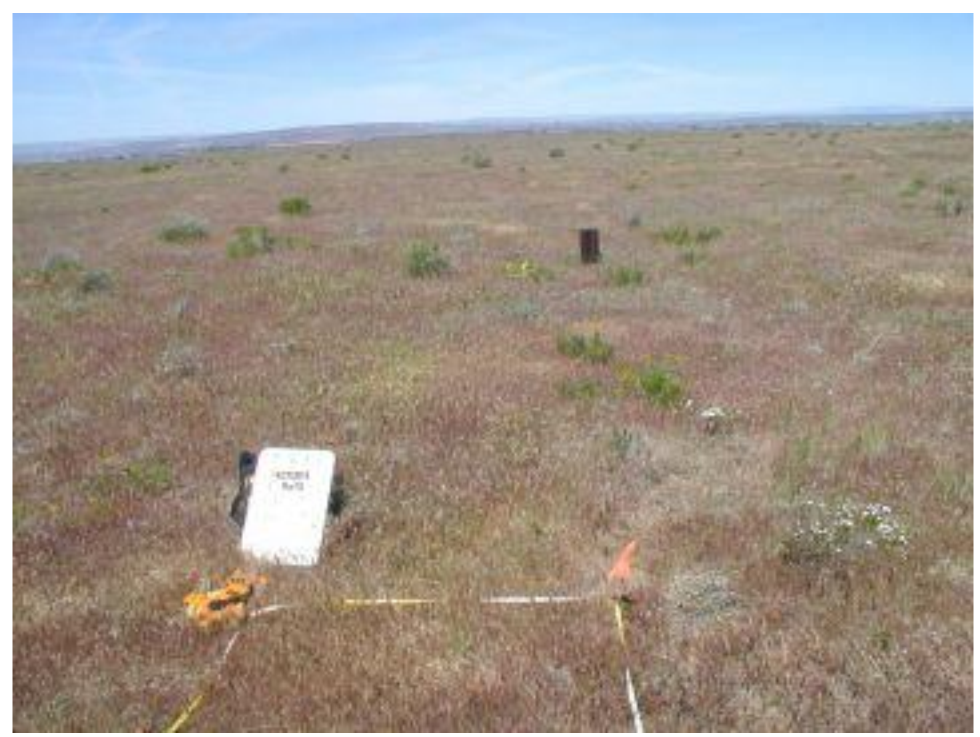


2015

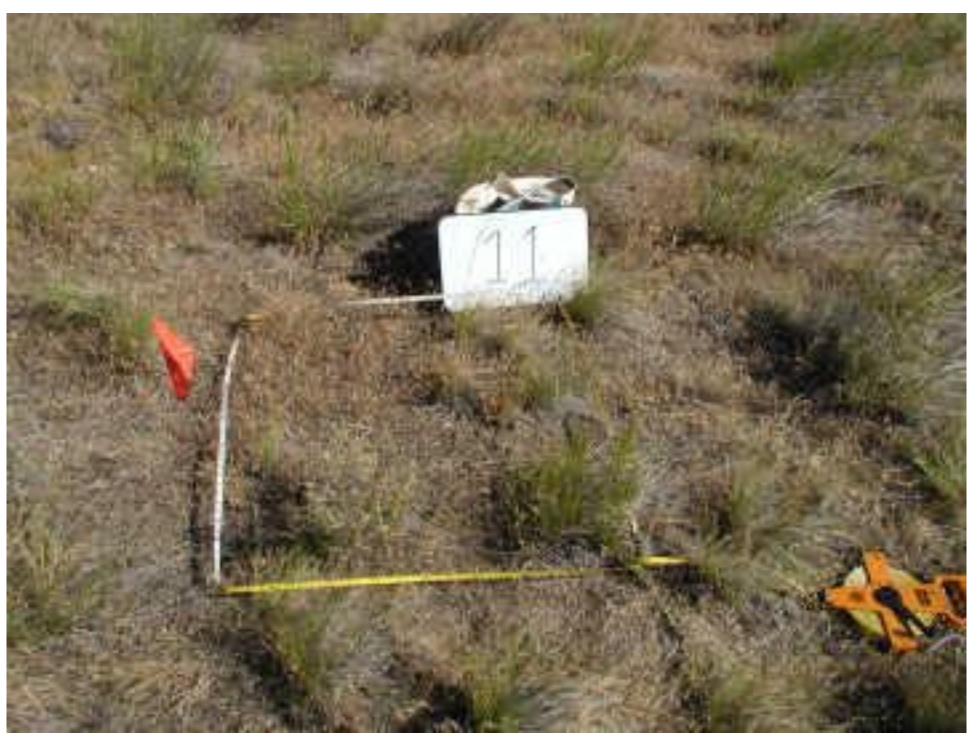

2017

Figure B10b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

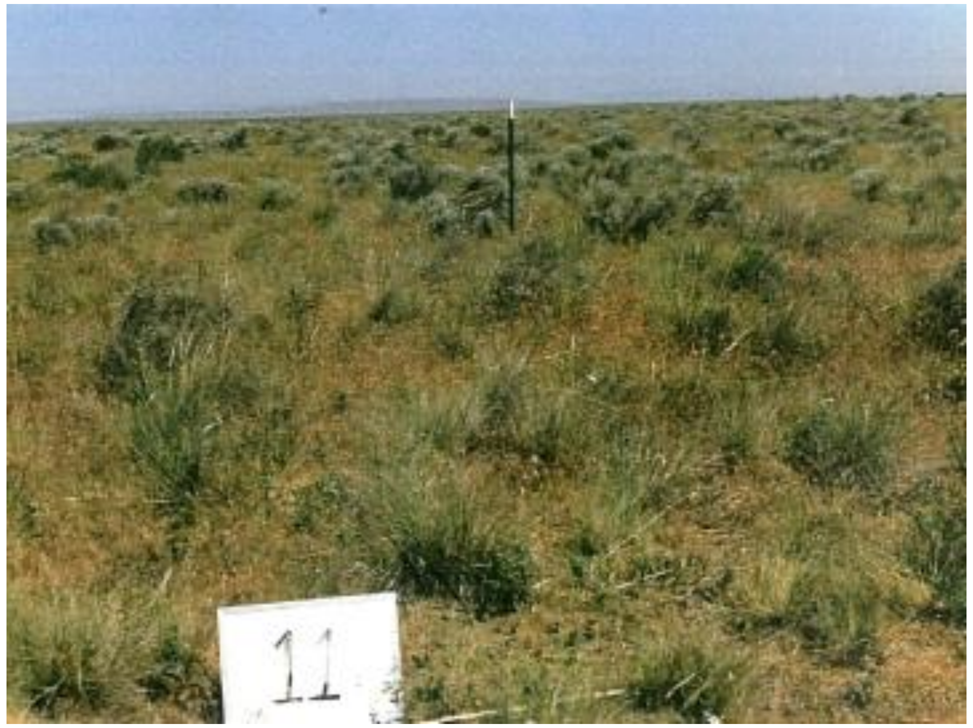



2013

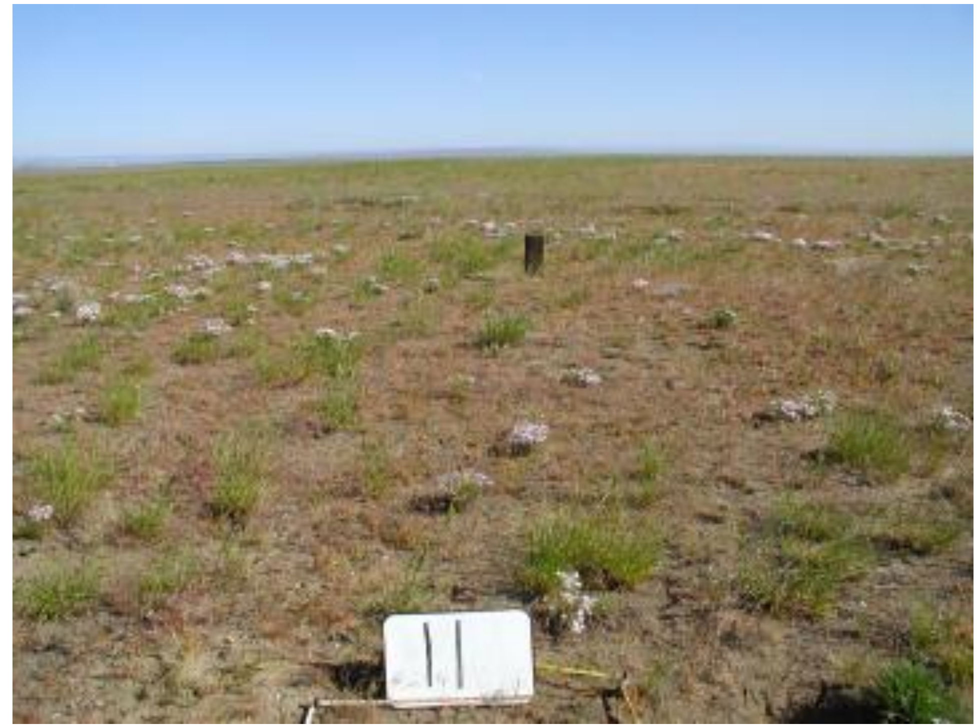

2015


2017

Figure B11a. Range monitoring plot at NWSTF Boardman – close-up photo




1987

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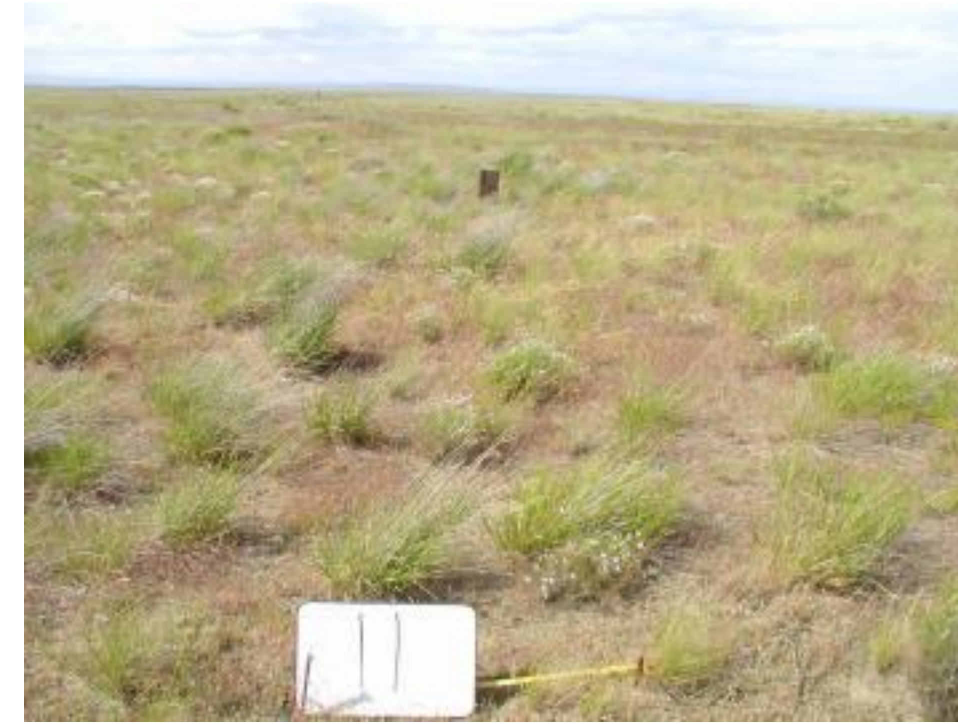


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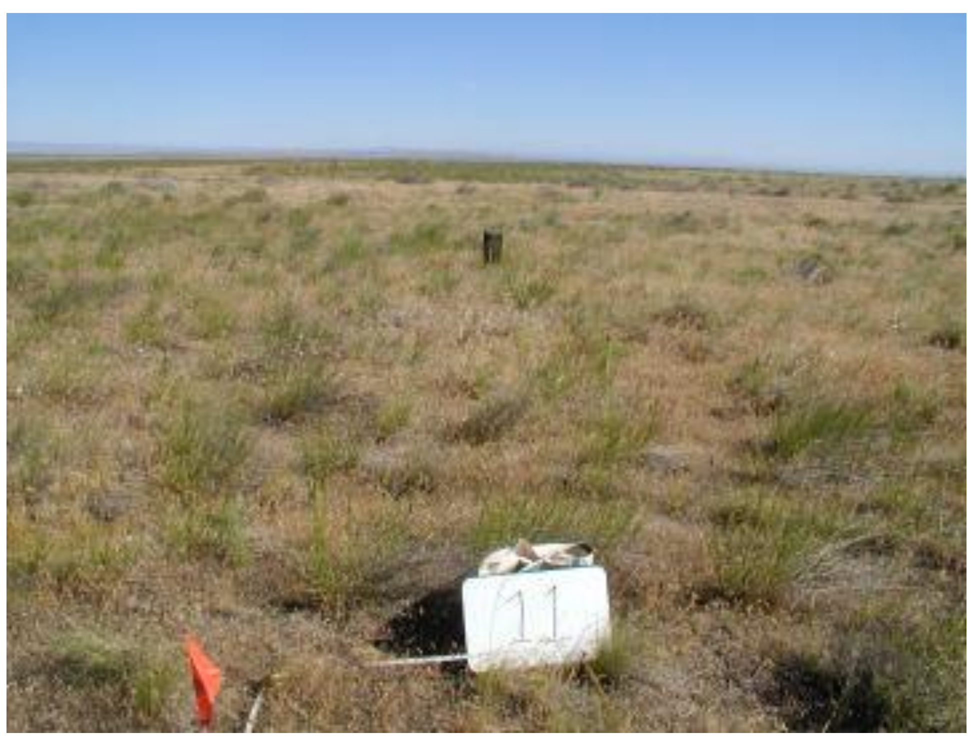
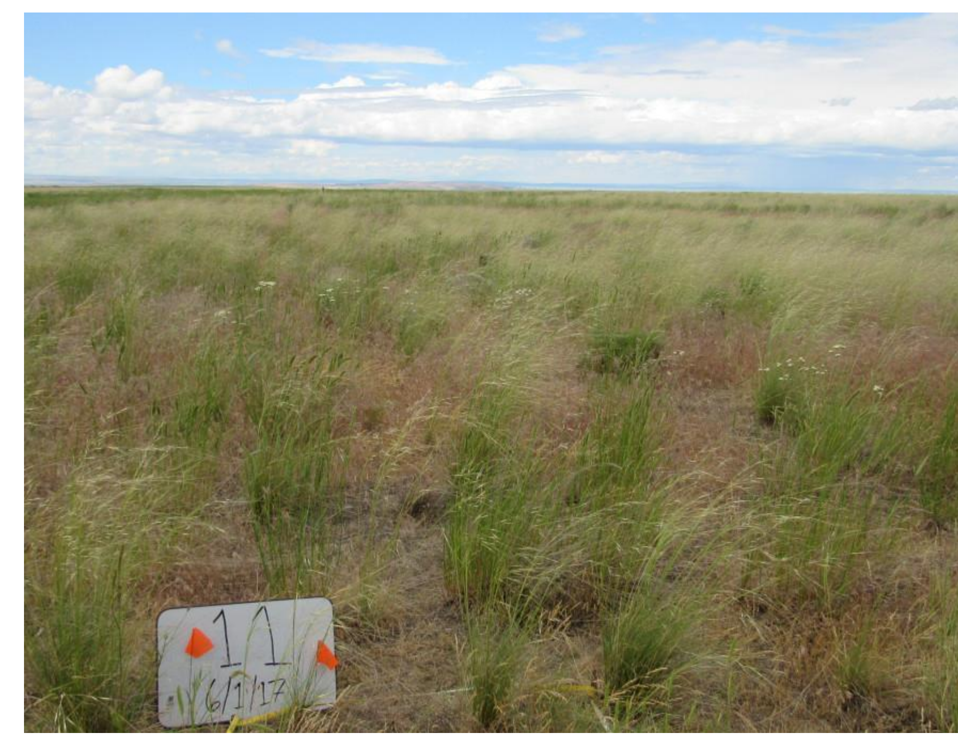



2013


2015




2017

Figure B11b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008

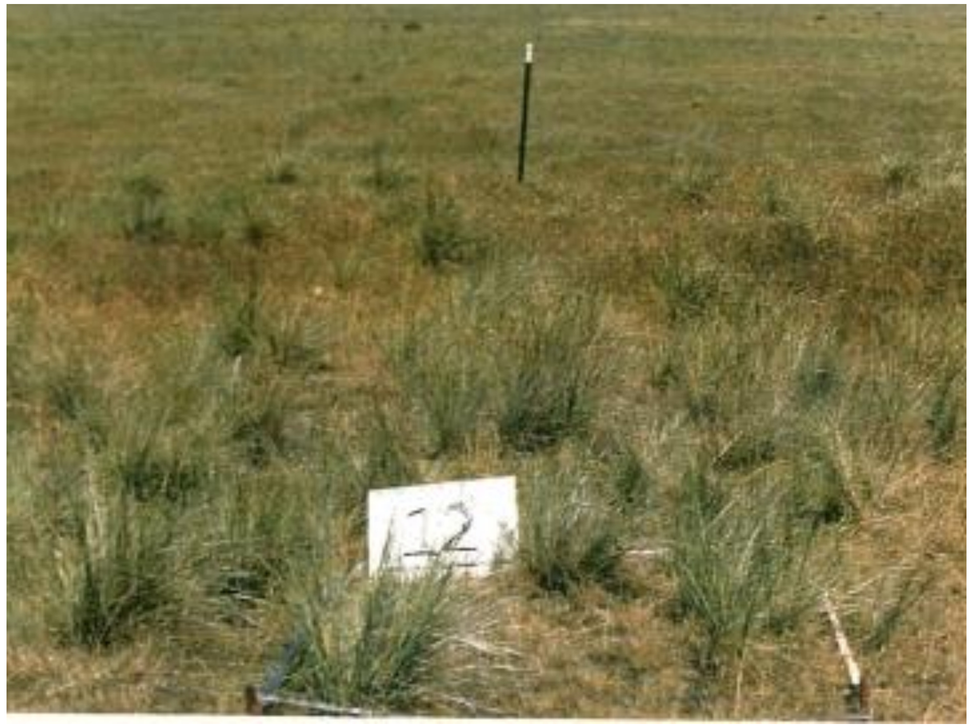

2011


2013

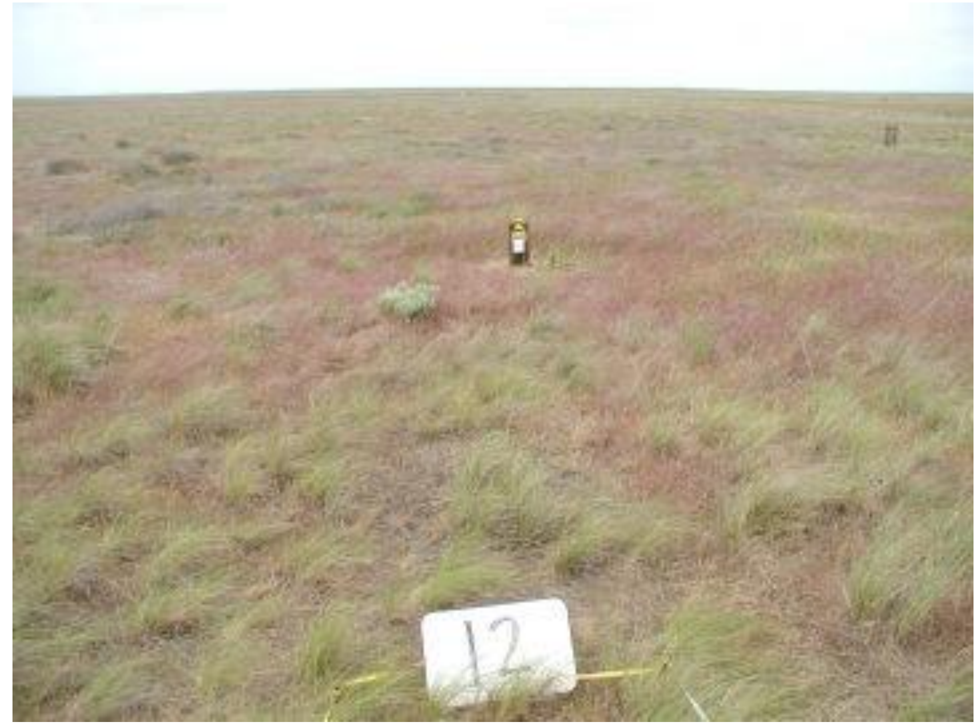

2015


2017

Figure B12a. Range monitoring plot at NWSTF Boardman – close-up photo




1987

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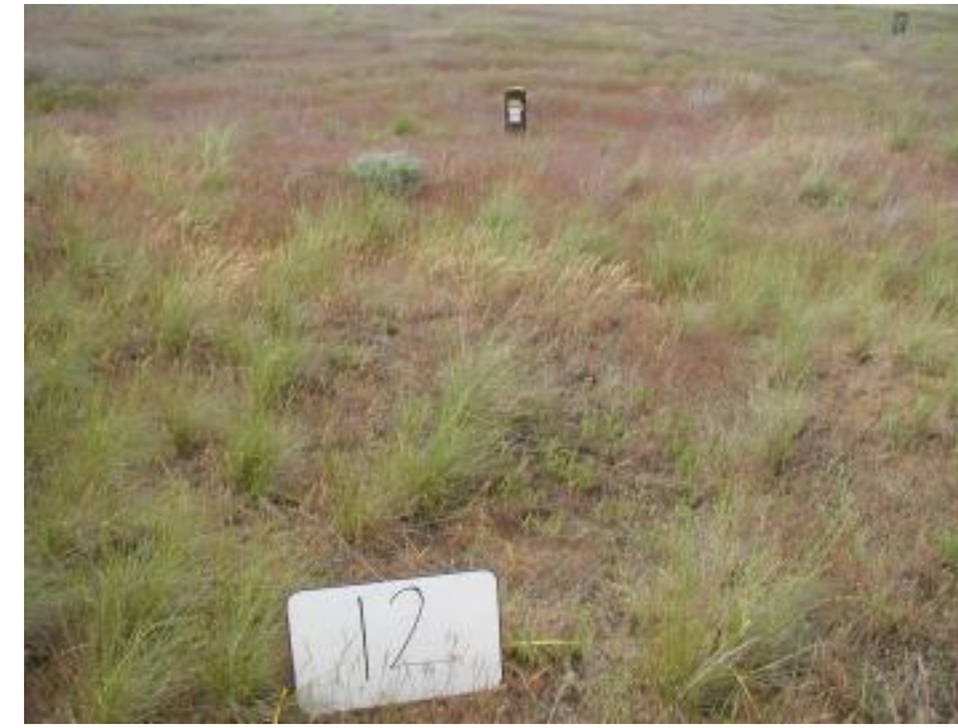


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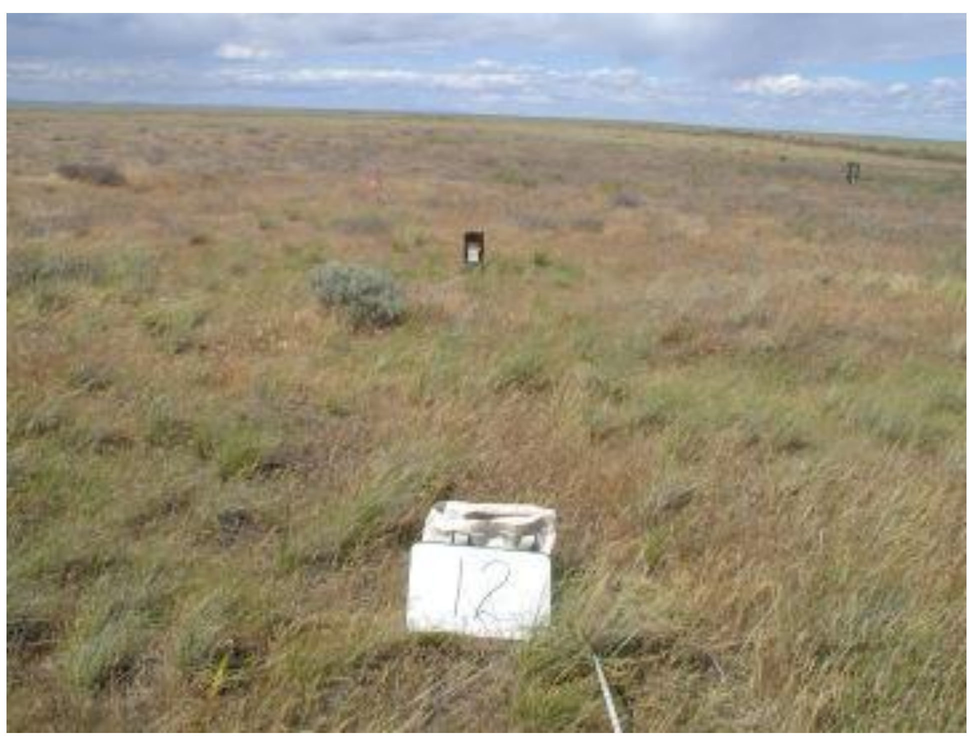


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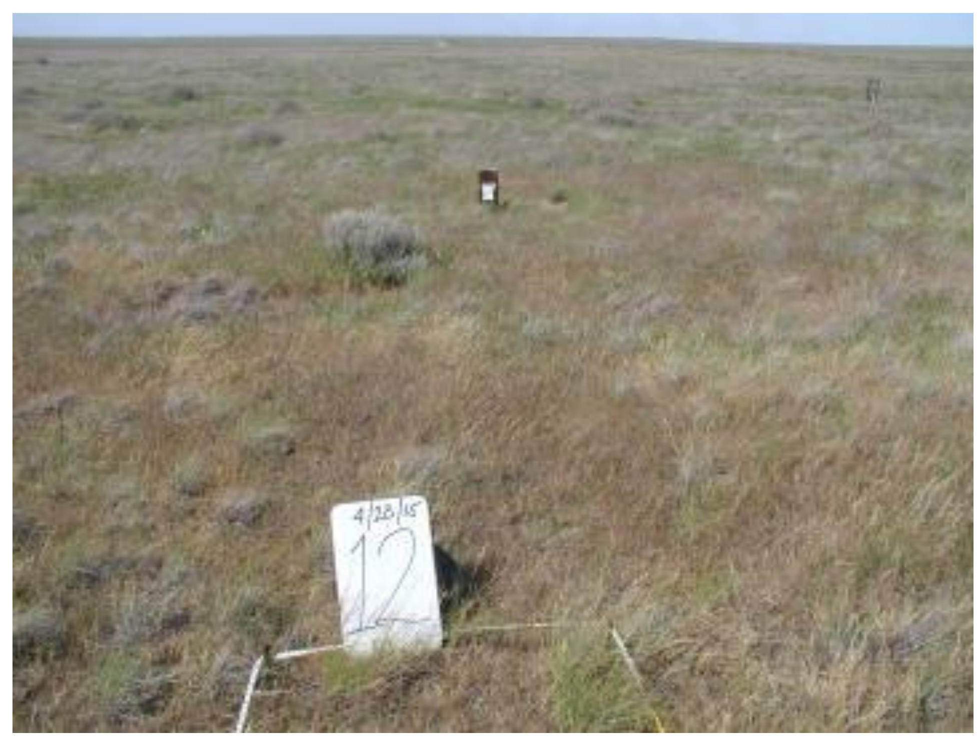
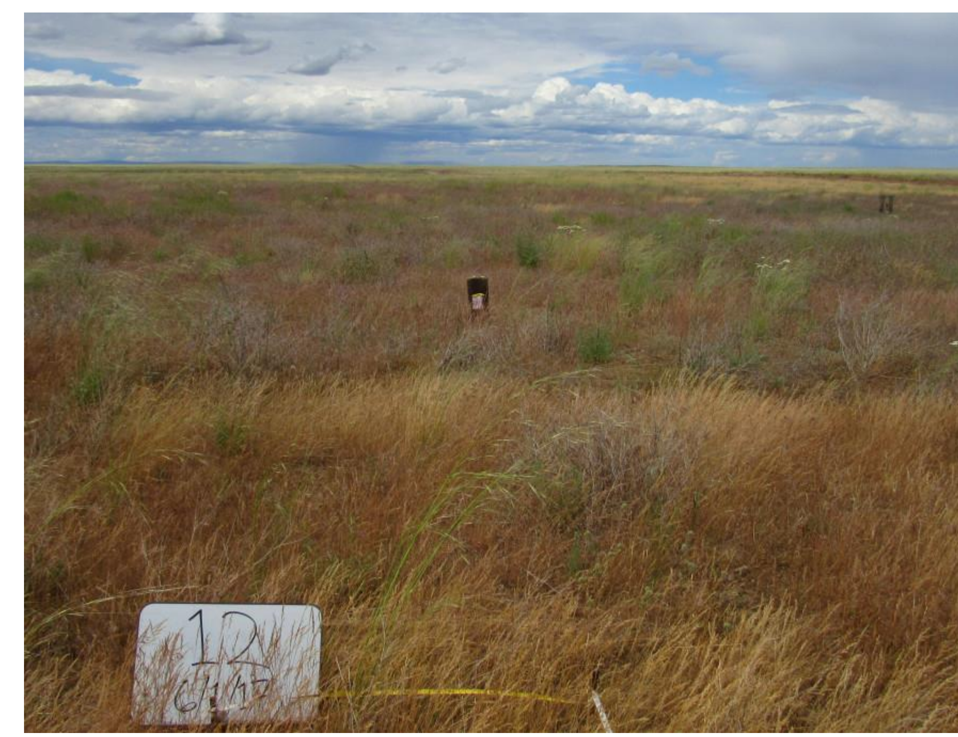



2015




2017

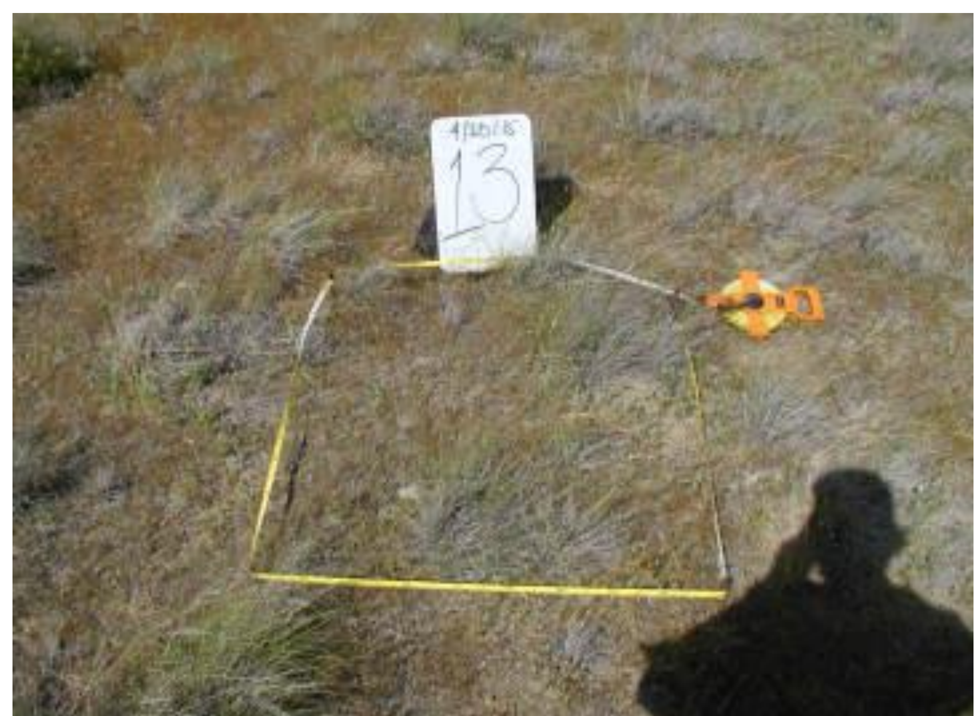
Figure B12b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

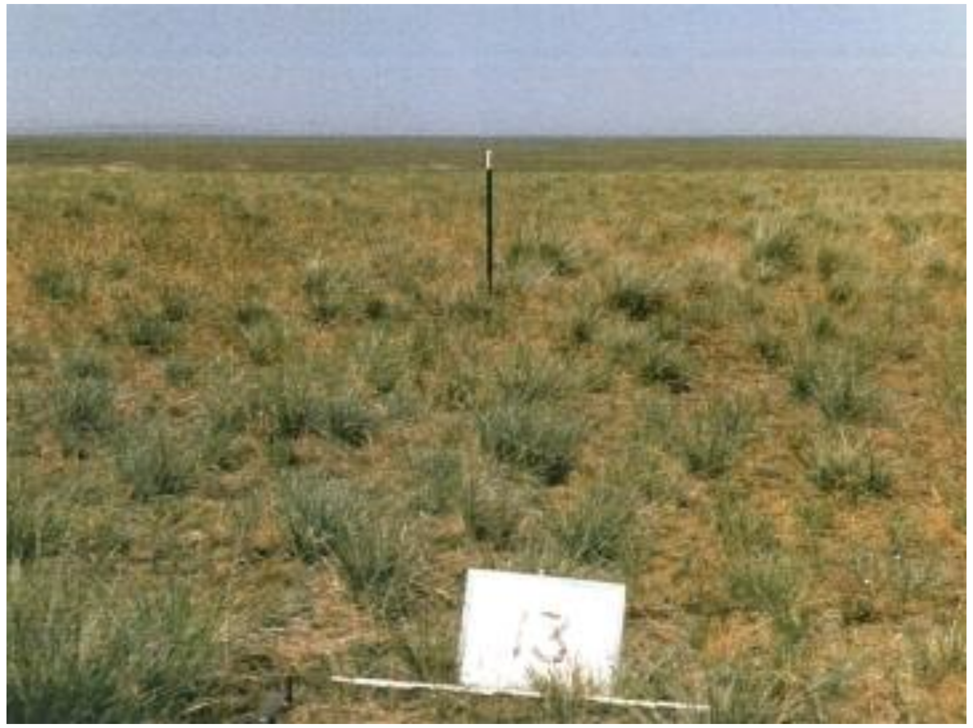

2013



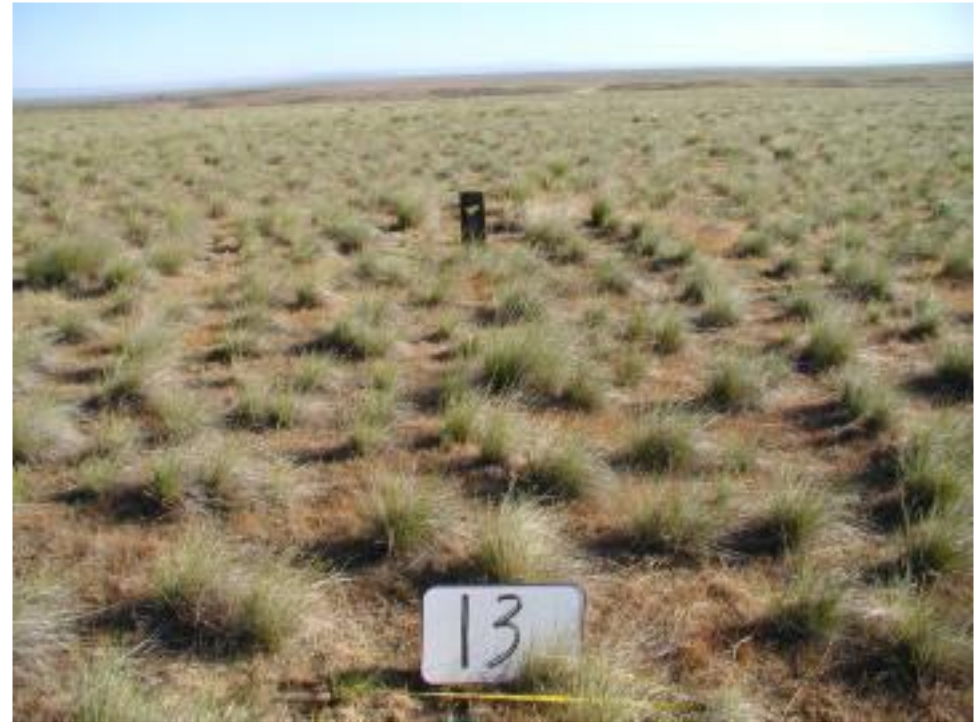

2015


2017

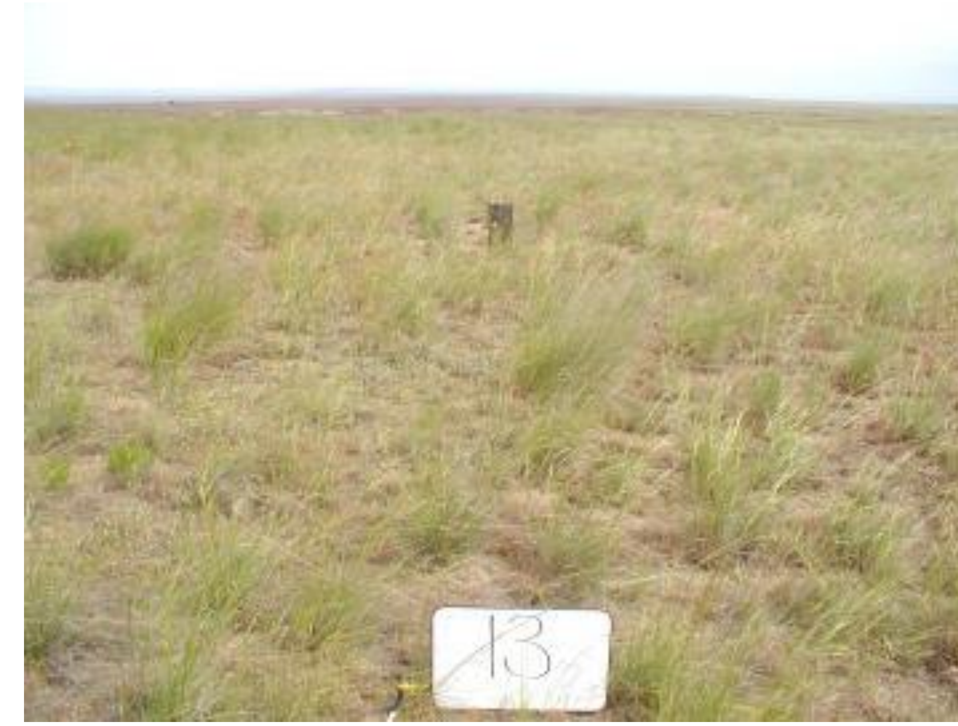
Figure B13a. Range monitoring plot at NWSTF Boardman – close-up photo




1987




2008

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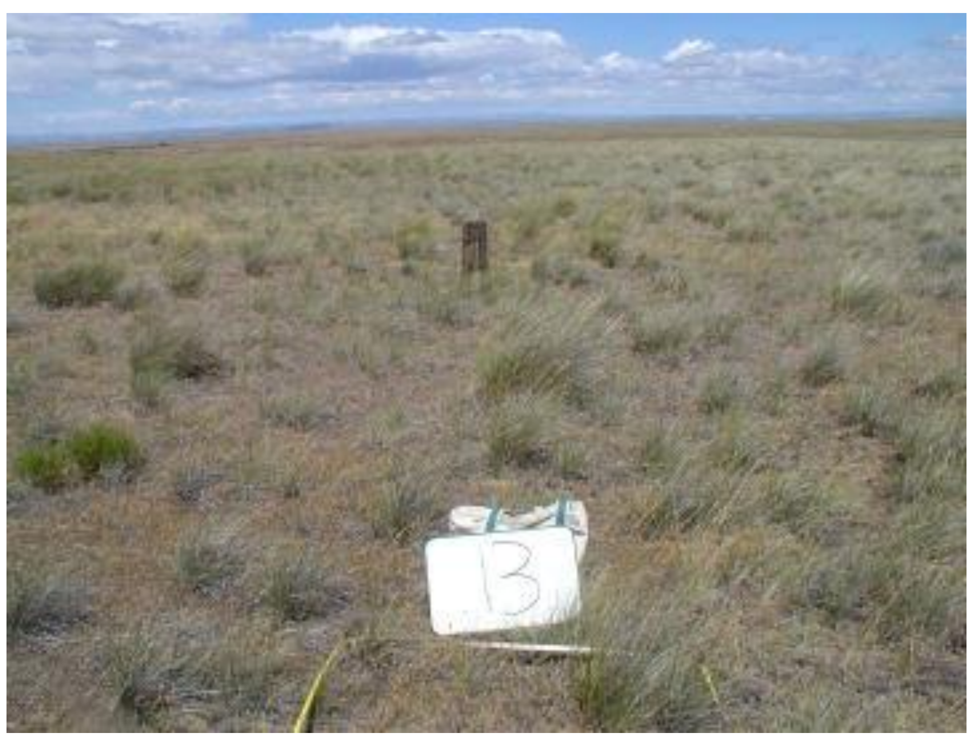


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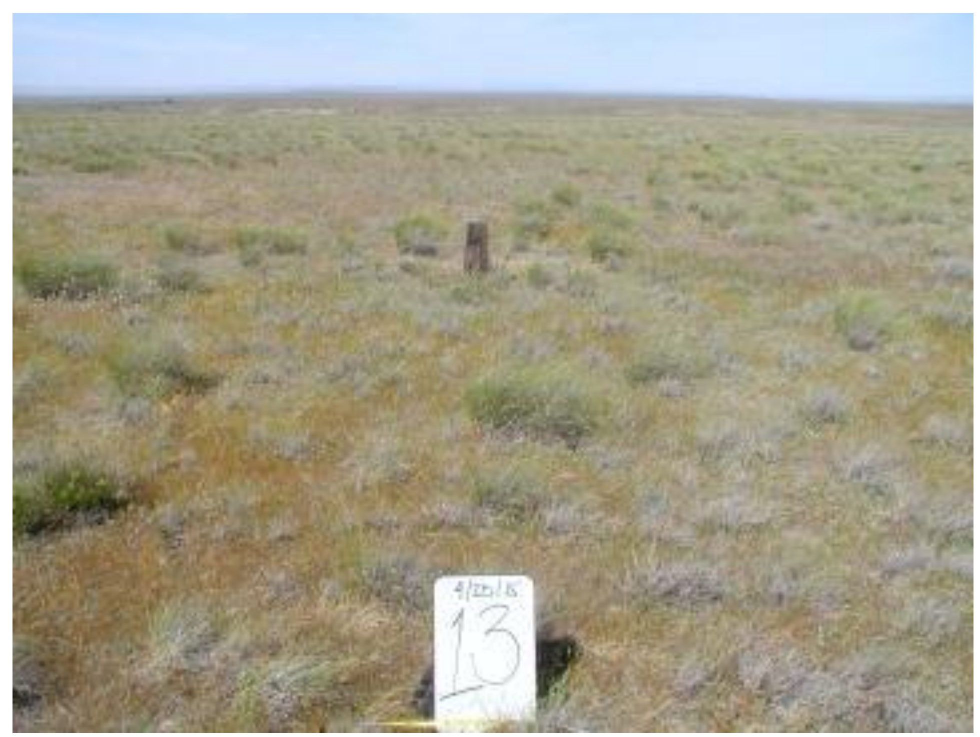
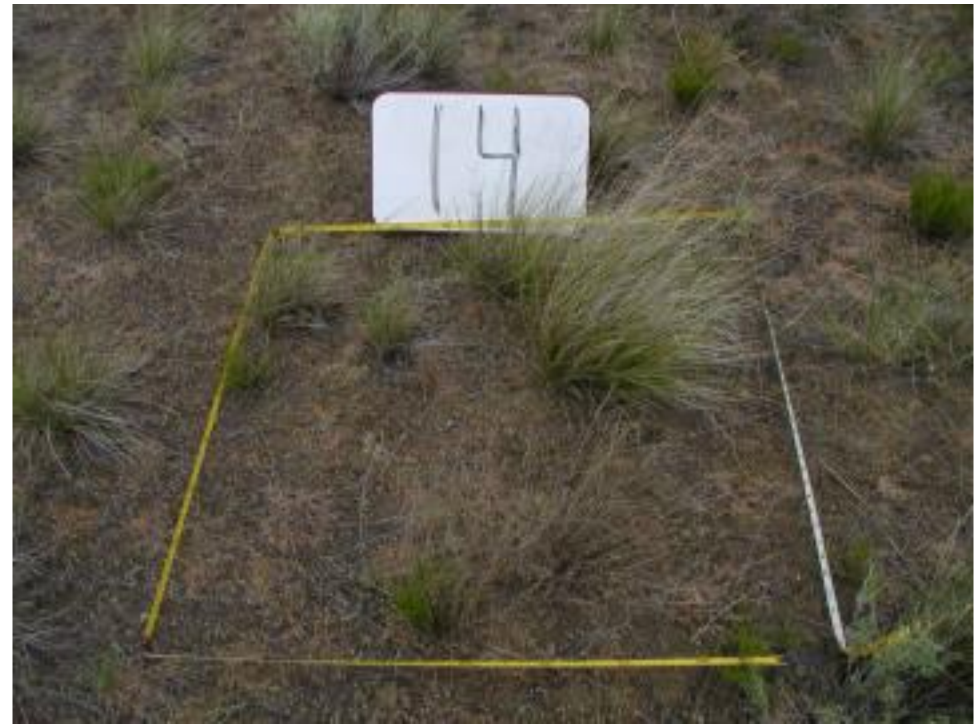



2015


2017

Figure B13b. Range monitoring plot at NWSTF Boardman – aspect photo

1987

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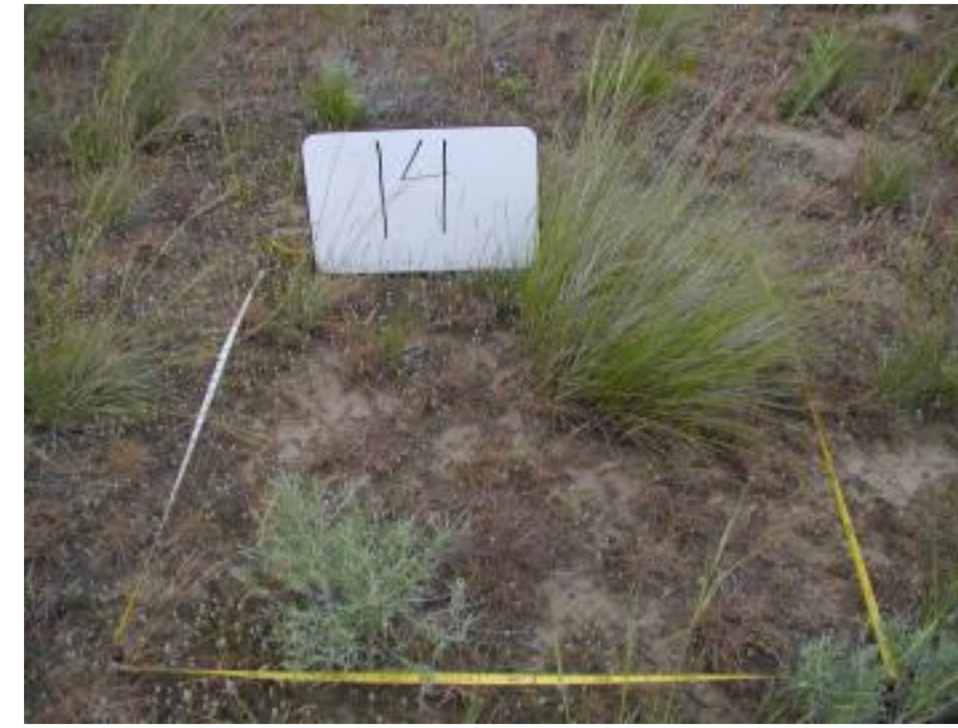
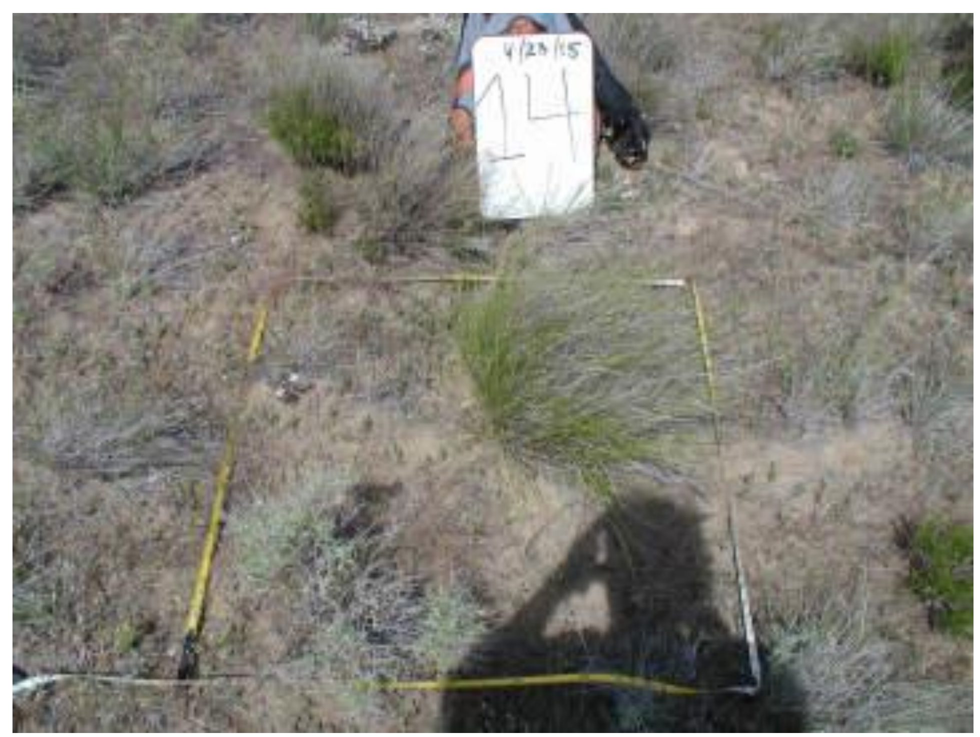



2011

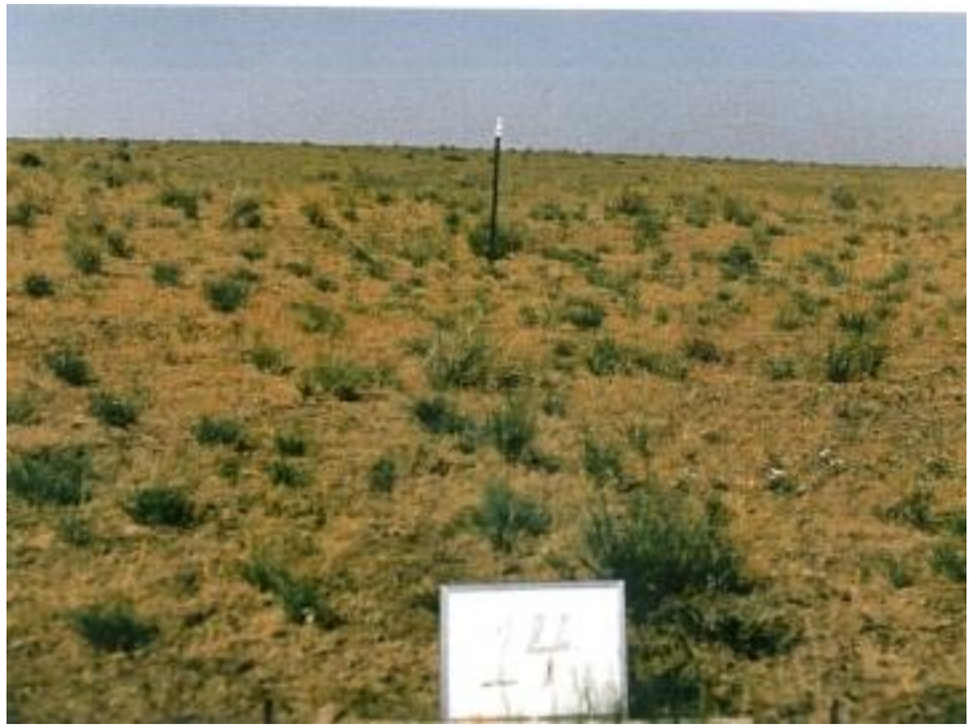
2013



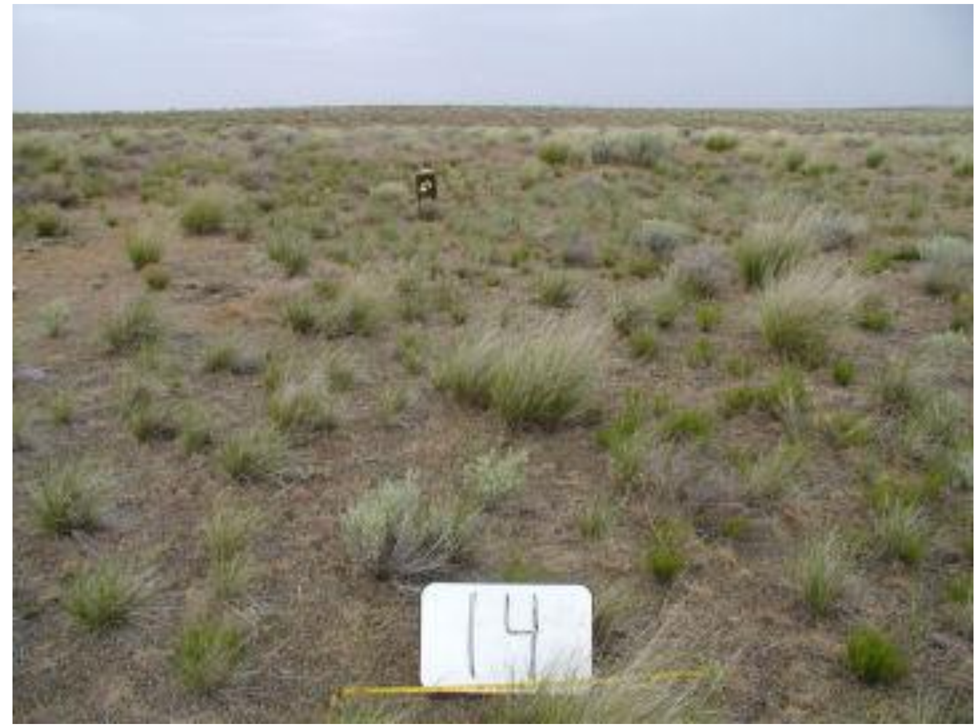

2015


2017

Figure B14a. Range monitoring plot at NWSTF Boardman – close-up photo




1987

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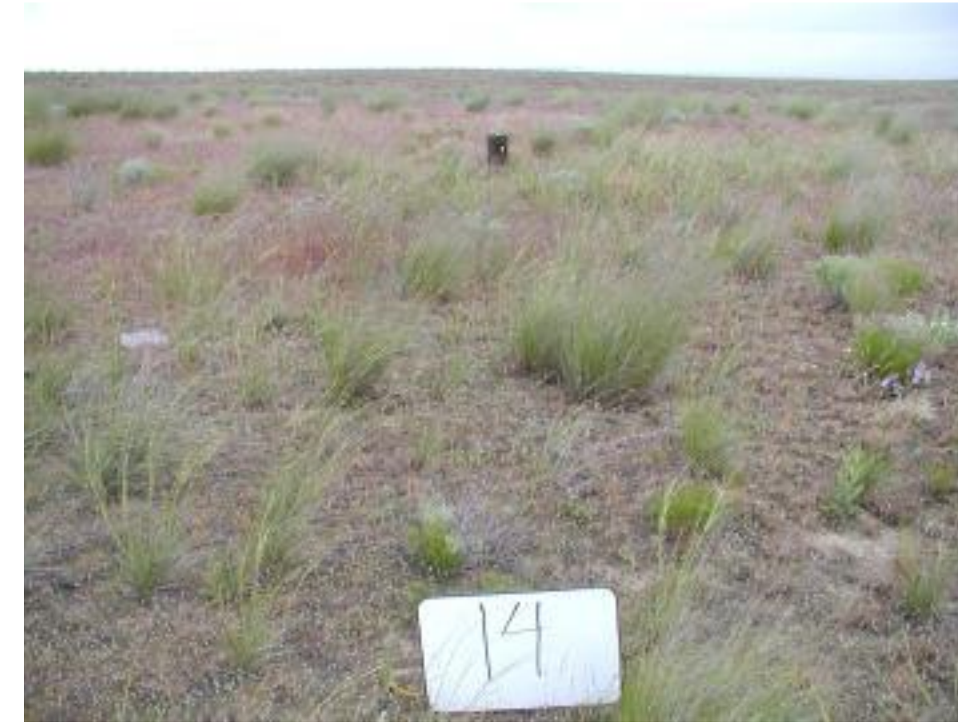
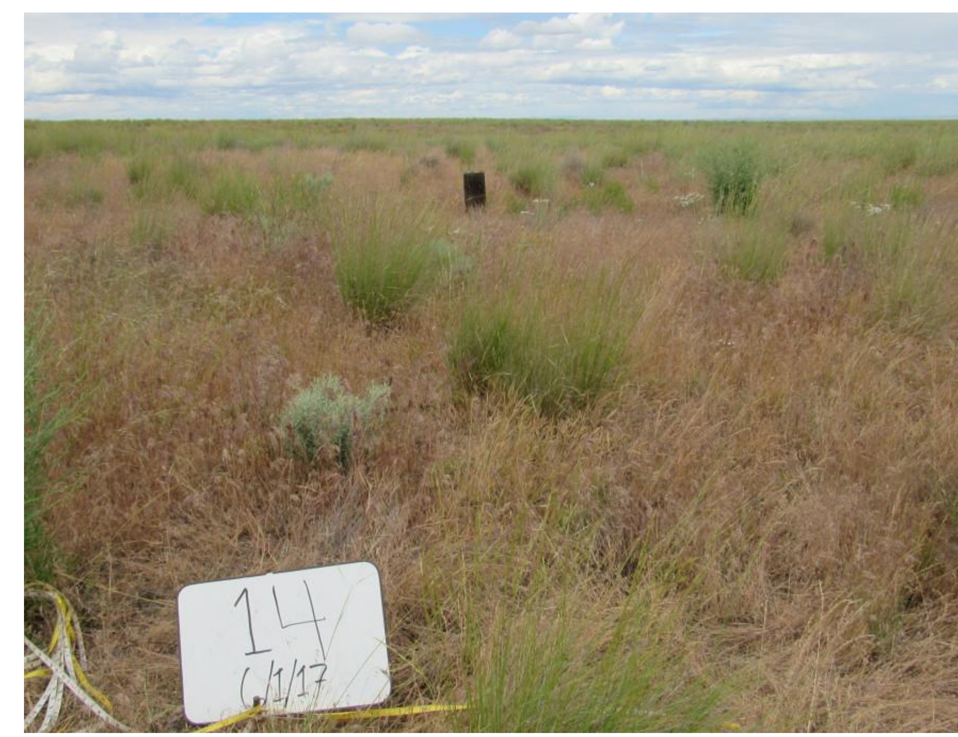



2011

2013

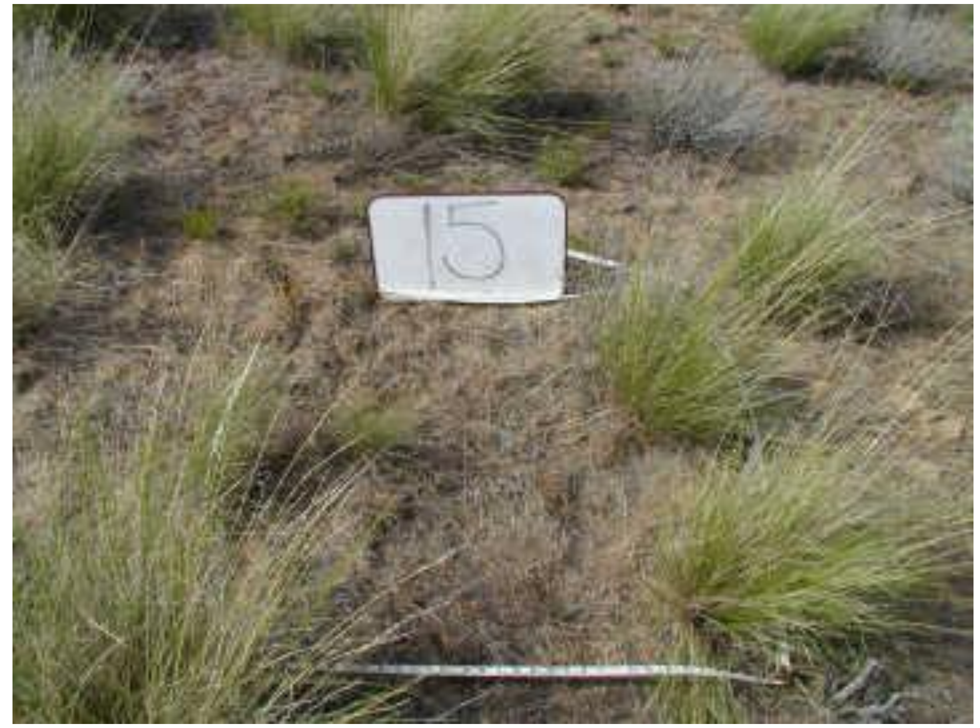

2015




2017

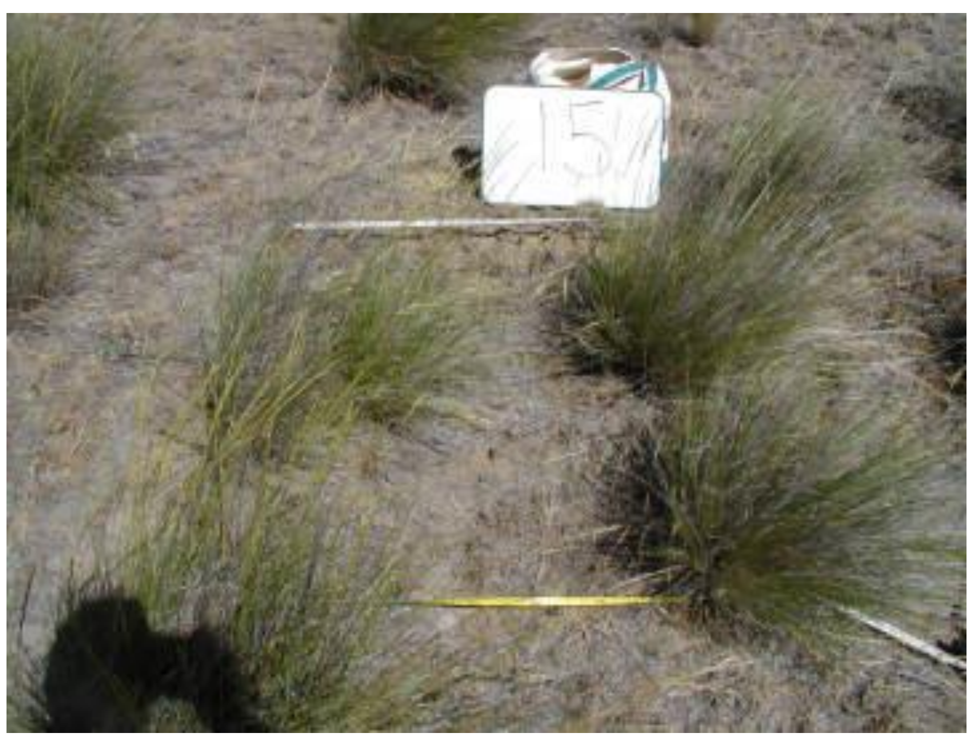
Figure B14b. Range monitoring plot at NWSTF Boardman – aspect photo

1987

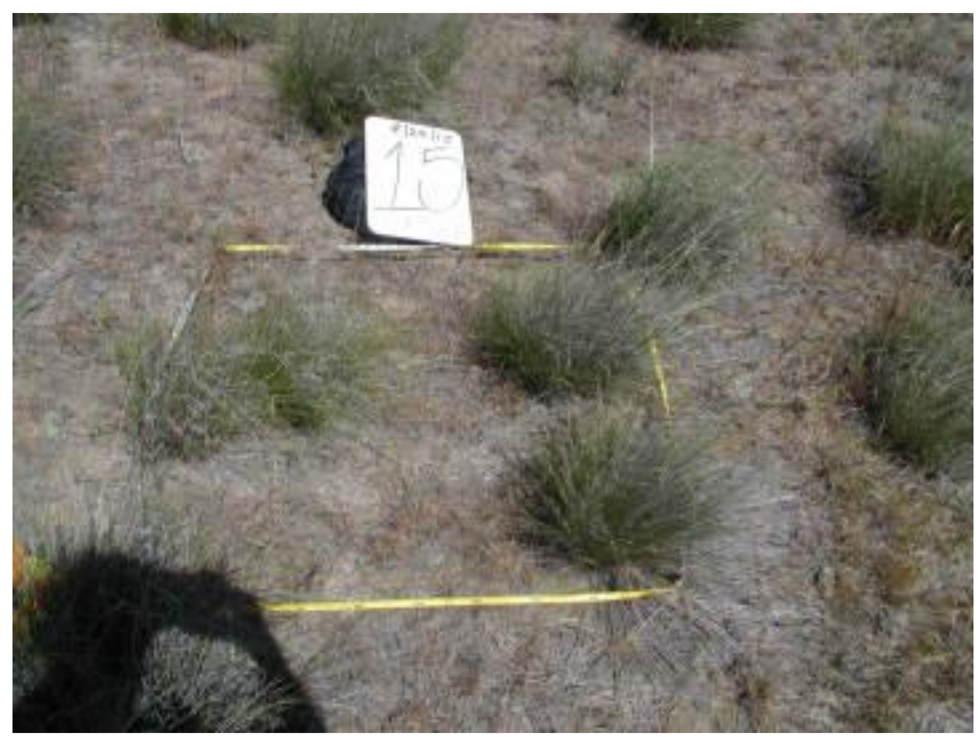



2008


2011



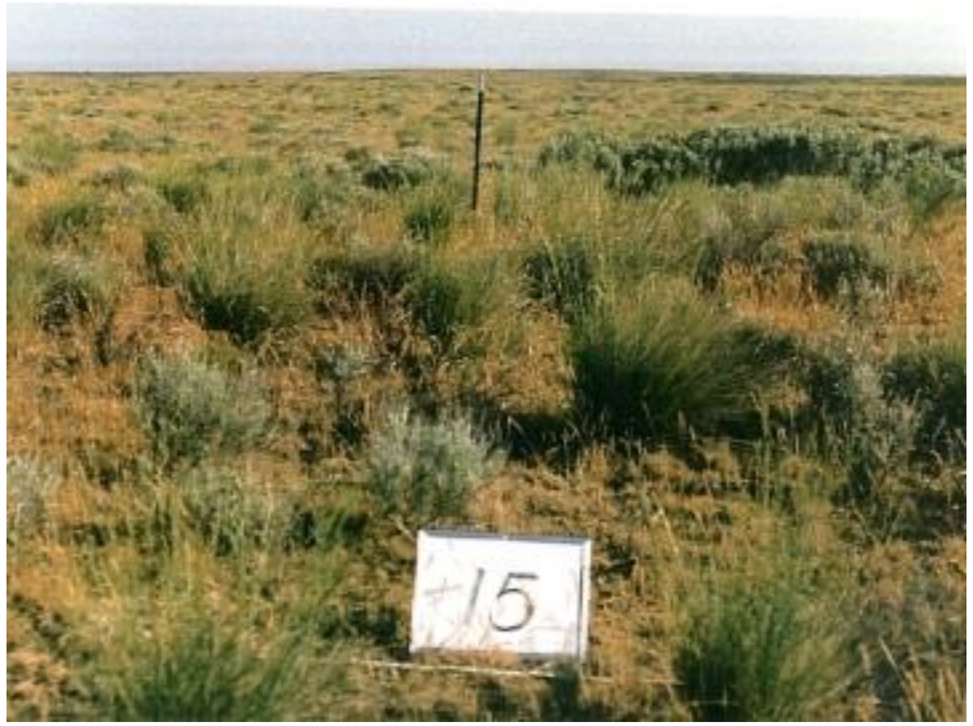

2013




2015


2017

Figure B15a. Range monitoring plot at NWSTF Boardman – close-up photo

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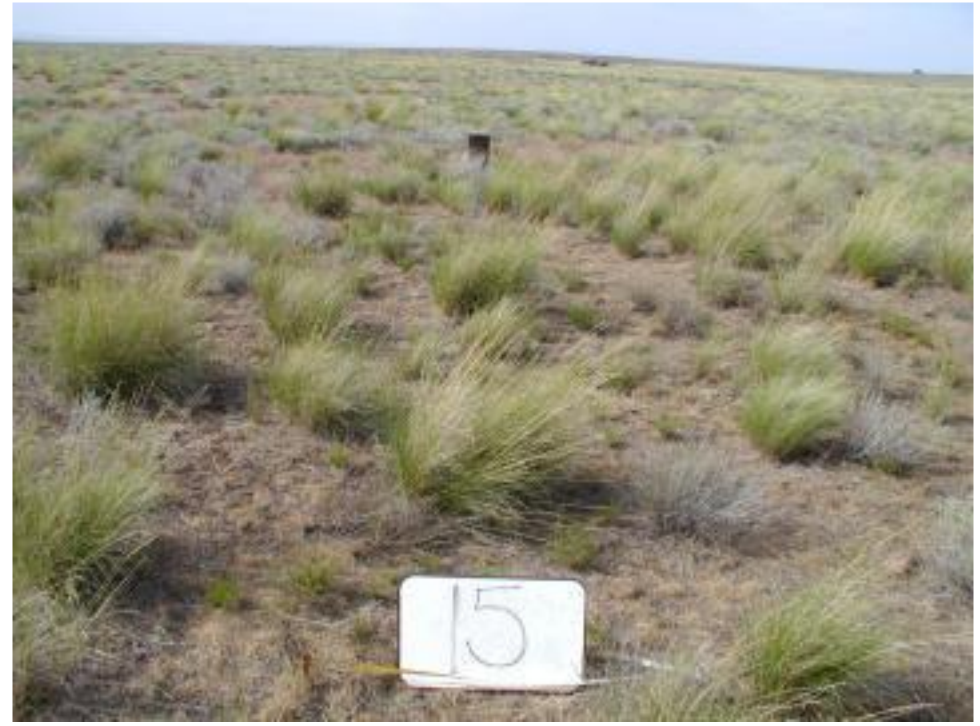


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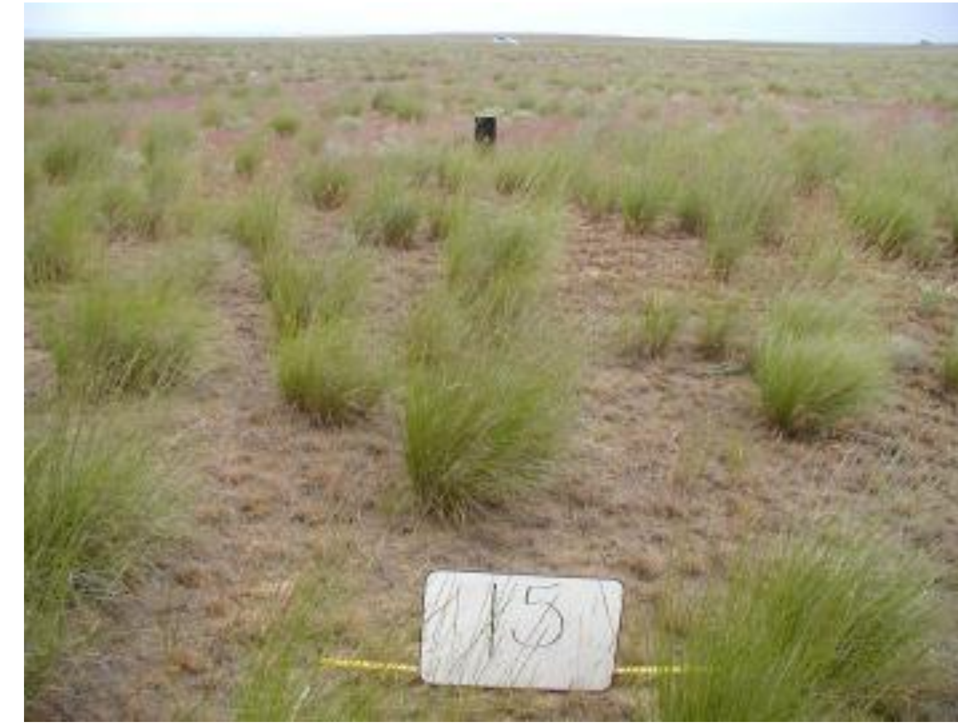
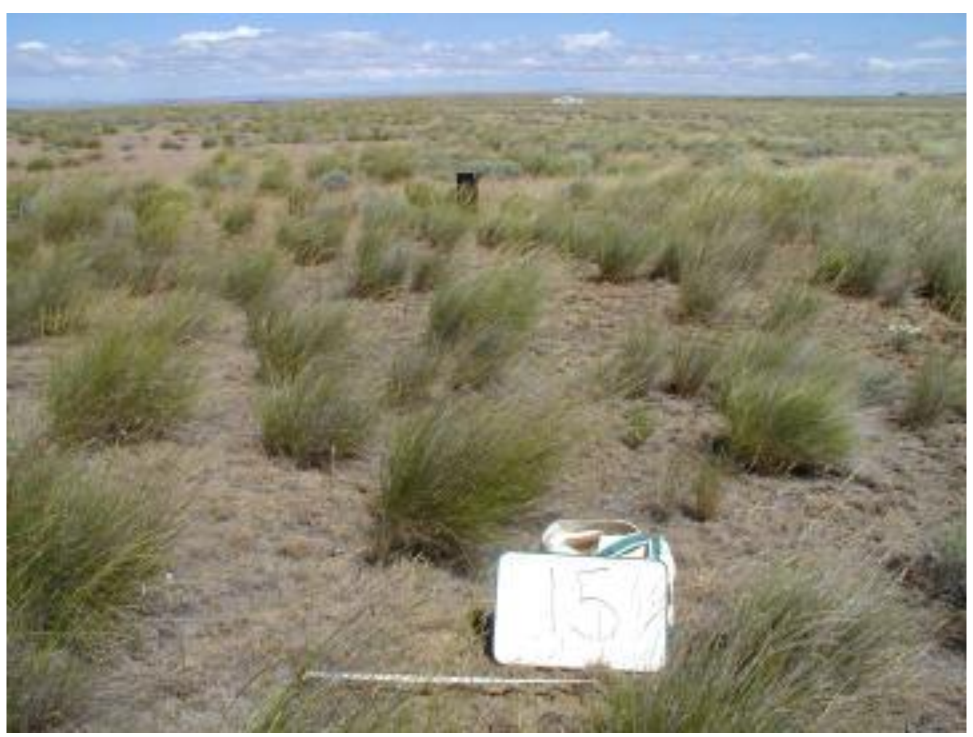



2011

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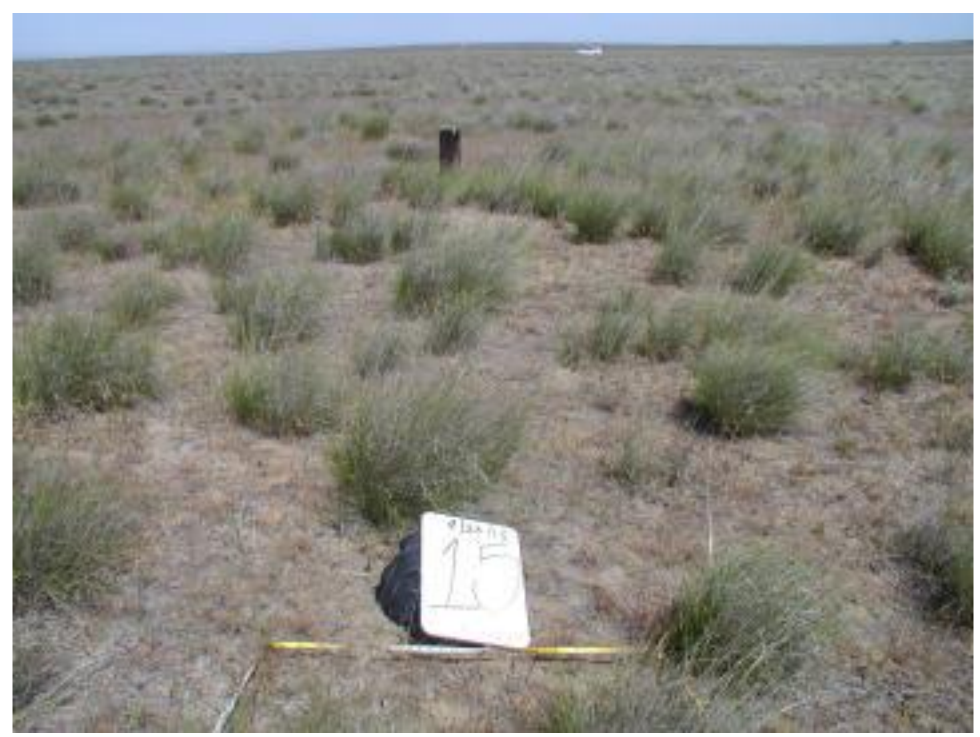


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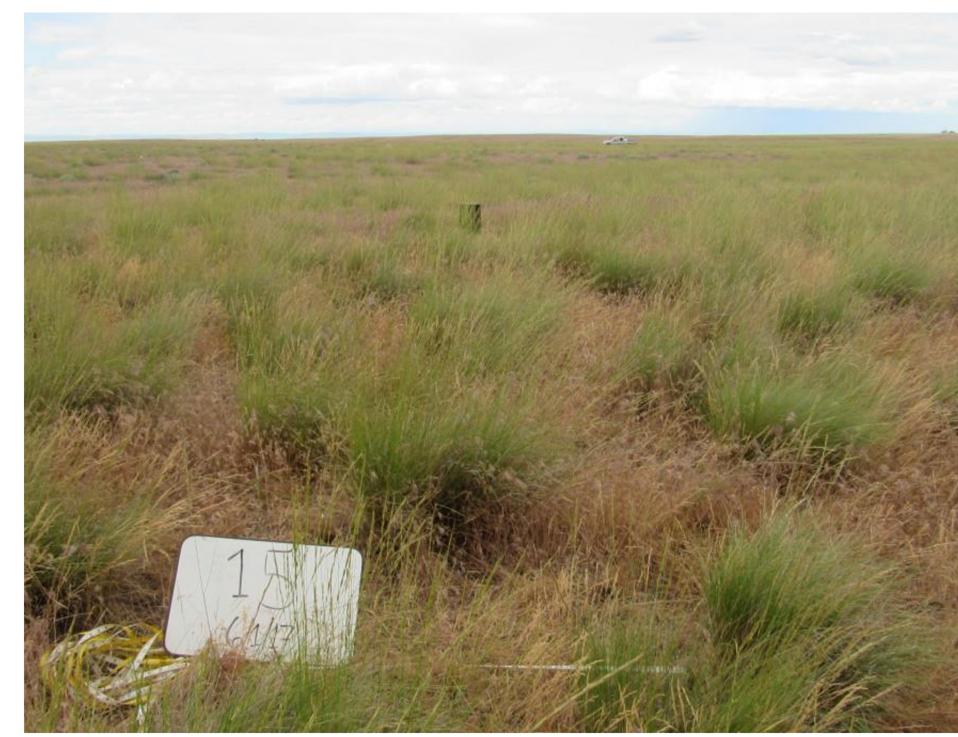
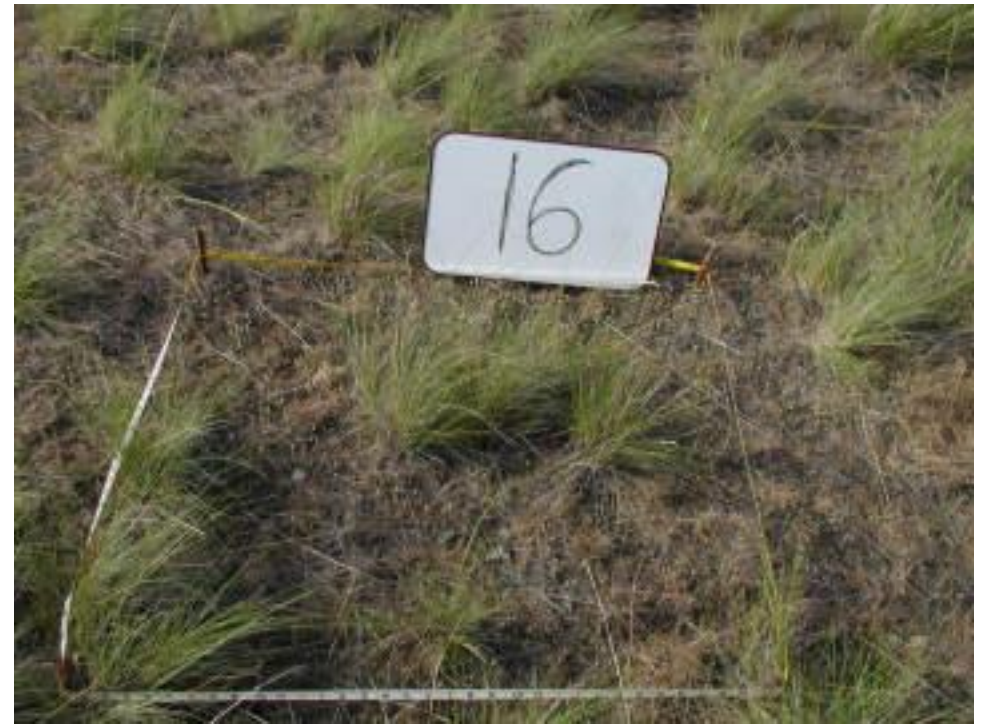



2017

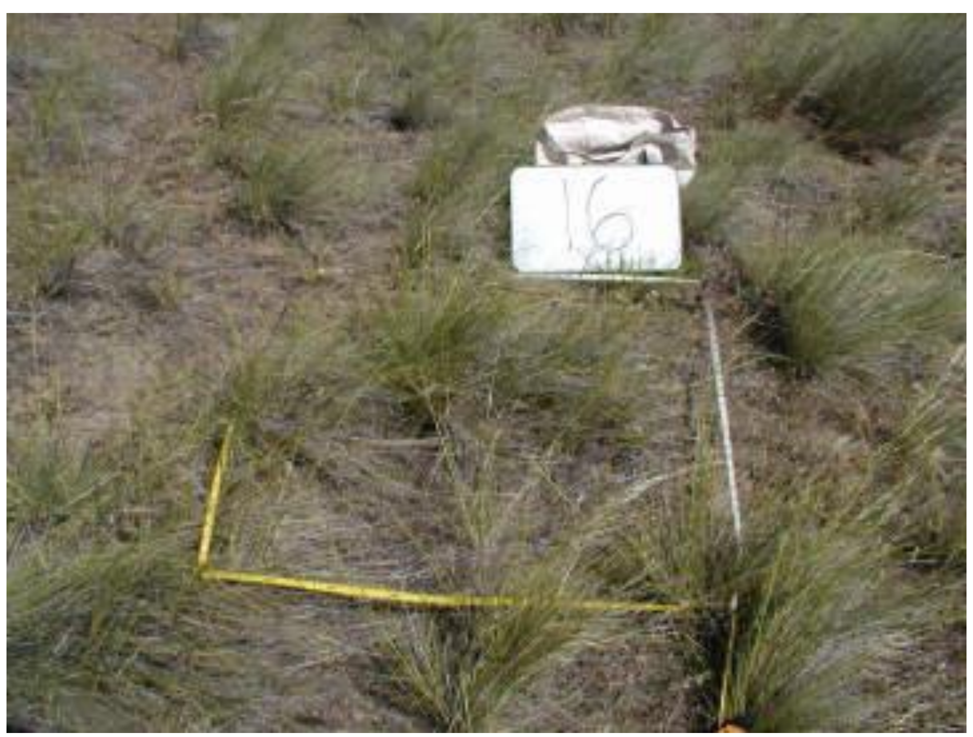
Figure B15b. Range monitoring plot at NWSTF Boardman – aspect photo

1987




2008


2011



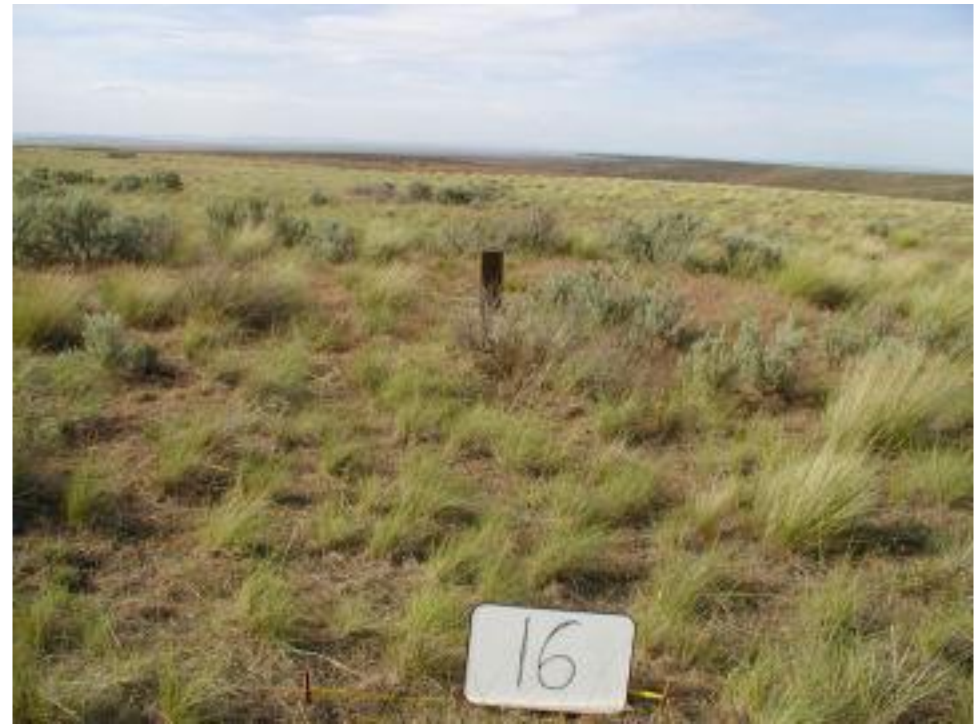

2013


2015


2017

Figure B16a. Range monitoring plot at NWSTF Boardman – close-up photo

1987

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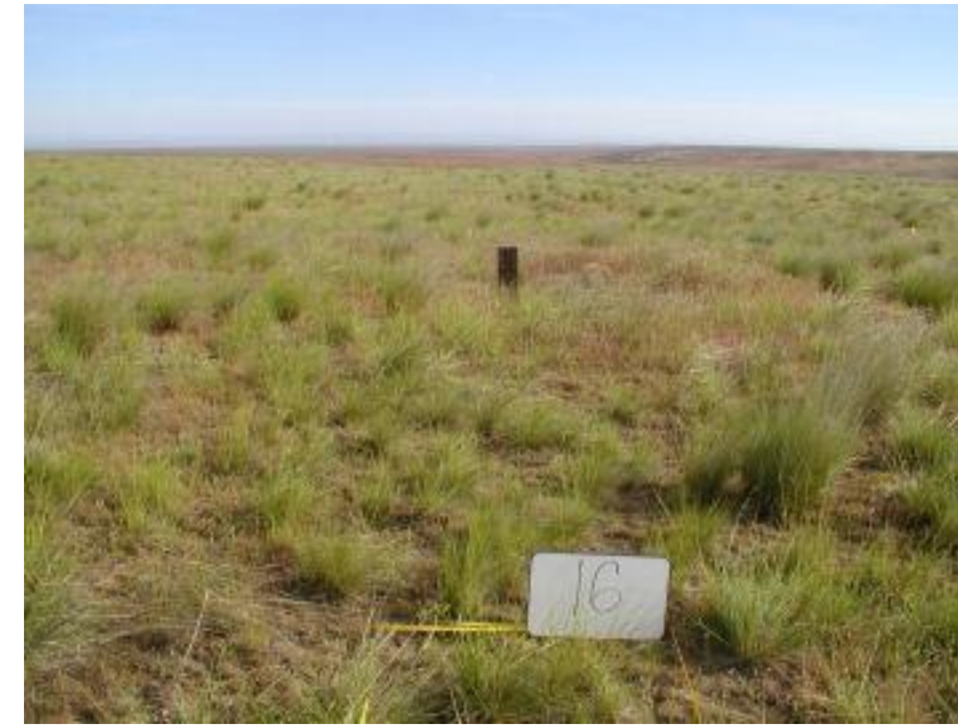
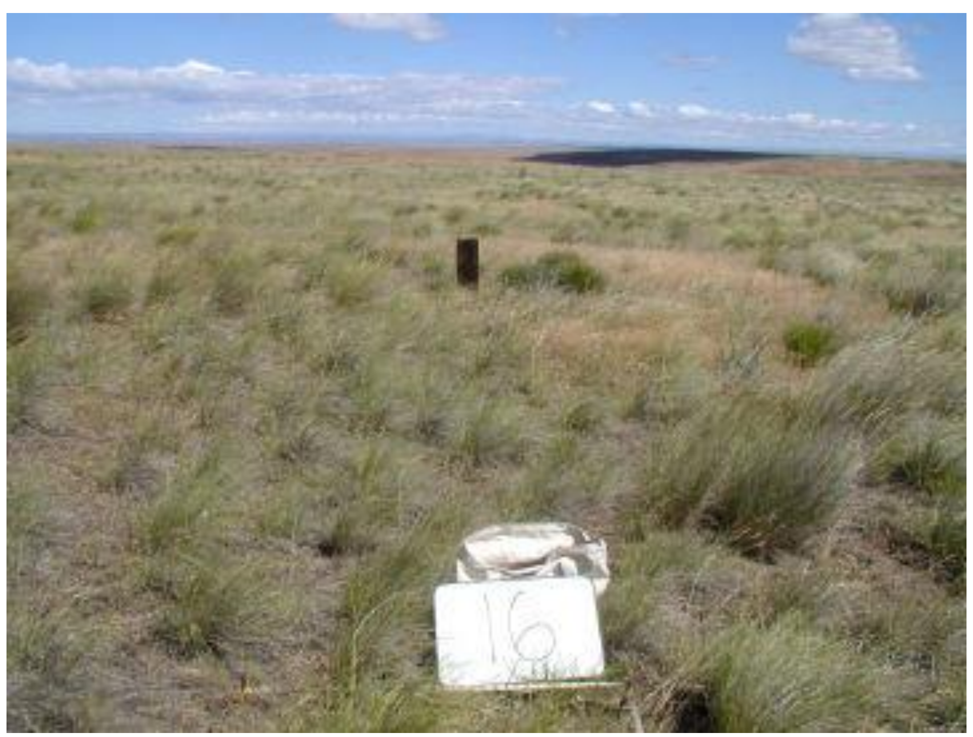
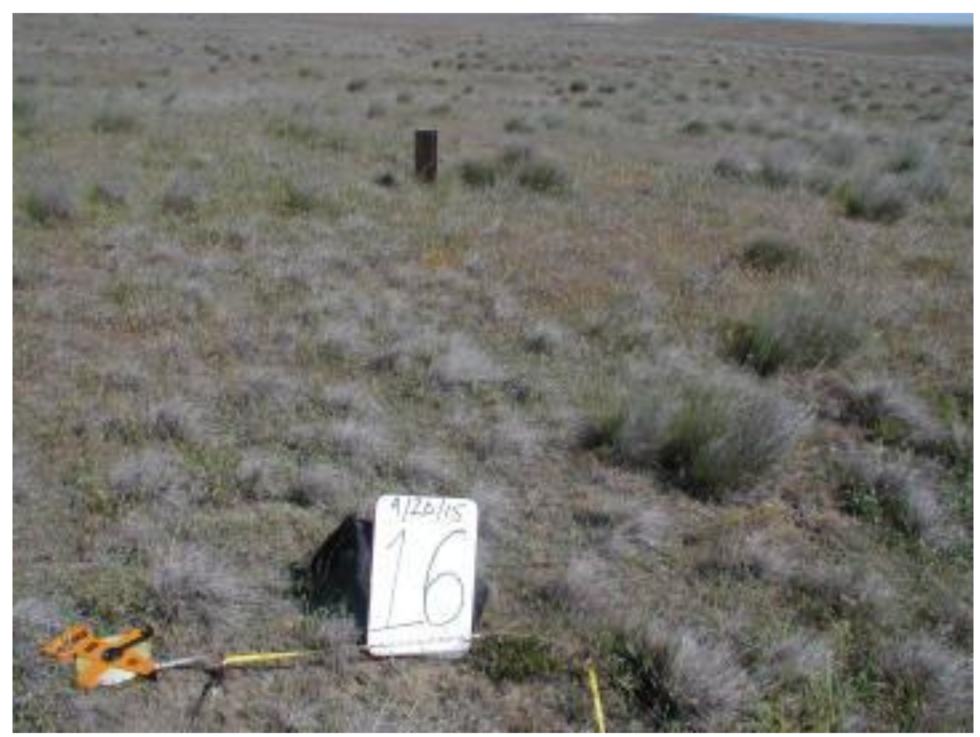



2011




2013




2015

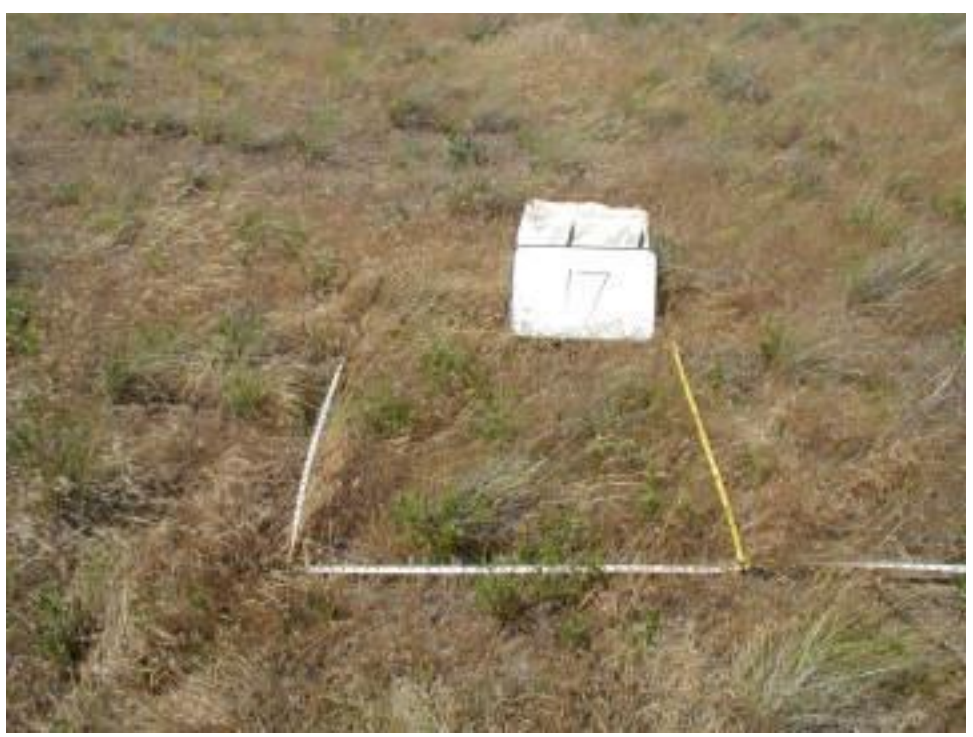

2017

Figure B16b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

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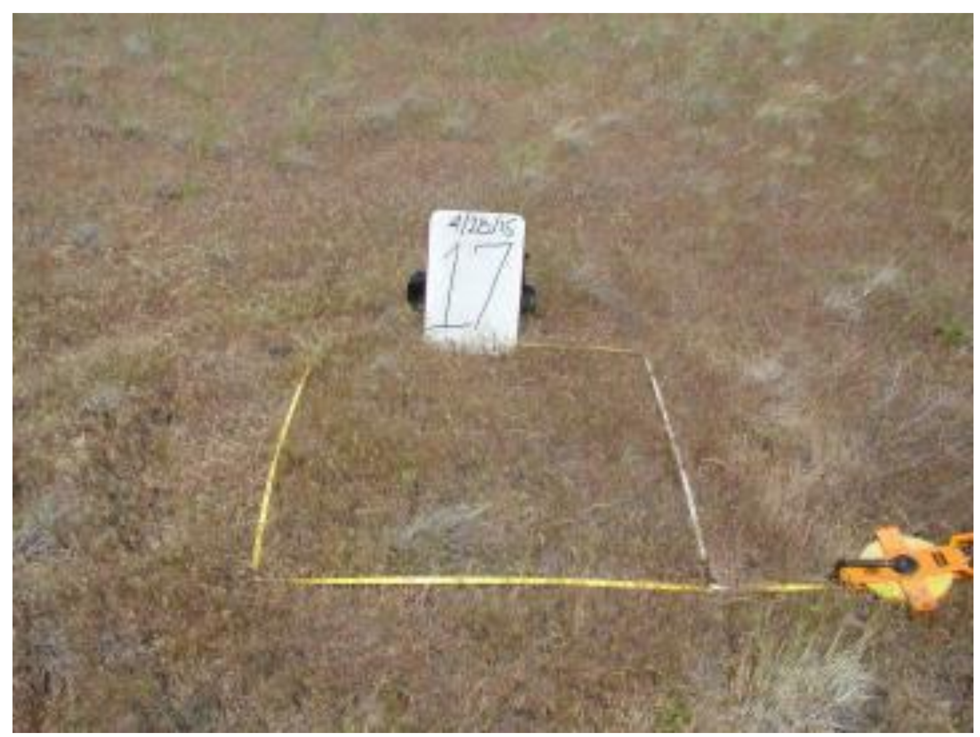



2015


2017

Figure B17a. Range monitoring plot at NWSTF Boardman – close-up photo

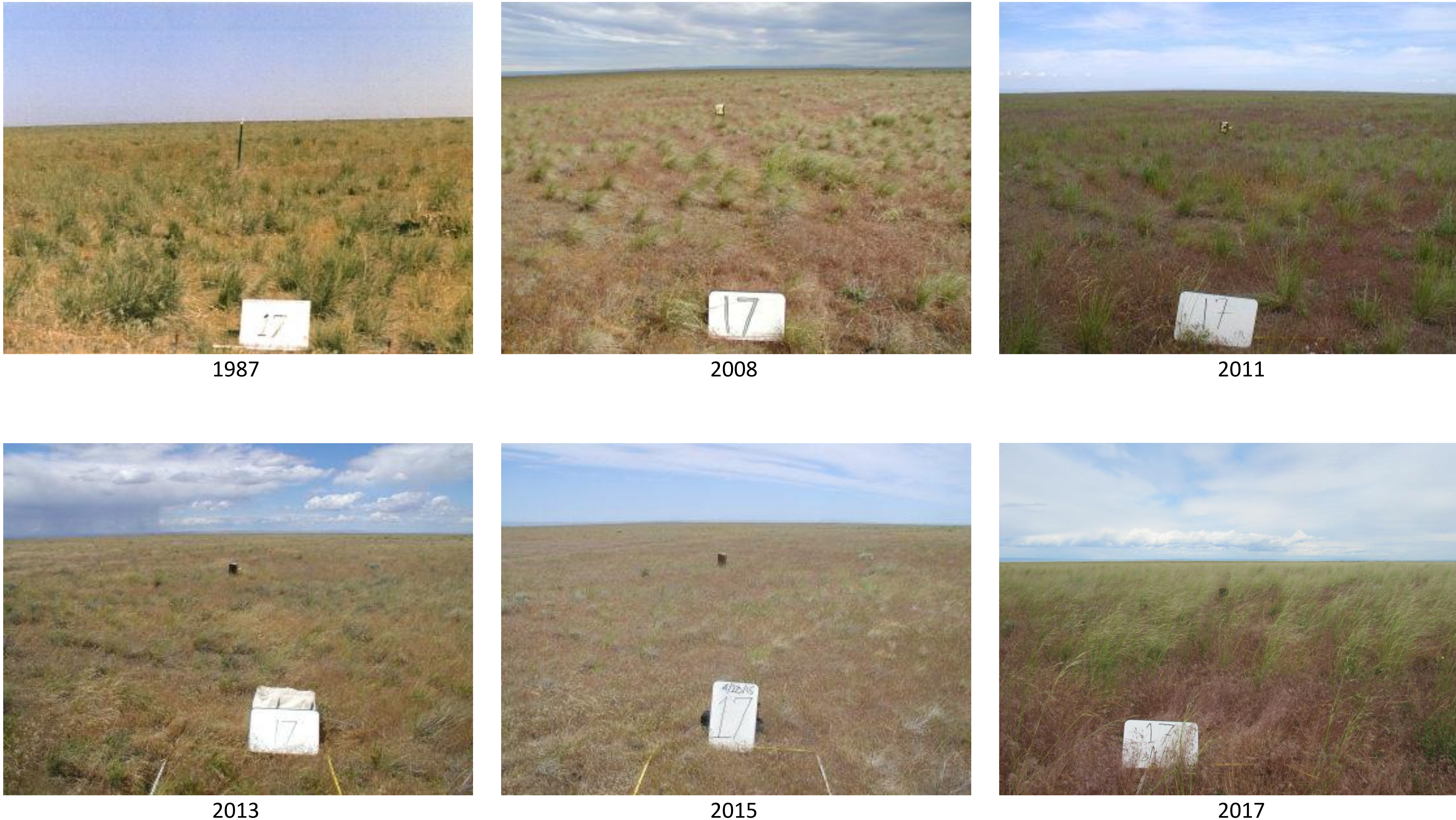
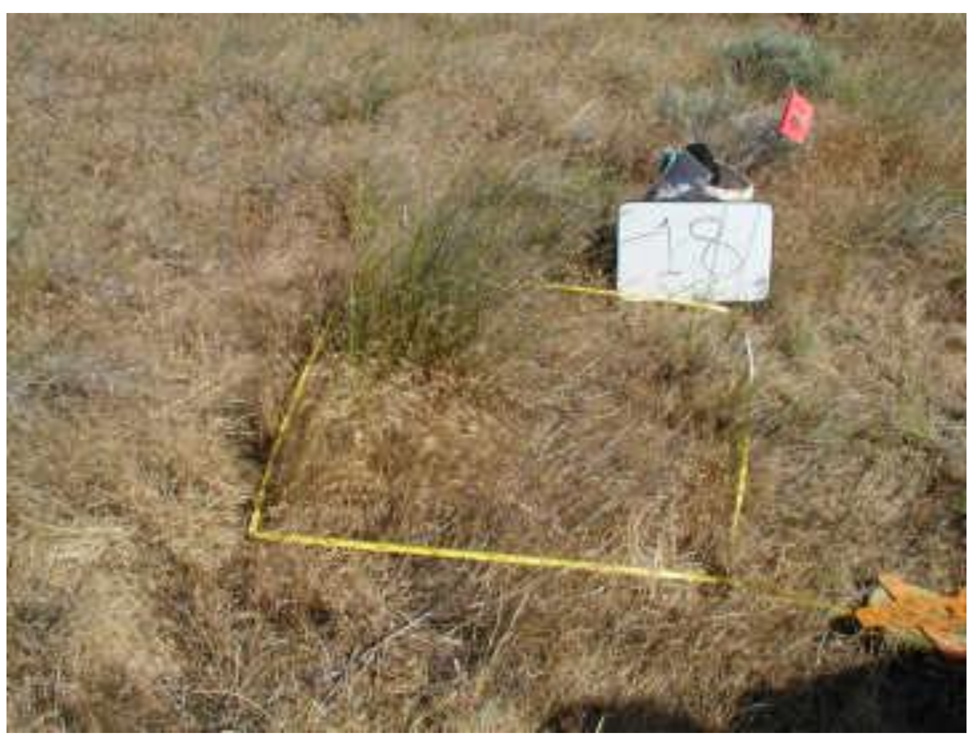



Figure B17b. Range monitoring plot at NWSTF Boardman – aspect photo


1987


2008


2011

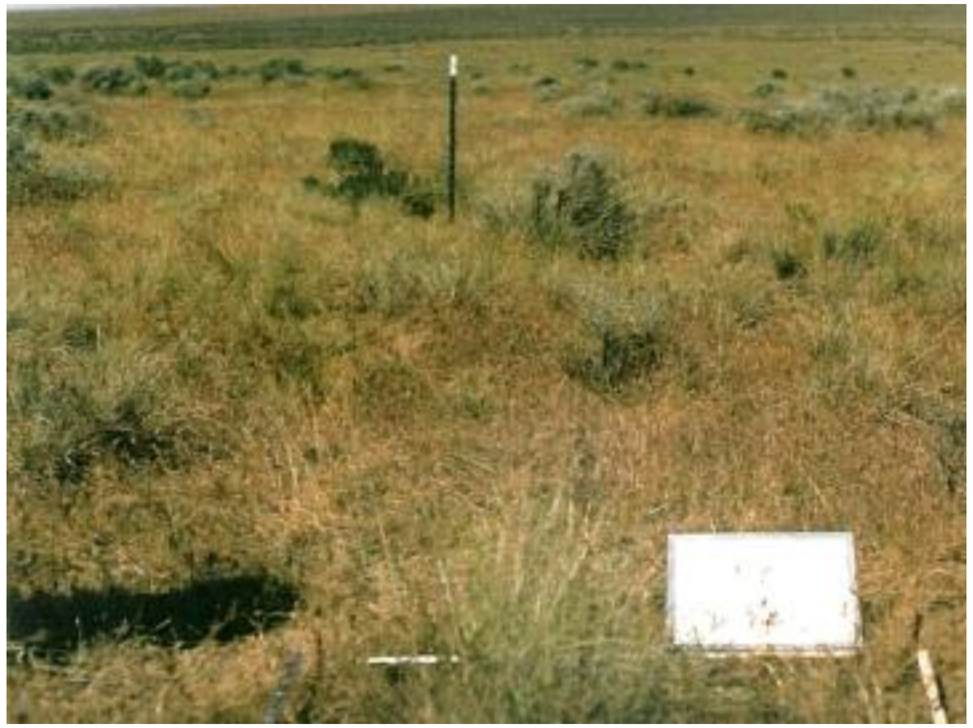



2013

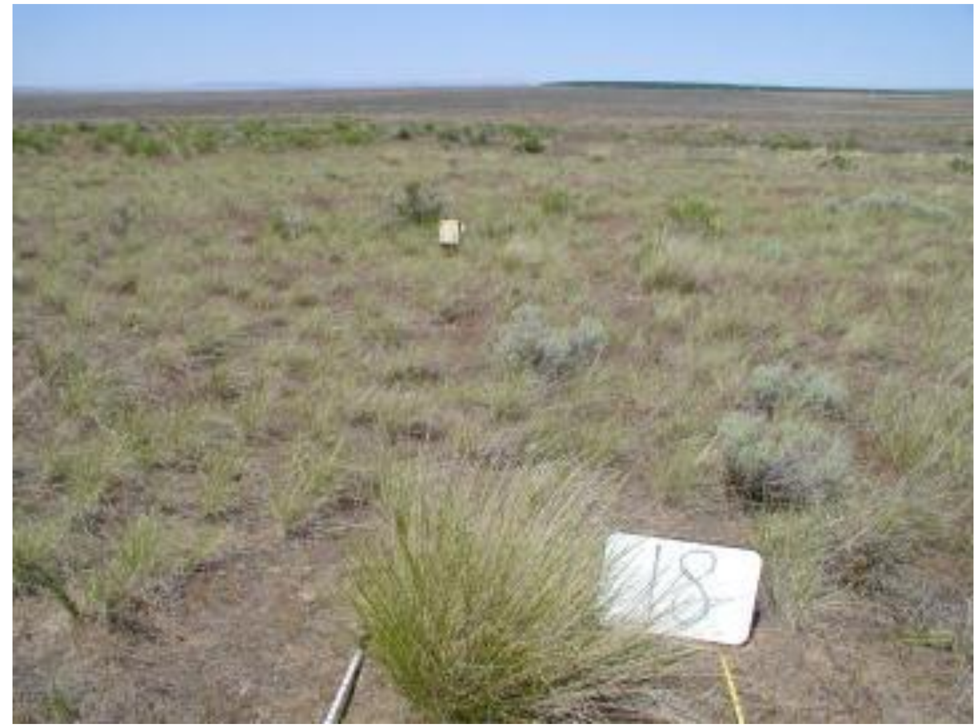
2015


2017

Figure B18a. Range monitoring plot at NWSTF Boardman – close-up photo



1987

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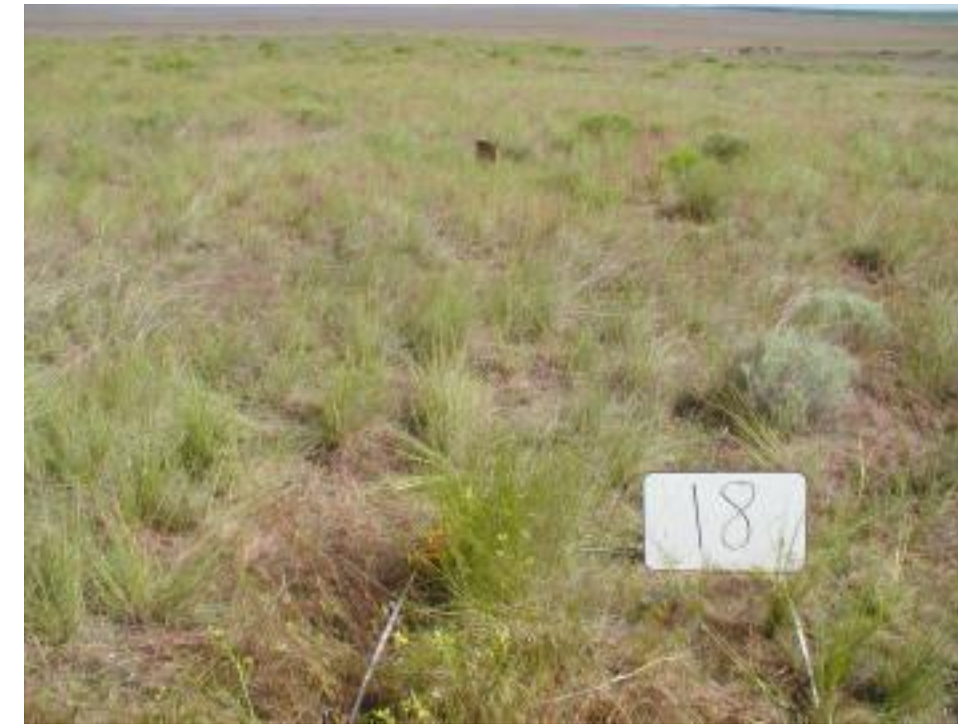
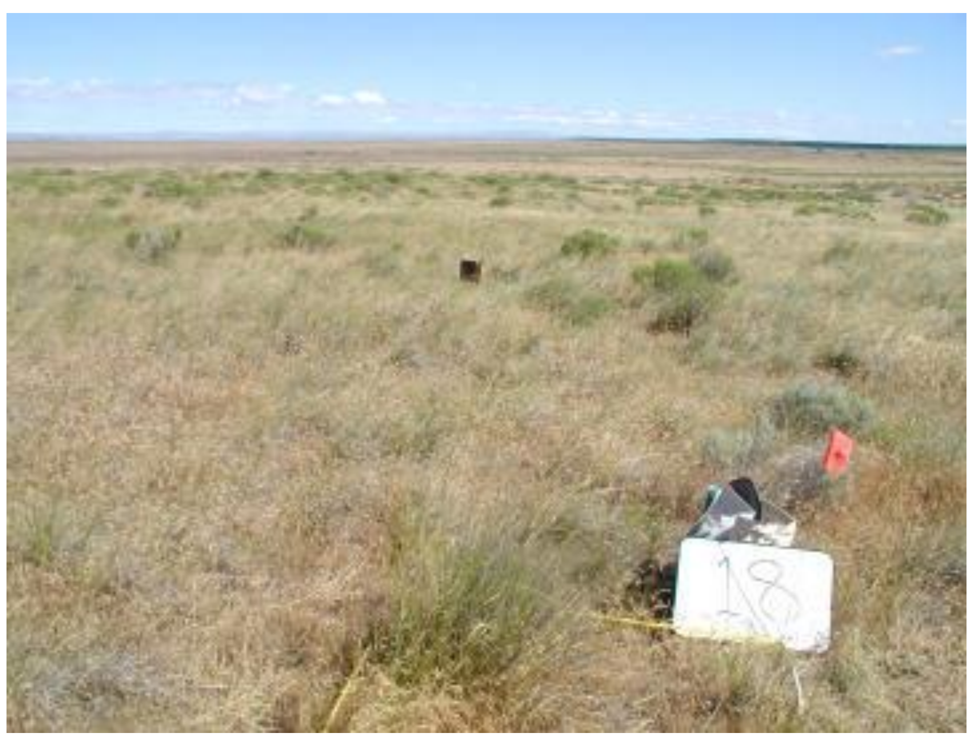
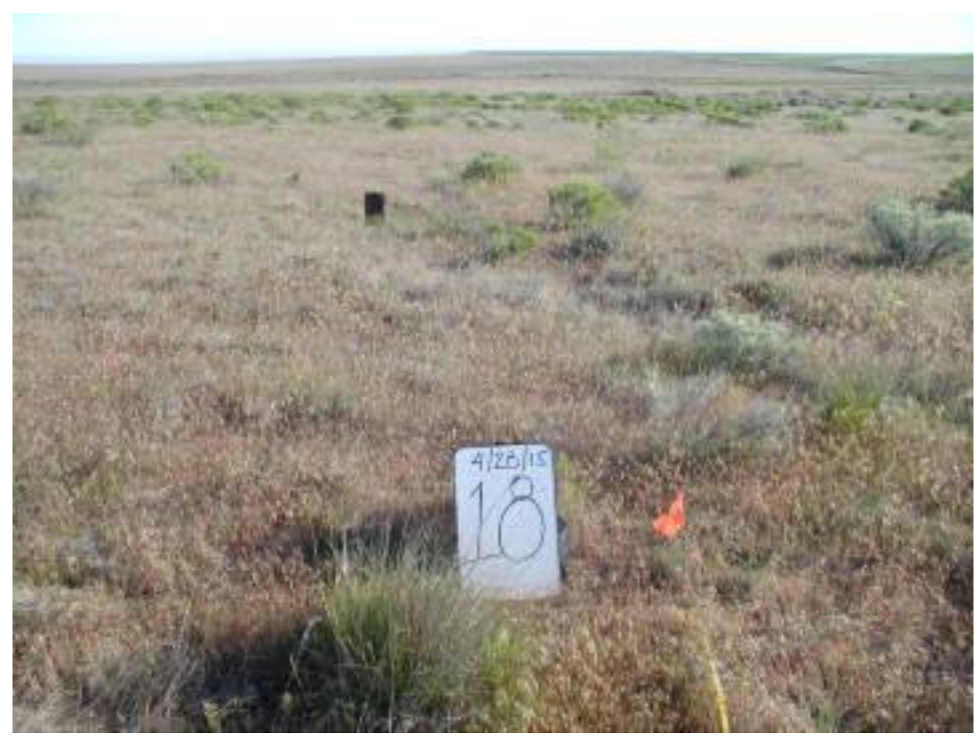



2011




2013

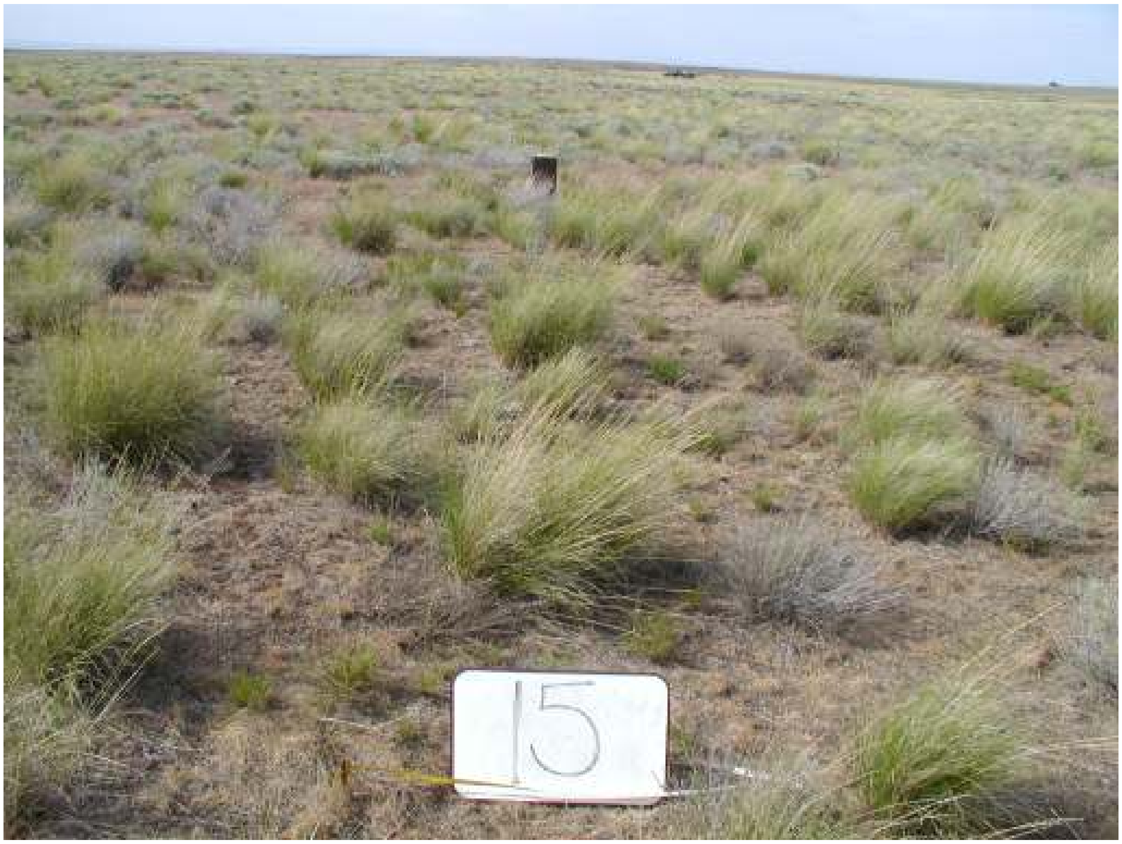



2015


2017

Figure B18b. Range monitoring plot at NWSTF Boardman – aspect photo

# Changes in vegetation on range monitoring plots at Naval Weapon Systems Training Facility (NWSTF) Boardman from 1987-2008





Adrien Elseroad
Plant Ecologist

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Leslie Nelson
Columbia Basin Project Manager

**The Nature Conservancy**


**January 2009**

The Nature Conservancy
Protecting nature. Preserving life.

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# Figures and Tables



# Appendices

# 1. Introduction

The Naval Weapon Systems Training Facility (NWSTF) Boardman, combined with the adjacent Boardman Conservation Area and other private lands, contain some of the best remaining grassland and shrub-steppe in the Columbia Plateau ecoregion (Oregon Department of Fish and Wildlife 2005). Grasslands and shrub-steppe at NWSTF Boardman provide important habitat for sensitive wildlife including the Washington ground squirrel, a candidate species under the Federal Endangered Species Act and listed species under the Oregon Endangered Species Act; and the loggerhead shrike, sage sparrow, ferruginous hawk, burrowing owl, and northern sagebrush lizard, all listed as a species of concern under the Federal Endangered Species Act, and critical or vulnerable under the Oregon Endangered Species Act (Oregon Natural Heritage Information Center 2004).

To track changes in grassland and shrub-steppe condition, a range monitoring program was developed at NWSTF Boardman in 1987. Data was last collected in 1987, and since then, several large fires have burned through the site, military training activities have been reduced, and the grazing program has ceased. In 2008, range monitoring plots were re-surveyed to document the changes in vegetation that have occurred over the last twenty-one years. The purpose of this report is to summarize the 2008 survey results and evaluate changes in grassland and shrub-steppe condition.

# 2. Methods

## 2.1 Site description

The 47,400 acre NWSTF Boardman is located in Morrow County, Oregon. Vegetation on the property is composed of a mosaic of grassland and shrubland plant communities. Dominant native vegetation includes bunchgrass communities composed of bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata* (*Agropyron spicatum*)), needle and threadgrass (*Hesperostipa* (*Stipa*) *comata*), and Sandberg's bluegrass (*Poa secunda*); and shrubland communities dominated by big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*), rabbitbrush (both *Ericameria nauseosa* and *Chrysothamnus viscidiflorus*) and western juniper (*Juniperus occidentalis*). Large portions of NWSTF Boardman have been invaded by cheatgrass (*Bromus tectorum*), a non-native annual grass. In most areas, cheatgrass occurs within a matrix of native vegetation, but some heavily disturbed areas are dominated by cheatgrass and other non-native species. A more detailed description of plant community types at NWSTF Boardman is available in Miller et al. (2007).

Several large-scale disturbances at NWSTF Boardman have influenced vegetation composition in recent history, including livestock grazing, military activities, and wildfires. Prior to purchase by the U.S. military, NWSTF Boardman was heavily grazed by horses and sheep, and cattle and sheep continued to graze large portions of the property until the grazing lease was terminated in 2002 (Miller et al. 2007). From 1943 to 1996, NWSTF Boardman was actively used by the military for aerial bombing and gunnery training but since 1996 has only been used infrequently for military training (Miller et al. 2007). Within the last ten years, several large wildfires have burned across the property. In 1998, 17,000 acres burned, in 2002, 5,000 acres burned, and in 2007, 11,600 acres burned (Miller et al. 2007). Another large wildfire burned in

July 2008, after range monitoring plots were re-surveyed. All of these disturbances have likely contributed to the establishment and spread of non-native plant species at NWSTF Boardman.

## 2.2 Vegetation sampling

In 1987, eighteen 50 ft. radius range monitoring plots were established at NWSTF Boardman (Figure 1) and data were collected following the methods described in Anderson (1986) and Anderson (1988). Between May 12$^{th}$ and 20$^{th}$ 2008, the eighteen plots were re-located and data were collected using the same methodology used in 1987. Data collection in both years consisted of estimating the percent cover of each plant species and ground surface category (bare ground, litter, and mosses and lichen), assigning a dominance rating to each plant species, estimating vigor and the number of seedlings for key species, and estimating perennial grass and forb biomass. In addition, two photographs were taken at each plot- one of the permanently marked 3 foot square subplot, and another of the permanently marked 25 foot line subplot.

Specific methods for estimating perennial grass and forb biomass were not outlined in Anderson (1986) or Anderson (1988). Therefore, in 2008, the field methods described in Brence and Sheley (2003) were used to collect biomass samples. Within each plot, a 92 inch circumference hoop was thrown in four random locations, and all perennial grasses and forbs within the hoop were clipped and combined into one paper bag. Samples were then air-dried for several weeks and weighed in grams. Weights for each sample were divided by four to obtain the average weight per hoop, and then multiplied by twenty to obtain pounds of perennial grass and forb forage per acre.

Unknown plants were keyed to species using Hitchcock and Cronquist's (1973) Flora of the Pacific Northwest.

## 2.3 Data analysis

To compare changes across all eighteen plots between 1987 and 2008, average plant cover by species and plant guild, and average cover of ground surface categories were calculated. Average percent cover was calculated by summing the total cover of each species or plant guild and dividing the value by the total number of plots (18). Plant species were assigned to one of the following guilds: shrubs, native perennial grasses, native perennial forbs, native annual forbs, and exotic annual forbs. Biennial species were treated as annuals for analysis. Species nativity and duration followed USDA (2008).

Paired t-tests were used to compare changes in plant guild cover, *Bromus tectorum* cover, cover of dominant native perennial grasses (*Pseudoroegneria spicata* ssp. *spicata*, *Hesperostipa comata*, and *Poa secunda*), species richness, and ground surface categories across all plots between 1987 and 2008. All statistical analyses were performed in SAS JMP version 7.0, with significant p-values set at 0.05.

## 2.4 Plot re-establishment

In 2008, many of the plots were missing one or more of the four pieces of rebar that marked the 3 foot square photoplot or were missing the rebar that marked one end of the 25 foot line plot (the other end is the plot monument, marked with a railroad tie). To re-establish the plot markers, a metal detector was used to determine whether the missing rebar was buried under the soil surface. When the missing rebar was detected, a new piece of rebar was pounded into the ground at the same location that the missing rebar was detected. When the metal detector was not successful in detecting the missing rebar, a tape measure and compass was used to determine the original location of the rebar. A new piece of rebar was pounded into the ground at that location, and distances and directions from the rebar to the plot monument were recorded (Table 1). At one plot (plot 12), the railroad tie marking the plot was also reset because it had been upended.

At all plots, GPS points were taken from the plot monument using a Trimble Juno GPS unit (Table 1). Additional information from 1987 and 1988 regarding plot locations is provided in Appendix A.

# 3. Results

## 3.1 Changes in vegetation across all plots from 1987 to 2008

There have been substantial changes in plant species abundance and composition over the past 21 years. Total plant cover averaged across all plots significantly increased from 45% in 1987 to 78% in 2008 ($p<0.0001$, Figure 2). Increases in plant cover were largely driven by *Bromus tectorum* and native perennial grasses (Figure 3). *Bromus tectorum* cover averaged across all plots significantly increased from 14% in 1987 to 26% in 2008 ($p=0.0138$), and native perennial grass cover averaged across all plots increased from 18% in 1987 to 27% in 2008, although increases in native perennial grasses were not significant ($p>0.05$). The native perennial grass that experienced the greatest increase in cover was *Hesperostipa comata* (Figure 4). *Hesperostipa comata* cover averaged across all plots significantly increased from 6% in 1987 to 12% in 2008 ($p=0.0161$). Native perennial forb cover also significantly increased, from 7% in 1987 to 10% in 2008 ($p=0.0008$). There were no significant differences in the cover of native or exotic annual forbs or shrubs from 1987 to 2008 (Figure 3).

In addition to increases in plant cover, a greater number of plant species were found on plots in 2008. Species richness averaged across all plots significantly increased from 15 species/plot in 1987 to 18 species/plot in 2008 ($p=0.0007$; Figure 6). Increases in species richness were largely driven by increases in native perennial forbs (Table 3).

Corresponding with the overall increase in plant cover was a decrease in bare ground and an increase in litter cover (Figure 2). Bare ground cover averaged across all plots significantly decreased from 52% in 1987 to 23% in 2008 ($p=0.0001$; Figure 2), and litter cover averaged across all plots significantly increased from 14% in 1987 to 26% in 2008 ($p=0.0025$). There were no significant differences in the cover of mosses and lichens from 1987 to 2008 (Figure 3).

Perennial grass and forb biomass estimates were substantially greater in 2008 than 1987 (Table 2). Perennial grass and forb biomass estimates averaged across all plots were 138 lbs./acre in 1987 and 317 lbs./acre in 2008. However, because the method used for estimating biomass in 1987 was not recorded, it cannot be assumed that the same method was used in both 1987 and 2008. Although results from 1987 and 2008 are not directly comparable, it is likely that perennial grass and forb biomass was greater in 2008, since both perennial grass and forb cover increased.

## 3.2 Changes within each plot from 1987 to 2008

Data collected at each plot in 1987 and 2008 are provided in Appendix B, and photos taken at each plot in 1987 and 2008 are provided in Appendix C. Summarized below are the major changes in cover that occurred within each plot from 1987 to 2008.

**Plot 1**

Plant cover at this plot in both 1987 and 2008 was dominated by *Purshia tridentata* and *Bromus tectorum*. Major changes that occurred included an increase in *Purshia tridentata* cover (from 10% in 1987 to 25% in 2008) and a decrease in bare ground cover (from 50% in 1987 to 15% in 2008) (Table B1, Figure C1). *Bromus tectorum* cover also increased, but only slightly (from 35% in 1987 to 40% in 2008). Several additional native annual and perennial forbs were found in 2008 that were not detected in 1987 (Table B1), although these species were only present in trace amounts (<1% cover).

**Plot 2**

Plant cover at this plot was dominated by *Ericameria nauseosa* and *Bromus tectorum* in 1987. Major changes that occurred included a decrease in *Ericameria nauseosa* cover (from 15% in 1987 to 5% in 2008), and an increase in *Bromus tectorum* (from 15% in 1987 to 40% in 2008) and *Purshia tridentata* cover (from 3% in 1987 to 10% in 2008; Table B2). Corresponding with the increase in plant cover was a decrease in bare ground cover, from 80% in 1987 to 30% in 2008 (Figure C3). Several additional native annual and perennial forbs were found in 2008 that were not detected in 1987 (Table B2), although these species were only present in trace amounts (<1% cover).

**Plot 3**

Plant cover at this plot was dominated by *Bromus tectorum* in 1987. Major changes that occurred included an increase in *Erodium cicutarium* (from 7% in 1987 to 50% in 2008), *Poa secunda* (from a trace amount in 1987 to 15% in 2008), and *Psoralidium lanceolatum* cover (from 5% in 1987 to 18% in 2008), and a decrease in *Bromus tectorum* percent cover (from 50% in 1987 to 30% in 2008; Table B3).

The wildfire that burned through this plot in 2007 probably consumed the few shrubs that were present in 1987 (Figure C6).

**Plot 4**

Plant cover at this plot was dominated by *Ericameria nauseosa* and *Bromus tectorum* in 1987. Major changes that occurred included a decrease in *Ericameria nauseosa* (from 20% in 1987 to a trace amount in 2008) and an increase in *Bromus tectorum* (from 7% in 1987 to 25% in 2008) and *Erodium cicutarium* cover (from 3% in 1987 to 30% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B4).

The wildfire that burned through this plot in 2007 probably consumed the *Ericameria nauseosa* shrubs that were present in 1987 (Figure C8). *Hesperostipa comata* clumps were also burned, but many of these were starting to resprout in 2008.

**Plot 5**

Plant cover at this plot was dominated by *Bromus tectorum* and *Psoralidium lanceolatum* in both 1987 and 2008. Major changes that occurred included an increase in *Bromus tectorum* (from 20% in 1987 to 38% in 2008) and *Poa secunda* cover (from 2% in 1987 to 12% in 2008), and a decrease in bare ground cover (from 30% in 1987 to 15% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B5).

The wildfire that burned through this plot in 2007 probably consumed the few shrubs that were present in 1987 (Figure C10).

**Plot 6**

Plant cover at this plot was dominated by *Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Both of these species substantially increased in cover. *Hesperostipa comata* increased from 7% in 1987 to 35% in 2008, and *Bromus tectorum* increased from 7% in 1987 to 40% in 2008. Corresponding with the increase in plant cover was a decrease in bare ground cover, from 75% in 1987 to 12% in 2008 (Figure C12). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B6).

**Plot 7**

Plant cover at this plot was dominated by *Bromus tectorum* in both 1987 and 2008. Major changes that occurred included an increase in *Bromus tectorum* (from 15% in 1987 to 60% in 2008) and a decrease in bare ground cover (from 80% in 1987 to 5% in 2008). There was also a decrease in cover for both species of rabbitbrush (Figure C14). *Ericameria nauseosa* cover decreased from 5% in 1987 to 1% in 2008, and *Chrysothamnus viscidiflorus* cover decreased from 6% in 1987 to 1% in 2008.

**Plot 8**

Plant cover at this plot was dominated by *Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Both of these species substantially increased in cover (Figure C16). *Hesperostipa comata* cover increased from 15% in 1987 to 30% in 2008, and *Bromus tectorum* cover increased from 15% in 1987 to 55% in 2008. Corresponding with the increase in plant cover was a decrease in bare ground cover, from 70% in 1987 to 10% in 2008. Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B8).

**Plot 9**

Plant cover at this plot was dominated by *Elymus lanceolatus*, *Hesperostipa comata* and *Bromus tectorum* in 1987. Major changes that occurred included a decrease in *Elymus lanceolatus* (from 10% in 1987 to a trace amount in 2008) and *Hesperostipa comata* (from 7% in 1987 to 2% in 2008) and an increase in *Bromus tectorum* cover (from 10% in 1987 to 15% in 2008) (Figure C18). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B9).

This plot burned in the 2007 wildfire, and in 2008, there was evidence of resprouting *Hesperostipa comata* as well as many *Hesperostipa comata* seedlings- therefore it is likely that the cover of this species will increases in future years.

**Plot 10**

Plant cover at this plot was dominated by *Bromus tectorum* in both 1987 and 2008. Major changes that occurred included increases in the cover of *Psoralidium lanceolatum* (from 2% in 1987 to 10% in 2008) and *Erodium cicutarium* (from 5% in 1987 to 22% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B10).

The wildfire that burned through this plot in 2007 probably consumed the few *Ericameria nauseosa* shrubs that were present in 1987 (Figure C20).

**Plot 11**

Plant cover at this plot was dominated by *Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Both of these species decreased in cover. *Hesperostipa comata* cover decreased from 15% in 1987 to 4% in 2008 and *Bromus tectorum* decreased from 20% in 1987 to 6% in 2008. Other changes included increases in *Poa secunda* (from 10% in 1987 to 20% in 2008) and *Phlox longifolia* (from 1% in 1987 to 10% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B11).

The wildfire that burned through this plot in 2007 probably consumed the few *Ericameria nauseosa* shrubs that were present in 1987 (Figure C22).

**Plot 12**

Plant cover at this plot was dominated by *Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Major changes that occurred included large increases in both of these species (Figure C24). *Hesperostipa comata* cover increased from 5% in 1987 to 25% in 2008 and *Bromus tectorum* increased from 25% in 1987 to 50% in 2008. Corresponding with the increase in plant cover was a decrease in bare ground cover, from 50% in 1987 to 5% in 2008. Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B12).

**Plot 13**

Plant cover at this plot was dominated by *Pseudoroegneria spicata* and *Poa secunda* in both 1987 and 2008 (Figure C26). The major change that occurred in this plot was a large increase in *Hesperostipa comata* cover, from a trace amount in 1987 to 15% in 2008. Mosses and lichens cover was relatively high in both years, although there was a decrease in cover from 40% in 1987 to 20% in 2008. In contrast to most of the other range monitoring plots, only trace amounts of *Bromus tectorum* were detected in 1987 and 2008. Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B13).

**Plot 14**

Plant cover at this plot was dominated by *Poa secunda* and *Plantago patagonica* in both 1987 and 2008. Neither of these species changed in cover, but there were increases in *Hesperostipa comata* (from 5% in 1987 to 15% in 2008), *Pseudoroegneria spicata* (from 1% in 1987 to 8% in 2008), and *Gutierrezia sarothrae* cover (from 1% in 1987 to 10% in 2008; Figure

C28). Mosses and lichens cover was relatively high in both years, and increased from 30% in 1987 to 40% in 2008. *Bromus tectorum* cover was low in both years (2% in 1987 and 3% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B14).

**Plot 15**

Plant cover at this plot was dominated by *Poa secunda* and *Erodium cicutarium* in 1987. Major changes that occurred included increases in *Pseudoroegneria spicata* (from 3% in 1987 to 28% in 2008), and decreases in *Erodium cicutarium* (from 15% in 1987 to a trace amount in 2008), and *Bromus tectorum* cover (from 6% in 1987 to 3% in 2008) (Figure C30). Mosses and lichens cover was relatively high in both years (35% in 1987 and 30% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B15).

**Plot 16**

Plant cover at this plot was dominated by *Poa secunda, Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Major changes that occurred included decreases in *Poa secunda* (from 30% in 1987 to 20% in 2008), and increases in *Hesperostipa comata* (from 7% in 1987 to 15% in 2008), *Pseudoroegneria spicata* (from 2% in 1987 to 10% in 2008), and *Artemisia tridentata* cover (from a trace amount in 1987 to 18% in 2008) (Figure C32). Mosses and lichens cover was relatively high in both years (30% in 1987 and 25% in 2008). Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B16).

**Plot 17**

Plant cover at this plot was dominated by *Poa secunda, Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. All of these species increased in cover between 1987 and 2008. *Poa secunda* increased from 3% in 1987 to 10% in 2008, *Hesperostipa comata* increased from 15% in 1987 to 25% in 2008 and *Bromus tectorum* increased from 3% in 1987 to 30% in 2008 (Figure C34). Corresponding with the increase in plant cover was a decrease in bare ground cover, from 75% in 1987 to 20% in 2008. Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B17).

**Plot 18**

Plant cover at this plot was dominated by *Poa secunda, Hesperostipa comata* and *Bromus tectorum* in both 1987 and 2008. Major changes that occurred included increases in *Hesperostipa comata* (from 15% in 1987 to 35% in 2008) and *Ericameria nauseosa* cover (from 2% in 1987 to 8% in 2008; Figure C36). Corresponding with the increase in plant cover was a decrease in bare ground cover, from 40% in 1987 to 8% in 2008. Several additional native forb species, both annual and perennial, were found in 2008 that were not detected in 1987, although these species were only present in trace amounts (<1% cover; Table B18).

# 4. Discussion

Plant species abundance and composition changed significantly over the last 21 years on range monitoring plots at NWSTF Boardman. Total plant cover was substantially greater in 2008 than in 1987, with increases largely driven by the native perennial grass *Hesperostipa comata*, native perennial forbs, and the non-native annual grass *Bromus tectorum*. There were also a greater number of plant species found on plots, primarily native perennial forbs. Other changes included a decrease in the amount of bare soil and an increase in the amount of litter.

Although the increases in native species cover and species richness indicate an improvement in condition since 1987, the associated increase in *Bromus tectorum* cover is not encouraging. This species alters natural fire regimes by creating more abundant and continuous fine fuels that can result in more intense, larger, and frequent fires, and after a series of intense fires high quality native habitats can be converted to a monoculture of cheatgrass and other non-native species. Reducing *Bromus tectorum* once it is well-established is difficult and costly; thus management strategies should focus on preventing further *Bromus tectorum* establishment in high-quality areas. The few range monitoring plots that did not experience large increases in *Bromus tectorum* were associated with high lichen and moss cover (i.e. plots 13-16); therefore preventing trampling of the biological soil crust may be an important strategy for minimizing further *Bromus tectorum* increases.

## 5. Literature Cited


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# 6. Figures and Tables

**Figure 1. Location of range monitoring plots at NWSTF Boardman.**

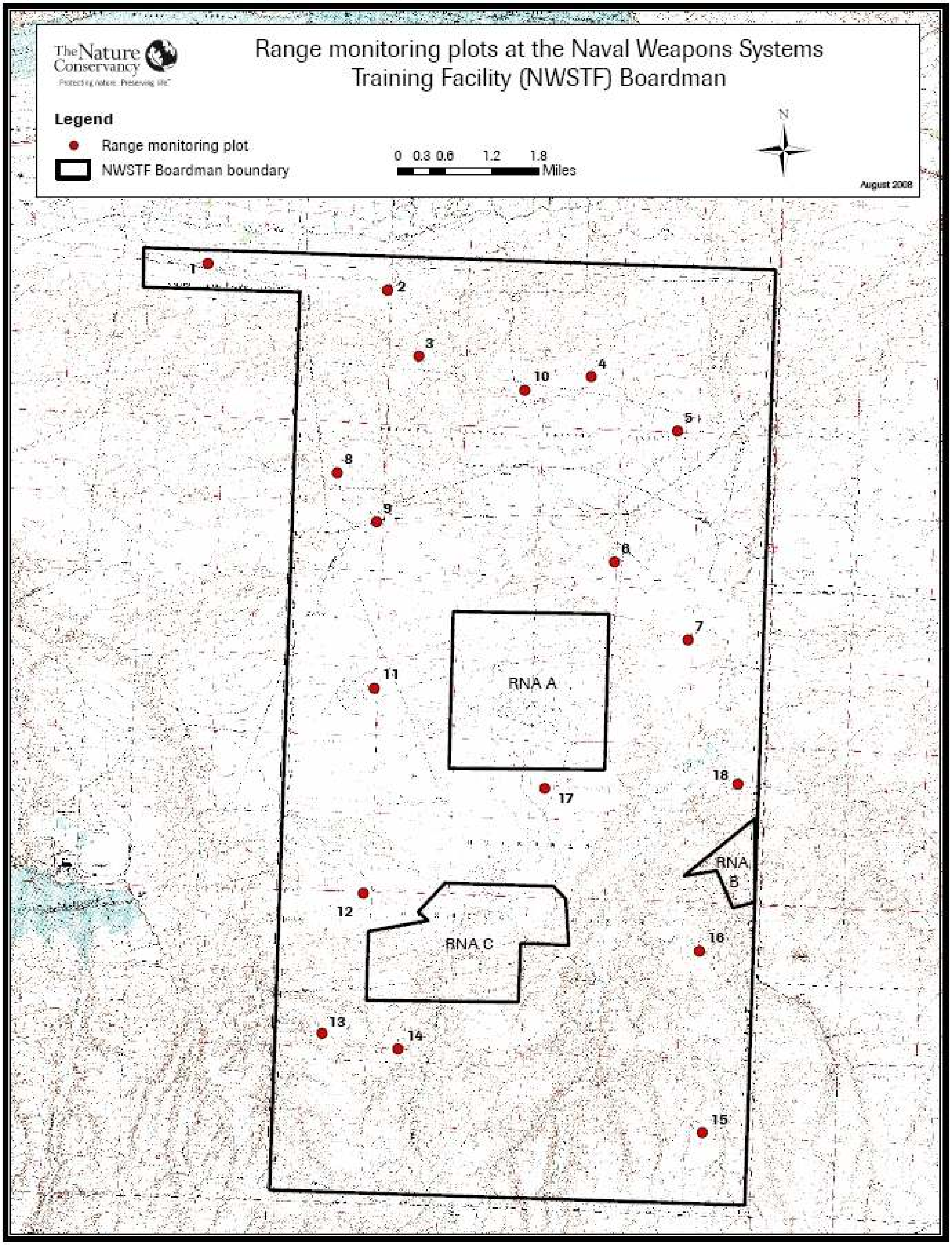


**Figure 2. Total plant cover and cover of ground surface categories on range monitoring plots at NWSTF Boardman in 1987 and 2008.** Values are averages ± SE; * represents significant differences between years (paired t-test, p<0.05, n=18).

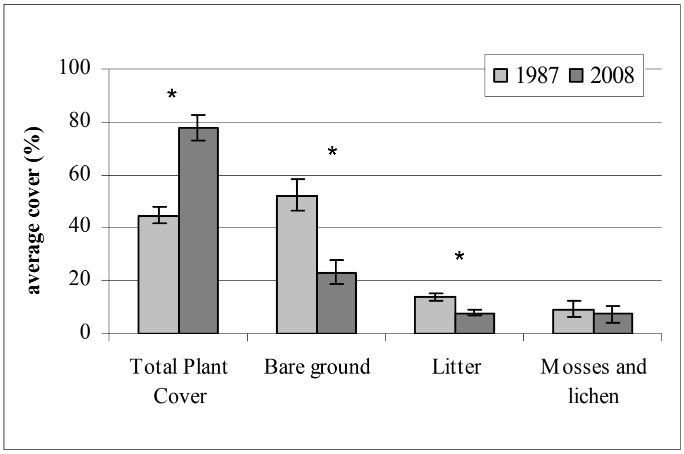



**Figure 3. Plant guild and *Bromus tectorum* cover on range monitoring plots at NWSTF Boardman in 1987 and 2008.** Values are averages ± SE; * represents significant differences between years (paired t-test, p<0.05, n=18).

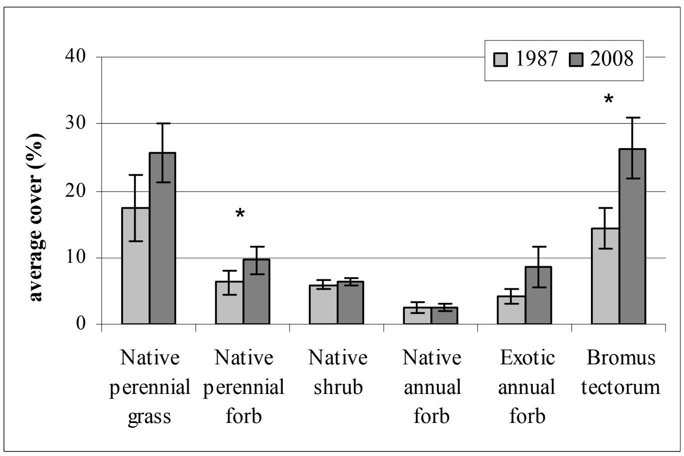



**Figure 4. Native perennial grass cover on range monitoring plots at NWSTF Boardman in 1987 and 2008.** Values are averages ± SE; * represents significant differences between years (paired t-test, p<0.05, n=18).

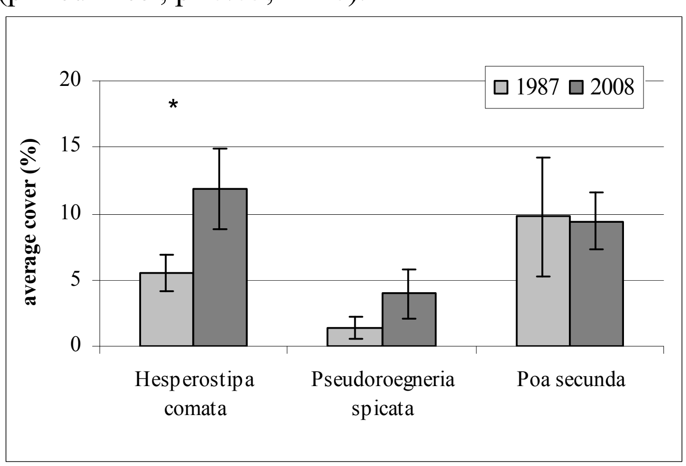


**Figure 5. Plant species richness on range monitoring plots at NWSTF Boardman in 1987 and 2008.** Values are averages ± SE; different letters represent significant differences between years (paired t-test, $p<0.05$, $n=18$).

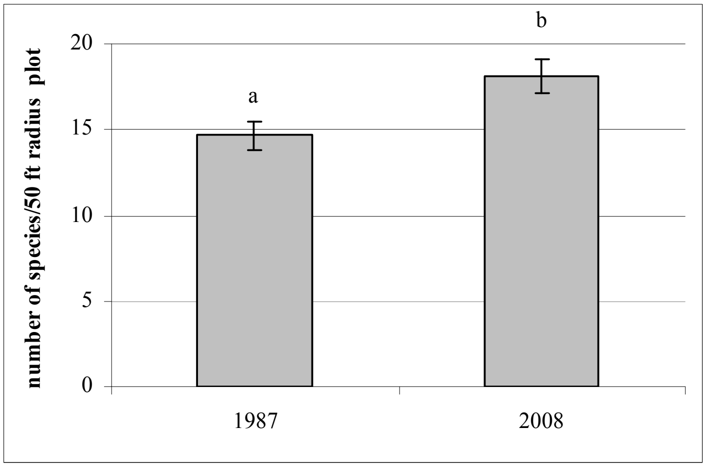



**Table 1. Location of range monitoring plots at NWSTF Boardman.** GPS datum are in NAD 1983, UTM zone 11.

| Plot | Northing | Easting | Plot marker information |
|---|---|---|---|
| 1 | 284459.5212 | 5076010.6508 | Reset the 25 foot line plot rebar. |
| 2 | 288813.1238 | 5074094.9413 | Reset all 4 rebar marking the 3 foot square photoplot. Center of photoplot is 180° from the center of the monument (railroad tie). |
| 3 | 288384.1736 | 5059783.7060 | |
| 4 | 292851.9509 | 5069848.2526 | |
| 5 | 291406.2497 | 5065169.6690 | |
| 6 | 294603.4683 | 5061802.5544 | Reset the 25 foot line plot rebar at 34' 6" and 172° from the monument center (railroad tie). |
| 7 | 294665.4984 | 5058057.9713 | |
| 8 | 286815.4557 | 5060111.3088 | |
| 9 | 287893.7427 | 5067235.6898 | Reset the 25 foot line plot rebar at 32' 3" and 155° from the monument center (railroad tie). |
| 10 | 287941.0083 | 5070676.7667 | Reset one rebar marking the 3 foot square photoplot and the 25 foot line plot rebar. |
| 11 | 295392.9575 | 5065255.1156 | |
| 12 | 288162.1390 | 5075457.7114 | Reset all 4 rebar marking the 3 foot square photoplot and the 25 foot line plot rebar. Reset plot monument (railroad tie). |
| 13 | 290996.3173 | 5073397.6448 | Reset one rebar marking the 3 foot square photoplot. |
| 14 | 292368.0480 | 5073671.3042 | Reset the 25 foot line plot rebar. |
| 15 | 294151.7775 | 5072550.8612 | |
| 16 | 294368.6810 | 5068237.2113 | Reset the 25 foot line plot rebar at 30' 9" and 167° from the monument center (railroad tie). |
| 17 | 287126.7000 | 5071688.7052 | Reset the 25 foot line plot rebar at 39' 6" and 156° from the monument center (railroad tie). |
| 18 | 287668.9405 | 5063004.3892 | Reset the 25 foot line plot rebar at 32' and 166° from the monument center (railroad tie). |

**Table 2. Perennial grass and forb biomass estimates for range monitoring plots at NWSTF Boardman in 1987 and 2008.** Different methods were likely used each year; therefore results between years are not comparable.

| Plot | 1987 (lbs./acre) | 2008 (lbs./acre) |
|---|---|---|
| 1 | 0 | 30 |
| 2 | 10 | 55 |
| 3 | 0 | 695 |
| 4 | 50 | 185 |
| 5 | 20 | 830 |
| 6 | 250 | 300 |
| 7 | 10 | 60 |
| 8 | 350 | 540 |
| 9 | 300 | 135 |
| 10 | 10 | 530 |
| 11 | 250 | 835 |
| 12 | 100 | 40 |
| 13 | 300 | 300 |
| 14 | 80 | 290 |
| 15 | 200 | 215 |
| 16 | 150 | 255 |
| 17 | 250 | 165 |
| 18 | 150 | 245 |
| **Average** | **138** | **317** |

**Table 3. Plant species found on NWSTF Boardman range monitoring plots in 1987 and 2008** (N=native, I=introduced, P=perennial, A=annual, B=biennial).

| Scientific name | Common name | Family | Or-igin | Dur-ation | Growth form | Present 1987 | Present 2008 |
|---|---|---|---|---|---|---|---|
| Abronia mellifera | sandverbena, white | Nyctaginaceae | N | P | forb | x | |
| Achillea millefolium | yarrow | Asteraceae | N | P | forb | x | x |
| Achnatherum hymenoides | ricegrass, indian | Poaceae | N | P | grass | x | x |
| Agoseris heterophylla | Agroseris, annual | Asteraceae | N | A | forb | x | x |
| Agropyron cristatum | wheatgrass, crested | Poaceae | I | P | grass | x | x |
| Alyssum alyssoides | pale madwort | Brassicaceae | I | A | forb | | x |
| Ambrosia sp. | bursage | Asteraceae | N | A | forb | | x |
| Amsinkia sp. | fiddleneck | Boraginaceae | N | P | forb | x | x |
| Antennaria dimorpha | pussytoes | Asteraceae | N | P | forb | x | x |
| Artemisia tridentata | sagebrush, basin big | Asteraceae | N | P | shrub | x | x |
| Astragalus purshii | loco, woolly pod | Fabaceae | N | P | forb | x | |
| Astralagus sclerocarpus | milkvetch, stalked pod | Fabaceae | N | P | forb | x | x |
| Astralagus succumbens | milkvetch, Columbia | Fabaceae | N | P | forb | x | x |
| Balsamorhiza careyana | balsamroot, Carey | Asteraceae | N | P | forb | x | x |
| Bromus tectorum | cheatgrass | Poaceae | I | A | grass | x | x |
| Calochortus macrocarpus | mariposa lily | Liliaceae | N | P | forb | x | x |
| Camissonia contorta | plains evening primrose | Onagraceae | N | P | forb | | x |
| Centaurea diffusa | diffuse knapweed | Asteraceae | I | A | forb | | x |
| Chaenactis douglasii var. achilleifolia | false yarrow | Asteraceae | N | P | forb | x | x |
| Chrysothamnus viscidiflorus | rabbitbrush, Douglas green | Asteraceae | N | P | shrub | x | x |
| Crepis atribarba | slender hawksbeard | Asteraceae | N | P | forb | | x |
| Cryptantha flaccida | weakstem cryptantha | Boraginaceae | N | A | forb | | x |
| Elymus elymoides | squirreltail | Poaceae | N | P | grass | x | x |
| Elymus lanceolatus | wheatgrass, thickspike | Poaceae | N | P | grass | x | x |
| Epilobium brachycarpum | tall annual willowherb | Onagraceae | N | A | forb | | x |
| Ericameria nauseosa | rabbitbrush, gray rubber | Asteraceae | N | P | shrub | x | x |
| Erigeron filifolius | fleabane, cushion | Asteraceae | N | P | forb | x | x |
| Erigeron pumilus | fleabane, shaggy | Asteraceae | N | P | forb | x | x |
| Eriogonum niveum | buckwheat, snow | Polygonaceae | N | P | forb | x | x |
| Erodium cicutarium | filaree | Geraniaceae | I | A | forb | x | x |
| Erysimum capitatum | wallflower | Brassicaceae | N | P | forb | x | |
| Gutierrezia sarothrae | snakeweed | Asteraceae | N | P | shrub | x | x |
| Hesperostipa comata | needle-and-thread | Poaceae | N | P | grass | x | x |
| Heterotheca villosa var. villosa | hairy false golden aster | Asteraceae | N | P | forb | | x |
| Holosteum umbellatum | chickweed, jagged | Caryophyllaceae | I | A | forb | x | x |
| Hordeum murinum | mouse barley | Poaceae | I | P | grass | | x |
| Hymenopappus filifolius | hymenopappus, fineleaf | Asteraceae | N | P | forb | | x |
| Lactuca serriola | lettuce, prickly | Asteraceae | I | A | forb | x | x |
| Layia glandulosa | white tidy-tips | Asteraceae | N | A | forb | | x |
| Lithospermum ruderale | stoneseed | Boraginaceae | N | P | forb | x | |
| Lomatium macrocarpum | Lomatium (gray carrot leaf) | Apiaceae | N | P | forb | | x |
| Machaeranthera canescens | Aster, hoary | Asteraceae | N | P | forb | x | x |
| Madia glomerata | cluster tarweed | Asteraceae | N | A | forb | | x |
| Microsteris gracilis | Microsteris | Polemoniaceae | N | A | forb | | x |
| Oenothera pallida | pale evening primrose | Onagraceae | N | P | forb | | x |

**Table 3. (cont.)**

| Scientific name | Common name | Family | Or-igin | Dur-ation | Growth form | Present 1987 | Present 2008 |
|---|---|---|---|---|---|---|---|
| Opuntia polyacantha | prickly pear | Cactaceae | N | P | forb | x | x |
| Penstemon acuminatus | penstemon | Scrophulariaceae | N | P | forb | x | |
| Phacelia linearis | phacelia, threadleaf | Hydrophyllaceae | N | A | forb | x | x |
| Phlox longifolia | phlox, longleaf | Poleminiaceae | N | P | forb | x | x |
| Plagiobothrys tenellus | popcorn flower, slender | Boraginaceae | N | A | forb | x | |
| Plantago patagonica | indianwheat, woolly | Plantaginaceae | N | A | forb | x | x |
| Poa bulbosa | bulbous bluegrass | Poaceae | I | P | grass | | x |
| Poa secunda | bluegrass, Sandberg | Poaceae | N | P | grass | x | x |
| Pseudoroegneria spicata | wheatgrass, bluebunch | Poaceae | N | P | grass | x | x |
| Psoralidium lanceolatum | scurfpea | Fabaceae | N | P | forb | x | x |
| Pteryxia terebinthina var. terebinthina | desert parsley, chimaya | Apiaceae | N | P | forb | x | x |
| Purshia tridentata | bitterbrush | Rosaceae | N | P | shrub | x | x |
| Salsola kali | Russian thistle | Chenopodiaceae | I | A | forb | | x |
| Sisymbrium altissimum | mustard, Jim Hill | Brassicaceae | I | A | forb | x | x |
| Stephanomeria paniculata | skeleton weed | Asteraceae | N | A/P | forb | | x |
| Tragopogon dubius | salsify | Asteraceae | I | A/B | forb | x | x |
| Triteleia grandiflora | largeflower triteleia | Liliaceae | N | A | forb | | x |
| Vulpia microstachys | Fescue, pacific | Poaceae | N | A | grass | x | |
| Vulpia octoflora | Fescue, six weeks | Poaceae | N | A | grass | x | |

## Appendix A: 1987 and 1988 descriptions of range monitoring plot locations at NWSTF Boardman

DEPARTMENT OF THE NAVY
WESTERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PACIFIC NORTHWEST BRANCH
P.O. BOX 2366
3505 N.W. ANDERSON HILL ROAD
SILVERDALE, WA 98383

MEMORANDUM

IN REPLY REFER TO:
22 APRIL 1988

From: 243NW
To: 243

Subj: NATURAL RESOURCES MANAGEMENT PLAN FOR NWSTF BOARDMAN, OREGON NOVEMBER 1987

Ref: (a) Site visit to subject installation 11-14 April 1988
(b) Appendix F of subject plan

1. During reference (a), the 18 permanent inventory and monitoring plots described in reference (b) (pgs 110 et seq.) were located and monumented. Some difficulty was experienced in locating several of the plots. This was due to errors in the Plan map showing plot locations and inaccurate text descriptions of those locations. The following comments and suggestions for map and text revisions should make it much easier to re-locate plots for future examinations. The yellow diamond signs referred to are the "US NAVY Natural Resources Project Do Not Disturb" type. Bearings are magnetic.

PLOT #1. Located in the NE 1/4 of the NE 1/4 of Section 26, T4N, R24E, WBM; 0.5 mile east of the main compound fence, about 150 feet south of road. Railroad tie with yellow plastic top set with 24" showing above grade. Plot tag and yellow diamond sign on N. side of tie. Small (1.75") oval aluminum tag #1 nailed to side of tie. Pins are south of tie.

PLOT #2. Located in the SW 1/4 of the NW 1/4 Section 29, T4N, R25E, WBM; located 30 feet East of the road running N-S along the West side of Section 29. Railroad tie with yellow plastic top set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small oval aluminum tag #2 nailed to W side of tie. Pins bear S 9 E from the tie. This N-S road is 0.6 mile West of the gate in the SE corner of pasture #1. The map used in this plan and the grazing outlease plan erroneously show that the fenceline and gate are located close to a full mile East of the N-S road. Based on observations and measurements of the locations of Plots #2 and #3, the gate/fenceline locations are mapped incorrectly, i.e., the SE'ly fence of pasture #1 is shown East of its true location.

PLOT #3. Located in the NE 1/4 of the NW 1/4 of Section 32, T4N, R25E, WBM; approximately 0.3 mile West of the gate in the SE corner of pasture #1; located 200 feet N of road (not 300 as the Plan says). Railroad tie with yellow plastic top set with 24" showing above grade; plot tag and yellow diamond sign nailed to N side of tie; small aluminum tag #3 nailed to W side of tie. Pins bear S 10 W from the tie.

PLOT #4. Located in the SW corner of the SW 1/4 of the NE 1/4 of Section 34, T 4 N, R 25 E, WBM. Map shows location incorrectly; plot is located south of the site indicated on the map; plot is 200 feet North (not South as the text says) of the road running NWW-SEE parallel (+/-) to the South fence of pasture #2, not north of the road (runs NEE-SWW) leading to the old tower site. Railroad tie with yellow plastic top set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #4 nailed on W side of tie. Pins bear S 2 W from tie.

PLOT #5. Located in the NE corner of the NW 1/4 of the NE 1/4 of Section 2, T 3 N, R 25 E, WBM; plot located 120 feet West of road. Railroad tie set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #5 nailed on W side of tie. Pins bear S 13 W from tie.

PLOT #6. Located in the SE corner of the SE 1/4 of Section 10, T 3 N, R 25 E, WBM; plot located 75 feet West of dirt road running N-S. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #6 nailed on W side of tie. Pins bear S 10 W from tie.

PLOT #7. Located in the NE corner of the SW 1/4 of the SW 1/4 of Section 13, T 3 N, R 25 E, WBM; plot located 175 feet East of the dirt road. Railroad tie with yellow cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #7 nailed on W side of tie. Pins bear S 11 W from tie.

PLOT #8. Located in the NW corner of the SW 1/4 of the SE 1/4 of Section 6, T 3 N, R 25 E, WBM; plot located 150 feet North of the road. Railroad tie set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #8 nailed on W side of tie. Pins bear S 2 W from tie.

PLOT #9. Located in the SE 1/4 of the NE 1/4 of Section 7, T 3 N, R 25 E, WBM; plot located 180 feet West of the dirt road. Railroad tie set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #9 nailed on W side of tie. Pins bear S 7 E from the tie.

PLOT #10. Located in the NE 1/4 of the SE 1/4 of Section 33, T 3 N, R 25 E, WBM; plot bears S 50 W 250 feet from the West gate post of the gate in the center of the North side of pasture 2B. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #10 nailed on the W side of the tie. Pins bear S 10 E from the tie.

PLOT #11. Located in the NW corner of the SW 1/4 of Section 20 , T 3 N, R 25 E, WBM; plot located 100 feet East of the dirt road, 100 feet South of the airplane run-in line. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #11 nailed on W side of tie. Pins bear S 3 E from the tie.

PLOT #12. Located in the NE corner of Section 6, T 2 N, R 25 E, WBM; plot located 160 feet West of the dirt road that runs N-S. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #12 nailed on W side of tie. Pins bear S 10 W from tie.

PLOT #13. Located in the SE corner of the SW 1/4 of Section 7, T 2 N, R 25 E, WBM; plot located approximately 0.15 mile North of the South fence of pasture 1B. This plot was re-established using the pins and the photos in the Plan. No steel fence post was present. However, the grass clumps shown in the photo, the distance from the pins given in the text and disturbed soil at what appeared to be the spot from which the steel post was removed, combined to aid re-establishment with a very high degree of confidence that the original posting has been duplicated. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #13 nailed on W side of tie. Pins bear S 8 W from the tie.

PLOT #14. Located in the NE corner of the NW 1/4 of Section 17, T 2 N, R 25 E, WBM; located 0.4 to 0.45 mile East of the N-S road running along the West side of Section 17; located 100 feet North of the E-W running road. Railroad tie with yellow cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #14 nailed on W side of tie. Pins bear S 3 W from tie.

PLOT 15. Located in the NW corner of the NE 1/4 of the NW 1/4 of Section 24, T 2 N, R 25 E, WBM; located about 350 feet South of the road. This plot is in pasture 2C, not 2B as the text states. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #15 nailed on W side of tie. Pins bear S 4 E from tie.

PLOT #16. Located in the NE corner of the NW 1/4 of Section 12, T 2 N, R 25 E, WBM. This plot is located 0.9 mile North of the E-W running road cited in the text. A newly bladed road (2/88) over an old track runs North and ends at the plot. The plot is 35 feet East of this dirt road. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #16 nailed on W side of the tie. Pins bear S 4 E from the tie.

PLOT #17. An understatement would be to say that this plot was difficult to find using the map. It is actually about 1/2 mile from the spot indicated on the map. Plot is actually located in the NW corner of the SE 1/4 of the SW 1/4 of Section 27, T 3 N, R 25 E, WBM; plot is located 20 feet East of the dirt road, 0.25 - 0.27 mile South of the Main Target fenceline. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #17 nailed on W side of tie. Pins bear S 11 E from tie.

PLOT #18. Located in the SW corner of the NE 1/4 of the NE 1/4 of Section 25, T 3 N, R 25 E, WBM; plot located 150 feet East of the dirt road 0.1 mile (not 0.2 mile as the text says) South of the E-W road entering off the Heppner Highway. Railroad tie with yellow plastic cap set with 24" above grade; plot tag and yellow diamond sign on N side of tie; small aluminum tag #18 nailed on W side of tie. Pins bear due South from the tie.

2. The above information should be combined with the text descriptions given in reference (b) to generate more accurate and complete. If you do issue an addendum to the Plan, please send me a copy.

3. If there are any questions about the above descriptions, please call me.

Walter Briggs

WALTER BRIGGS
Staff Forester

## 3. RANGE MONITORING PROGRAM 1987

The range monitoring program developed for the station is a procedure that consists of two phases, one conducted annually and one periodically over a span of years.

The annual phase consists of interpreting patterns of utilization that exist following the livestock grazing season. The procedure involves judging five classes of utilization on key species, mapping use zones within a pasture, and evaluating these zones to determine the effects that the current grazing system and existing facilities and improvements collectively are having on the resources within the pasture. This entire procedure is outlined in an article written by:

Anderson, E. William and W.F. Currier. 1973. Evaluating zones of Utilization. Journal of Range Management 26(2) 87-91.

The periodic phase consists of interpreting data collected on permanent plots. The objective of this procedure is to measure changes that occur in the plant community. These measured changes consist of the following: floristic composition; canopy cover; litter; plant vigor; and forage production. In this procedure, each permanent plot consists of three components: a 3 foot square plot marked by steel pegs which serves as a close-up photo point; a 25 foot line plot marked by a steel fence post to encompass the photo plot, which serves as a general aspect photo line; and an unmarked plot approximately 50 feet in radius centered on the smaller photo plot which serves as the area where all plant species are recorded and canopy coverage determined. Data collection begins by listing all species that occur within the 50 feet circle and then estimating the canopy cover and dominance rating for each individual species. Determinations are also made for bare ground, litter and mulch, rocks, and mosses and lichens. Estimations are made on forage production, and apparent vigor of key species. This entire procedure is outlined in a manuscript written by:

Anderson, E. William. 1987. Canopy cover as a method of monitoring trend in ecological and soil status. Submitted to Rangelands.

The periodic phase of this monitoring program was initiated in early May and the annual phase in early June after the cattle were removed from the station. The information obtained from this program is contained herein.

Plot #1 is in Pasture 5 south of the main road going SE from Navy Headquarters. It is located about 70 yd. south of the 0.5 mile marker (a post marked 5). The plot, which is marked with a 6' steel fencepost and lies about 25-30 feet south of this post, consists of a 3-feet-square marked at each corner by a steel rod painted red. A fifth steel rod slightly south of the plot is the photo point for the camera tripod from which photos are taken of the plot itself and of the site aspect with the steel post in the middle.

The soil at this plot is Koehler loamy sand

0-30" loamy sand          30" + calcareous pan

Cover data represents the area approximately 50 feet radius from the 3-feet-square plot.

Plot #2 is in Pasture 1 east of the N-S road that bisects the pasture and about 0.3-0.4 mile south of the north boundary fence. The plot lies about 70 feet east of the road on a hummock which is marked by a steel fencepost which is about 20 feet north of a 3-feet-square plot marked by 4 steel pegs painted red.

Cover data represents the area approximately 50 ft. radius from the 3-feet-square plot.

Soil is Hezel loamy sand (0-12" loamy sand; 12-42: sandy loam laminated calcareous, hard; 42" + soft silt loam).

Plot #3 is in Pasture 1. It is located north of the road that parallels the south fence about 0.3 mile west from the east gate and 100 yds. north of the road. The plot is marked with a steel fencepost which is about 30 feet north of the 3-feet-square plot which is marked by 4 steel pegs. A fifth steel peg south of the plot marks the photo point from which the 3-feet-plot and the site aspect were photographed.

Soil is Quincy loamy sand.

Plot #4 is located in Pasture 2, 0.4 mile west and 100 yds. south of the gate in NW corner of Pasture 2C where it joins Pasture 2. The plot is marked by a steel fencepost which is about 20 feet north of the 3-feet-square plot marked by 4 steel pegs painted red. A fifth steel peg just south of the 3-feet square is the photo hub from which photos of the plot and site aspect were taken. Vegetation data represents the area approximately 50 feet radius from the 5-feet-square plot.

Soil is Quincy loamy sand.

Plot #5 is located in Pasture 2C on the west side of the N-S road through the middle of the pasture and 0.3-0.4 mile south of the north boundary fence. It is marked by a steel fencepost 40-50 yds. west of the road which is about 20 ft. north of the 3-feet-square plot marked by 4 steel pegs painted red. A fifth steel peg south of the 3-feet-plot is the photo point for photos of the 3-feet plot and the site aspect. Data represents the area within about 50' radius of the 3-feet-square plot.

Soil is Quincy loamy sand.

Plot #6 is located in Pasture 4B about 0.3 mile south of the buried pipeline that runs diagonally NW to SE across the pasture. It is located about 100 feet west of the N-S road through center of pasture and is marked by a steel fencepost that is about 30 feet north of the 3-feet-square plot which is marked by 4 steel rods pointed red. A fifth steel rod slightly south of the 3-feet plot is the photo hub from which color photos of the 3-feet plot and site aspect were taken. Vegetation data represents an area about 50 feet radius from the 3-feet-square plot.

Soil is Quincy loamy sand.

Plot #7 is located in Pasture E about 0.6 mile south of the gate in NW corner of Pasture E. It is located east of the road about 100 yds. where the road bends to the SE. It is marked by a steel fencepost which is about 25 feet north of the 3-feet-square plot which is marked by 4 steel pegs painted red. A fifth steel peg slightly south of the 3-feet square plot is the photo hub from which photos of the plot and site aspect were taken. Vegetation data represents an area about 50 ft. radius from the 3-feet square plot.

Soil is Royal loamy very fine sand.

Plot #8 is located in the SW portion of Pasture 3. It is located about 50 yds. north of the E-W road about 0.2 mile east of the main N-S grave road. It is marked by a steel fencepost which is about 25 feet north of the 3-feet-square plot marked by 4 steel pegs painted red. A fifth steel peg slightly south of the 3-feet plot is the photo hub from which photos of the plot and site aspect were taken. Vegetation data represent an area about 50' radius from the 3-feet-square plot.

Soil is Koehler loamy sand (36" caliche).

Plot #9 is located in Pasture 4A about 0.3 mile south of the gravel road in the NW portion of the pasture. The plot lies about 50 yds. west of the N-S road, in the west half of Pasture 4A. The plot is marked with a steel fencepost which is about 25 feet north of the 3-feet-square plot which is marked by 4 steel pegs painted red.

The soil is Quincy loamy sand (over 54" deep). Note that the soil map rates this area as Koehler but no duripan was encountered at the plot site in 54 inches.

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #10 is located in Pasture (Mobile Target Area) about 100 yds. SW from the gate in the north boundary fence on the N-S road in the center of the pasture. It is marked by a steel fencepost which is about 30' north of the 3-feet-square plot marked by 4 steel pegs painted red.

The soil is Quincy loamy sand over 54" deep.

Note that this area is used to have a stand of bitterbrush as evidenced by some burned stubs and standing skeletons visible.

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #11 is in proposed Pasture 4C about 0.75 mile south of the graveled road that runs diagonally NW to SE in the northern portion of the pasture. It is located about 100' east of the N-S road and 100' south of W-E target approach line in the center of Pasture 4C.

The soil is Koehler loamy fine sand (42" to gravelly, calcareous duripan).

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #12 is located in Pasture 1A about 0.25 mile south of the north gate of the N-S road in the pasture. It is about 200 ft. west of the road and is marked by a steel fencepost which is about 20 feet north of the 3-feet-square plot marked by 4 steel pegs painted red.

Soil is Royal fine sandy loam (over 48' deep).

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #13 is in Pasture B. It is located 0.5 mile west from the gate in the SE corner and 0.2 mile north from the south boundary fence. It is marked with a steel fencepost which is about 20 feet north of a 3-feet-square plot marked with 4 steel rods painted red.

The soil is Warden silt loam.

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #14 is located in the west central portion of Pasture 2A. It is 0.5 miles east from the main N-S road and about 10 ft. north of the E-W road through the middle of the pasture. It is marked by a steel fencepost which is about 25 feet north of the 3-feet-square plot marked by 4 steel pegs painted red.

Soil is Warden silt loam.

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

Plot #15 is located in Pasture 2B south of the Old Oregon Trail and in the SE portion of the pasture. It is located about 0.1 miles south or the road E-W which is about halfway between the south boundary and the Old Oregon Trail. It is marked by a steel fencepost which is about 25 feet north of the 3-feet-square plot marked by 4-steel pegs painted red.

The soil is Warden silt loam.

Plot #16 is located in Pasture 2B, NE quarter north of the Old Oregon Trail. It is located about 1.0 miles north of the main E-W road which is north of the Old Oregon Trail. It is marked by a steel fencepost which is about 25 feet north of the 3-feet-square plot marked with 4 steel rods painted red.

Soil is Warden very fine sandy loam.

Plot #17 is located in Pasture 3A about 1.4 miles east of gate at SW corner of Main Target area and 0.2 mile on a road NE-SW of the Main Target south boundary fence. The plot is marked by a steel fencepost about 50' east of the road which is about 25'north of the 3-feet-square plot marked with 4 steel rods painted red.

The soil is Koehler loam fine sand (30" to gravel and fragments of calcareous duripan).

Plot #18 is located in the east portion of Pasture 3A about 1/4 mile from the Bombing Range road. It is 0.3 mile west on the E-W road that enters the pasture near the potato shed east of the highway and 0.2 mile south of this road on a N-S road that skirts several dune areas. The plot is located 50 yds. east of this road that goes up a hill. It is marked by a steel fencepost about 25 ft. north of the 3-feet-square plot marked with 4 steel pegs painted red.

The soil is Sagehill very fine sandy loam (32" to silt loam).

Cover data represents the area approximately 50' radius from the 3-feet-square plot.

## Appendix B: Range monitoring plot datasheets for NWSTF Boardman in 1987 and 2008

## Table B1. Data collected on range monitoring plot 1 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/4/87 | | DATE: 5/13/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 50 | xxx | 15 |
| Gravel & Stones | | xxx | 3 | xxx | 0 |
| Litter & Mulch | | xxx | 1 | xxx | 8 |
| Mosses & Lichens | | 1 | T | 1 | T |
| | | | | | |
| **Grasses** | | | | | |
| Cheatgrass | Bromus tectorum | 4 | 35 | 5 | 40 |
| | | | | | |
| **Forbs** | | | | | |
| buckwheat, snow (tall) | Eriogonum niveum | 3 | 1 | 3 | 3 |
| Filaree | Erodium cicutarium | 3+ | 10 | 2 | 2 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 3- | 1 | 3 | 2 |
| mustard, Jim hill | Sisymbrium altissimum | 2 | T | 3 | 3 |
| fiddleneck | Amsinkia sp. | 1 | T | 3 | 2 |
| false yarrow | Chaenactis douglasii var. achilleifolia | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | 3 | T | 2 | T |
| chickweed, jagged | Holosteum umbellatum | 3 | 10 | 0 | 0 |
| sandverbena, white | Abronia mellifera | 2 | T | 0 | 0 |
| milkvetch, Columbia | Astralagus succumbens | 1 | T | 0 | 0 |
| salsify | Tragopogon dubius | | | 1 | T |
| largeflower triteleia | Triteleia grandiflora | | | 1 | T |
| pale evening primrose | Oenothera pallida | | | 1 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| indianwheat, woolly | Plantago patagonica | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| bitterbrush | Purshia tridentata | 5 | 10 | 4 | 25 |
| rabbitbrush, green | Chrysothamnus viscidiflorus | 3 | 1 | 1 | 1 |
| rabbitbrush, (gray) rubber | Ericameria nauseosa | 4 | 5 | 0 | 0 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 73 | xxx | 79 |
| **Perennial Cover:** | | xxx | 18 | xxx | 31 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 0 | | 30 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| Bitterbrush | Purshia tridentata | M | | M | |
| | | | | | |
| | | | | | |
| **Seedlings:** | | | | | |
| Buckwheat | Eriogonum niveum | Some | | None | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 1 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy sand terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** Approx. 70yd south from 0.5 mile post east of Navy Hdqrtrs in Pasture 5, 25-30' S of tall steel fencepost | | | | |

## Table B2. Data collected on range monitoring plot 2 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/4/87 | | DATE: 5/20/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 80 | xxx | 30 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 20 | xxx | 7 |
| Mosses & Lichens | | 1 | T | 1 | T |
| | | | | | |
| **Grasses** | | | | | |
| squirreltail | Elymus elymoides | 3- | 1 | 1 | T |
| cheatgrass | Bromus tectorum | 3+ | 15 | 4 | 40 |
| ricegrass, Indian | Achnatherum hymenoides | 1 | T | 0 | 0 |
| | | | | | |
| **Forbs** | | | | | |
| milkvetch, Columbia | Astralagus succumbens | 1 | T | 3 | 3 |
| milkvetch, stalked pod | Astralagus sclerocarpus | 3 | 3 | 3 | 2 |
| sandverbena, white | Abronia mellifera | 3 | 3 | 0 | 0 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 1 | T | 0 | 0 |
| mustard, Jim Hill | Sisymbrium altissimum | 3- | 1 | 3 | 1 |
| fiddleneck | Amsinkia sp. | 1 | T | 1 | T |
| hymenopappus fineleaf | Hymenopappus filifolius | 2 | T | 1 | T |
| yarrow | Achillea millefolium | 1 | T | 1 | T |
| pale evening primrose | Oenothera pallida | | | 3 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| salsify | Tragopogon dubius | | | 1 | T |
| false yarrow | Chaenactis douglasii var. achilleifolia | | | 2 | T |
| cluster tarweed | Madia glomerata | | | 1 | T |
| bursage | Ambrosia sp. | | | 1 | T |
| filaree | Erodium cicutarium | | | 1 | T |
| mariposa lily | Calochortus macrocarpus | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| bitterbrush | Purshia tridentata | 5 | 3 | 5 | 10 |
| rabbitbrush, rubber | Ericameria nauseosa | 4 | 15 | 4 | 5 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3+ | 3 | 3 | 3 |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 44 | xxx | 66 |
| **Perennial Cover:** | | xxx | 28 | xxx | 24 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 10 | | 55 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| bitterbrush | Purshia tridentata | M | | M | |
| ricegrass | Achnatherum hymenoides | M | | - | |
| | | | | | |
| **Seedlings:** | | | | | |
| bitterbrush | Purshia tridentata | Some | | None | |
| sandverbena, white | Abronia mellifera | Abundant | | None | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 2 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** sand-loam terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B3. Data collected on range monitoring plot 3 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 | | DATE: 5/13/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 30 | xxx | 35 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 20 | xxx | 10 |
| Mosses & Lichens | | 3 | 1 | | |
| | | | | | |
| **Grasses** | | | | | |
| cheatgrass | Bromus tectorum | 5 | 50 | 4 | 30 |
| bluegrass, Sandberg | Poa secunda | 3- | T | 3 | 15 |
| Fescue sp. | Vulpia sp. | | | 3 | 7 |
| | | | | | |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 5 | 3 | 18 |
| filaree | Erodium cicutarium | 3 | 7 | 5 | 50 |
| mustard, Jim Hill | Sisymbrium altissimum | 3 | T | 3 | 1 |
| prickly pear | Opuntia polyacantha | 2 | T | 0 | 0 |
| aster, hoary | Machaeranthera canescens | 1 | T | 0 | 0 |
| fiddleneck | Amsinkia sp. | 1 | T | 3 | 1 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 1 | T | 3 | T |
| lettuce, prickly | Lactuca serriola | 1 | T | 0 | 0 |
| buckwheat, snow | Eriogonum niveum | 1 | T | 0 | 0 |
| yarrow | Achillea millefolium | 1 | T | 0 | 0 |
| sandverbena, white | Abronia mellifera | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | | | 1 | T |
| salsify | Tragopogon dubius | | | 1 | T |
| mariposa lily | Calochortus macrocarpus | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | 2 | 0 | 0 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | T | 1 | T |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| Total Cover: | | xxx | 65 | xxx | 122 |
| Perennial Cover: | | xxx | 7 | xxx | 34 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 0 | | 695 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| Sandberg bluegrass | Poa secunda | M | | H | |
| | | | | | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT**: Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 3 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B4. Data collected on range monitoring plot 4 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 | | DATE: 5/12/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 70 | xxx | 45 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 25 | xxx | 1 |
| Mosses & Lichens | | 1 | T | 1 | T |
| | | | | | |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 3 | 1 | 4 | 12 |
| bluegrass, Sandberg | Poa secunda | 3 | 1 | 3 | 8 |
| cheatgrass | Bromus tectorum | 3 | 7 | 4 | 25 |
| | | | | | |
| **Forbs** | | | | | |
| filaree | Erodium cicutarium | 3 | 3 | 5 | 30 |
| prickly pear | Opuntia polyacantha | 2 | T | 1 | T |
| lettuce, prickly | Lactuca serriola | 2 | T | 0 | 0 |
| phacelia, threadleaf | Phacelia linearis | 1 | T | 1 | T |
| mustard, Jim Hill | Sisymbrium altissimum | 3- | T | 3 | 1 |
| yarrow | Achillea millefolium | 1 | T | 1 | T |
| scurfpea | Psoralidium lanceolatum | 3- | 1 | 3 | 2 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 1 | T | 3 | 2 |
| sandverbena, white | Abronia mellifera | 2 | T | 0 | 0 |
| popcornflower, slender | Plagiobithrys tenellus | 1 | T | 0 | 0 |
| pale evening primrose | Oenothera pallida | | | 3 | 3 |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 2 | T |
| milkvetch, stalked pod | Astragalus sclerocarpus | | | 1 | T |
| fiddleneck | Amsinkia sp. | | | 2 | T |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| largeflower triteleia | Triteleia grandiflora | | | 1 | T |
| salsify | Tragopogon dubius | | | 1 | T |
| bursage | Ambrosia sp. | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 5 | 20 | 1 | T |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 34 | xxx | 74 |
| **Perennial Cover:** | | xxx | 23 | xxx | 29 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 50 | | 185 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | L | | M | |
| Sandberg bluegrass | Poa secunda | H | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| needle-and-thread | Hesperostipa comata | | | Some | |
| | | | | | |

| | | | |
|---|---|---|---|
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | **PLOT:** 4 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy Sand Terrace | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | |

## Table B5. Data collected on range monitoring plot 5 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 | | DATE: 5/12/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 30 | xxx | 15 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 8 |
| Mosses & Lichens | | | 10 | | 1 |
| | | | | | |
| **Grasses** | | | | | |
| bluegrass, Sandberg | Poa secunda | 3 | 2 | 3 | 12 |
| cheatgrass | Bromus tectorum | 5 | 20 | 5 | 38 |
| | | | | | |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 4 | 30 | 4 | 35 |
| prickly pear | Opuntia polyacantha | 3+ | 3 | 1 | T |
| filaree | Erodium cicutarium | 3+ | 10 | 3 | 10 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 3 | 1 | 3 | 1 |
| phacelia, threadleaf | Phacelia linearis | 1 | T | 0 | 0 |
| popcornflower, slender | Plagiobithrys tenellus | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | 1 | T | 1 | T |
| false yarrow | Chaenactis douglasii var. achilleifolia | 1 | T | 0 | 0 |
| fiddleneck | Amsinkia sp. | | | 1 | T |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| mustard, Jim Hill | Sisymbrium altissimum | | | 1 | T |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | 1 | 0 | 0 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | T | 1 | T |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 68 | xxx | 97 |
| **Perennial Cover:** | | xxx | 38 | xxx | 49 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 20 | | 830 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| Sandberg bluegrass | Poa secunda | H | | H | |
| | | | | | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 5 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy Sand Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B6. Data collected on range monitoring plot 6 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 DOMI-NANCE | DATE: 5/5/87 CANOPY COVER | DATE: 5/14/08 DOMI-NANCE | DATE: 5/14/08 CANOPY COVER |
|---|---|---|---|---|---|
| Bare Ground | | xxx | 75 | xxx | 12 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 15 | xxx | 15 |
| Mosses & Lichens | | 3 | 1 | | 1 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 5 | 7 | 4 | 35 |
| cheatgrass | Bromus tectorum | 3 | 7 | 4 | 40 |
| bluegrass, Sandberg | Poa secunda | 3 | 2 | 2 | 1 |
| Fescue sp. | Vulpia sp. | | | 1 | T |
| | | | | | |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 2 | 3 | 1 |
| fiddleneck | Amsinkia sp. | 1 | T | 2 | T |
| Agoseris, annual | Agroseris heterophylla | 1 | T | 0 | 0 |
| mustard, Jim Hill | Sisymbrium altissimum | 1 | T | 1 | T |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 2 | T | 3 | 1 |
| prickly pear | Opuntia polyacantha | 2 | T | 1 | T |
| phlox, longleaf | Phlox longifolia | 3 | T | 3 | 2 |
| yarrow | Achillea millefolium | 2 | T | 3 | T |
| buckwheat, snow | Eriogonum niveum | 1 | T | 1 | T |
| milkvetch, stalkpod | Astralagus sclerocarpus | 1 | T | 1 | T |
| popcornflower, slender | Plagiobithrys tenellus | 1 | T | 0 | 0 |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 1 | T |
| indianwheat, woolly | Plantago patagonica | | | 1 | T |
| filaree | Erodium cicutarium | | | 2 | T |
| pale evening primrose | Oenothera pallida | | | 1 | T |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| largeflower triteleia | Triteleia grandiflora | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 4 | 3 | 1 | T |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 2 | T | 1 | T |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 23 | xxx | 88 |
| **Perennial Cover:** | | xxx | 16 | xxx | 41 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 250 | | 300 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | H | | H | |
| Sandberg, bluegrass | Poa secunda | H | | M | |
| | | | | | |
| **Seedlings:** | | | | | |
| yarrow | Achillea millefolium | Some | | None | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 6 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy Sand Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B7. Data collected on range monitoring plot 7 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 DOMI-NANCE | DATE: 5/5/87 CANOPY COVER | DATE: 5/12/08 DOMI-NANCE | DATE: 5/12/08 CANOPY COVER |
|---|---|---|---|---|---|
| Bare Ground | | xxx | 80 | xxx | 5 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 20 | xxx | 13 |
| Mosses & Lichens | | 2 | 2 | | T |
| | | | | | |
| **Grasses** | | | | | |
| cheatgrass | Bromus tectorum | 4 | 15 | 5 | 60 |
| needle-and-thread | Hesperostipa comata | 2 | T | 1 | T |
| bluegrass, Sandberg | Poa secunda | 2 | T | 3 | 1 |
| Fescue sp. | Vulpia sp. | | | 1 | 2 |
| | | | | | |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 2 | 3 | 2 |
| mustard, Jim Hill | Sisymbrium altissimum | 3 | T | 3 | T |
| filaree | Erodium cicutarium | 3 | 5 | 4 | 15 |
| Agoseris, annual | Agroseris heterophylla | 1 | T | 1 | T |
| fiddleneck | Amsinkia sp. | 2 | T | 3 | 1 |
| Aster? | Aster sp. | 3 | 2 | 0 | 0 |
| lettuce, prickly | Lactuca serriola | 1 | T | 0 | 0 |
| Indian wheat, woolly | Plantago patagonica | 1 | T | 0 | 0 |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 1 | T |
| phlox, longleaf | Phlox longifolia | | | 1 | T |
| pale evening primrose | Oenothera pallida | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 4 | 5 | 3 | 1 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 4 | 6 | 3 | 1 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 35 | xxx | 84 |
| **Perennial Cover:** | | xxx | 15 | xxx | 6 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 10 | | 60 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| Sandberg bluegrass | Poa secunda | H | | H | |
| | | | | | |
| | | | | | |
| **Seedlings:** | | | | | |
| Aster? | Aster sp. | Some | | None | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 7 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Light Loamy Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

**Table B8. Data collected on range monitoring plot 8 in 1987 and 2008 at NWSTF Boardman.**

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/5/87 DOMI-NANCE | DATE: 5/5/87 CANOPY COVER | DATE: 5/13/08 DOMI-NANCE | DATE: 5/13/08 CANOPY COVER |
|---|---|---|---|---|---|
| Bare Ground | | xxx | 70 | xxx | 10 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 15 | xxx | 10 |
| Mosses & Lichens | | 1 | T | | 4 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 3 | 15 | 4 | 30 |
| cheatgrass | Bromus tectorum | 5 | 15 | 5 | 55 |
| Fescue, pacific | Vulpia sp. | 2 | T | 1 | T |
| bluegrass, sandberg | Poa secunda | 1 | T | 2 | 1 |
| ricegrass, Indian | Achnatherum hymenoides | 1 | T | 0 | 0 |
| wheatgrass, beardless bluebunch | Pseudoroegneria spicata | 1 | T | 0 | 0 |
| wheatgrass, thickspike | Elymus lanceolatus | | | 3 | 2 |
| | | | | | |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 3 | 3 | 8 |
| yarrow | Achillea millefolium | 2 | T | 3 | 1 |
| popcornflower | Plagiobithrys tenellus | 1 | T | 0 | 0 |
| mustard, Jim Hill | Sisymbrium altissimum | 1 | T | 1 | T |
| indianwheat | Plantago patagonica | 3- | T | 1 | T |
| phacelia, threadleaf | Phacelia linearis | 1 | T | 0 | 0 |
| Aster? | Aster sp. | 1 | T | 0 | 0 |
| fiddleneck | Amsinkia sp. | 1 | T | 3 | 2 |
| filaree | Erodium cicutarium | 2 | T | 2 | 5 |
| Agoseris, annual | Agroseris heterophylla | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | | | 1 | T |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| milkvetch, stalked pod | Astragalus sclerocarpus | | | 1 | T |
| salsify | Tragopogon dubius | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | 1 | 3 | 1 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | T | 3 | 1 |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 35 | xxx | 107 |
| **Perennial Cover:** | | xxx | 19 | xxx | 44 |
| **Growing season this year:** | | | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 350 | | 540 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | H | | H | |
| Poa secunda | Poa secunda | | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 8 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy Sand Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B9. Data collected on range monitoring plot 9 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 | | DATE: 5/15/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 80 | xxx | 68 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 2 |
| Mosses & Lichens | | 1 | T | | 0 |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 5 | 7 | 4 | 2 |
| wheatgrass, thickspike | Elymus lanceolatus | 3 | 10 | 1 | T |
| cheatgrass | Bromus tectorum | 3 | 10 | 5 | 15 |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 5 | 3 | 1 |
| Indian wheat, woolly | Plantago patagonica | 3 | 7 | 1 | T |
| phacelia, threadleaf | Phacelia linearis | 1 | T | 2 | T |
| yarrow | Achillea millefolium | 2 | T | 3 | 1 |
| Aster? | Aster sp. | 1 | T | 0 | 0 |
| milkvetch, Columbia | Astralagus succumbens | 1 | T | 1 | T |
| popcorn flower | Plagiobithrys tenellus | 1 | T | 0 | 0 |
| fiddleneck | Amsinkia sp. | 1 | T | 3 | 1 |
| sandverbena, white | Abronia mellifera | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | 1 | T | 3 | 2 |
| Agoseris, annual | Agroseris heterophylla | 1 | T | 0 | 0 |
| plains evening primrose | Camissonia contorta | | | 1 | T |
| pale evening primrose | Oenothera pallida | | | 3 | 2 |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 2 | T |
| milkvetch, stalked pod | Astragalus sclerocarpus | | | 1 | T |
| filaree | Erodium cicutarium | | | 2 | 3 |
| mustard, Jim Hill | Sisymbrium altissimum | | | 3 | 1 |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| slender hawksbeard | Crepis atribarba | | | 1 | T |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | | | 3 | 1 |
| Russian thistle | Salsola kali | | | 1 | T |
| Microsteris | Microsteris gracilis | | | 1 | T |
| chickweed, jagged | Holosteum umbellatum | | | 1 | T |
| false yarrow | Chaenactis douglasii var. achilleifolia | | | 1 | T |
| aster, hoary | Macharanthera canescens | | | 1 | T |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 1 | T | 2 | T |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | 1 | 2 | T |
| **Total Cover:** | | xxx | 39 | xxx | 33 |
| **Perennial Cover:** | | xxx | 21 | xxx | 10 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 300 | | 135 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | H | | L | |
| | | | | | |
| **Seedlings:** | | | | | |
| needle-and-thread | Hesperostipa comata | | | Some | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 9 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B10. Data collected on range monitoring plot 10 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 | | DATE: 5/15/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 80 | xxx | 55 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 1 |
| Mosses & Lichens | | 2 | 2 | | 0 |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 3 | T | 1 | T |
| cheatgrass | Bromus tectorum | 4 | 15 | 4 | 15 |
| ricegrass, Indian | Achnatherum hymenoides | 1 | T | 0 | 0 |
| bluegrass, Sandberg | Poa secunda | 2 | T | 1 | T |
| wheatgrass, beardless bluebunch | Pseudoroegneria spicata | 1 | T | 0 | 0 |
| wheatgrass, thickspike | Elymus lanceolatus | 1 | T | 1 | T |
| **Forbs** | | | | | |
| desert parsley | Pteryxia terebinthina var. terebinthina | 3+ | 5 | 4 | T |
| scurfpea | Psoralidium lanceolatum | 3 | 2 | 3 | 10 |
| yarrow | Achillea millefolium | 3 | 1 | 3 | T |
| phacelia, lineleaf | Phacelia linearis | 3 | 1 | 0 | 0 |
| phlox, longleaf | Phlox longifolia | 2 | T | 3 | 1 |
| filaree | Erodium cicutarium | 3 | 5 | 5 | 22 |
| fiddleneck | Amsinkia sp. | 3 | T | 1 | T |
| prickly pear | Opuntia polyacantha | 3 | 1 | 1 | T |
| mustard, Jim Hill | Sisymbrium altissimum | 2 | T | 2 | T |
| balsamroot, Carey | Balsamorhiza careyana | 3 | T | 2 | T |
| milkvetch, stalkpod | Astralagus sclerocarpus | 1 | T | 1 | T |
| wallflower | Erysium capitatum | 1 | T | 0 | 0 |
| popcorn flower | Plagiobithrys tenellus | 2 | T | 0 | 0 |
| buckwheat, snow | Eriogonum niveum | 1 | T | 1 | T |
| sandverbena, white | Abronia mellifera | 1 | T | 0 | 0 |
| lettuce, prickly | Lactuca serriola | 1 | T | 0 | 0 |
| bursage | Ambrosia sp. | | | 1 | T |
| false yarrow | Chaenactis douglasii var. achilleifolia | | | 1 | T |
| largeflower triteleia | Triteleia grandiflora | | | 1 | T |
| white tidy-tips | Layia glandulosa | | | 1 | T |
| Microsteris | Microsteris gracilis | | | 1 | T |
| pale evening primrose | Oenothera pallida | | | 2 | T |
| **Shrubs** | | | | | |
| bitterbrush | Purshia tridentata | 1 | T | 0 | 0 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | T | 1 | T |
| rabbitbrush, rubber | Ericameria nauseosa | 4 | 2 | 1 | T |
| **Total Cover:** | | xxx | 33 | xxx | 50 |
| **Perennial Cover:** | | xxx | 11 | xxx | 14 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 10 | | 530 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| bluegrass, Sandberg | Poa secunda | H | | M | |
| needle-and-thread | Hesperostipa comata | H | | L | |
| wheatgrass, beardless bluebunch | Pseudoroegneria spicata | H | | - | |
| **Seedlings:** | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 10 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Loamy Sand Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

**Table B11. Data collected on range monitoring plot 11 in 1987 and 2008 at NWSTF Boardman.**

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 | | DATE: 5/15/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 60 | xxx | 55 |
| Gravel & Stones | | xxx | T | xxx | T |
| Litter & Mulch | | xxx | 15 | xxx | 1 |
| Mosses & Lichens | | 3 | 1 | | 1 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 5 | 15 | 3 | 4 |
| bluegrass, sandberg | Poa secunda | 3+ | 10 | 5 | 20 |
| cheatgrass | Bromus tectorum | 3+ | 20 | 3 | 6 |
| wheatgrass, crested | Agropyron cristatum | 2 | T | 4 | 8 |
| ricegrass, Indian | Achnatherum hymenoides | 2 | T | 0 | 0 |
| Fescue sp. | Vulpia sp. | | | 2 | 2 |
| wheatgrass, thickspike | Elymus lanceolatus | | | 1 | T |
| bulbous bluegrass | Poa bulbosa | | | 1 | T |
| **Forbs** | | | | | |
| scurfpea | Psoralidium lanceolatum | 3 | 3 | 3 | 2 |
| indianwheat, woolly | Plantago patagonica | 3 | 1 | T | T |
| phlox, longleaf | Phlox longifolia | 3 | 1 | 3 | 10 |
| pussytoes | Antennaria dimorpha | 1 | T | 0 | 0 |
| balsamroot, Carey | Balsamorhiza careyana | 1 | T | 2 | T |
| stoneseed | Lithospermum ruderale | 1 | T | 0 | 0 |
| Agoseris, annual | Agroseris heterophylla | 1 | T | 0 | 0 |
| yarrow | Achillea millefolium | 1 | T | 2 | T |
| mustard, Jim Hill | Sisymbrium altissimum | | | 1 | T |
| filaree | Erodium cicutarium | | | 1 | 3 |
| mariposa lily | Calochortus macrocarpus | | | 1 | T |
| fiddleneck | Amsinkia sp. | | | 1 | T |
| milkvetch, stalked pod | Astragalus sclerocarpus | | | 1 | T |
| milkvetch, Columbia | Astragalus succumbens | | | 1 | T |
| tall annual willowherb | Epilobium brachycarpum | | | 1 | T |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | | | 1 | T |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 4 | 5 | 2 | T |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3- | T | 2 | T |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 55 | xxx | 57 |
| **Perennial Cover:** | | xxx | 34 | xxx | 47 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 250 | | 835 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | | H | | L | |
| Crested wheatgrass | | H | | H | |
| bluegrass, Sandberg | Poa secunda | | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| balsamroot, Carey | | Some | | None | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **Plot:**11 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | **ECOL. SITE:** Loamy Sand Terrace | | | |

## Table B12. Data collected on range monitoring plot 12 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 | | DATE: 5/19/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 50 | xxx | 5 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 20 | xxx | 8 |
| Mosses & Lichens | | 3 | 10 | 1 | 1 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 4 | 5 | 4 | 25 |
| cheatgrass | Bromus tectorum | 4 | 25 | 5 | 50 |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 1 | T | 0 | 0 |
| bluegrass, Sandberg | Poa secunda | 2 | T | 1 | 1 |
| wheatgrass, thickspike | Elymus lanceolatus | 1 | T | 1 | T |
| Fescue sp. | Vulpia sp. | | | 1 | T |
| mouse barley | Hordeum murinum | | | 1 | T |
| | | | | | |
| **Forbs** | | | | | |
| salsify | Tragopogon dubius | 1 | T | 0 | 0 |
| mustard, Jim Hill | Sisymbrium altissimum | 1 | T | 2 | T |
| lettuce, prickly | Lactuca serriola | 1 | T | 0 | 0 |
| filaree | Erodium cicutarium | 1 | T | 1 | T |
| mariposa Lily | Calochortus macrocarpus | 1 | T | 1 | T |
| phlox, longleaf | Phlox longifolia | 1 | T | 1 | T |
| indianwheat, woolly | Plantago patagonica | 1 | T | 1 | T |
| fiddleneck | Amsinkia sp. | | | 3 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| weakstem cryptantha | Cryptantha flaccida | | | 1 | T |
| diffuse knapweed | Centaurea diffusa | | | 1 | T |
| pale madwort | Alyssum alyssoides | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | | | 3 | T |
| rabbitbrush, douglas green | Chrysothamnus viscidiflorus | | | 3 | T |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 30 | xxx | 78 |
| **Perennial Cover:** | | xxx | 5 | xxx | 37 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 100 | | 40 | |
| Shrubs: | | 0 | | 0 | |
| | | | | | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread grass | Hesperostipa comata | H | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| bluebunch wheatgrass | Pseudoroegneria spicata | Some | | None | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 12 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Light Loamy Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B13. Data collected on range monitoring plot 13 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 DOMI-NANCE | DATE: 5/6/87 CANOPY COVER | DATE: 5/15/08 DOMI-NANCE | DATE: 5/15/08 CANOPY COVER |
|---|---|---|---|---|---|
| Bare Ground | | xxx | 15 | xxx | 5 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 8 |
| Mosses & Lichens | | | 40 | | 20 |
| | | | | | |
| **Grasses** | | | | | |
| wheatgrass bluebunch | Pseudoroegneria spicata | 5 | 15 | 4 | 20 |
| bluegrass, Sandberg | Poa secunda | 3 | 20 | 3 | 20 |
| needle-and-thread | Hesperostipa comata | 2 | T | 4 | 15 |
| cheatgrass | Bromus tectorum | 1 | T | 2 | T |
| Fescue sp. | Vulpia sp. | | | 3 | 15 |
| | | | | | |
| **Forbs** | | | | | |
| indianwheat, woolly | Plantago patagonica | 3- | 1 | 2 | 1 |
| phlox, spreading | Phlox longifolia | 3 | 3 | 3 | 2 |
| mariposa | Calochortus macrocarpus | 1 | T | 1 | T |
| Lomatium (gray carrot leaf) | Lomatium macrocarpum | 2 | T | 0 | 0 |
| pussytoes | Antennaria dimorpha | 1 | T | 1 | T |
| yarrow | Achillea millefolium | 1 | T | 0 | 0 |
| filaree | Erodium cicutarium | | | 1 | T |
| diffuse knapweed | Centaurea diffusa | | | 1 | T |
| mustard, Jim Hill | Sisymbrium altissimum | | | 1 | T |
| salsify | Tragopogon dubius | | | 1 | T |
| tall annual willowherb | Epilobium brachycarpum | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| snakeweed | Gutierrezia sarothrae | 3 | 1 | 3 | T |
| rabbitbrush, rubber | Ericameria nauseosa | | | 3 | T |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 41 | xxx | 74 |
| **Perennial Cover:** | | xxx | 39 | xxx | 58 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 300 | | 300 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | H | | H | |
| needle-and-thread | Hesperostipa comata | | | H | |
| bluegrass, Sandberg | Poa secunda | | | M | |
| | | | | | |
| **Seedlings:** | | | | | |
| bluegrass, Sandberg | Poa secunda | Some | | None | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | Some | | None | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 13 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Silty Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B14. Data collected on range monitoring plot 14 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/6/87 DOMI-NANCE | DATE: 5/6/87 CANOPY COVER | DATE: 5/13/08 DOMI-NANCE | DATE: 5/13/08 CANOPY COVER |
|---|---|---|---|---|---|
| Bare Ground | | xxx | 40 | xxx | 10 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 5 |
| Mosses & Lichens | | 3+ | 30 | | 40 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 4 | 5 | 4 | 15 |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 3 | 1 | 5 | 8 |
| bluegrass, Sandberg | Poa secunda | 4 | 20 | 4 | 20 |
| cheatgrass | Bromus tectorum | 3 | 2 | 2 | 3 |
| squirreltail | Elymus elymoides | | | 1 | T |
| Fescue sp. | Vulpia sp. | | | 1 | T |
| | | | | | |
| **Forbs** | | | | | |
| phlox, spreading | Phlox longifolia | 3 | 1 | 2 | 1 |
| lettuce, prickly | Lactuca serriola | 2 | T | 1 | T |
| salsify | Tragopogon dubius | 3 | 1 | 0 | 0 |
| filaree | Erodium cicutarium | 3 | 2 | 1 | T |
| indianwheat, woolly | Plantago patagonica | 3+ | 10 | 3 | 10 |
| fleabane, cushion | Erigeron filifolius | 1 | T | 1 | T |
| diffuse knapweed | Centaurea diffusa | | | 1 | T |
| pussytoes | Antenarria dimorpha | | | 1 | T |
| Lomatium (gray carrot leaf) | Lomatium macrocarpum | | | 1 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| fleabane, shaggy | Erigeron pumilis | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| snakeweed | Gutierrezia sarothrae | 3 | 1 | 3 | 10 |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | T | 3 | 5 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 43 | xxx | 74 |
| **Perennial Cover:** | | xxx | 29 | xxx | 60 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 80 | | 290 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | L | | M | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT**: Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 14 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Silty Terrace | | | |
| **PHOTO/MAP**: | **PLOT LOCATION:** | | | | |

**Table B15. Data collected on range monitoring plot 15 in 1987 and 2008 at NWSTF Boardman.**

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/7/87 | | DATE: 5/14/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 10 | xxx | 10 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 7 | xxx | 8 |
| Mosses & Lichens | | 3+ | 35 | | 30 |
| | | | | | |
| **Grasses** | | | | | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 4 | 3 | 5 | 28 |
| bluegrass, Sandberg | Poa secunda | 4 | 20 | 4 | 25 |
| cheatgrass | Bromus tectorum | 3 | 6 | 3 | 3 |
| squirreltail | Elymus elymoides | 1 | T | 2 | 1 |
| Fescue sp. | Vulpia sp. | | | 1 | T |
| | | | | | |
| **Forbs** | | | | | |
| filaree | Erodium cicutarium | 3 | 15 | 1 | T |
| fleabane, cushion | Erigeron filifolius | 1 | T | 2 | T |
| fleabane, shaggy | Erigeron pumilus | 1 | T | 2 | T |
| pussytoes | Antennaria dimorpha | 1 | T | 2 | T |
| cluster tarweed | Madia glomerata | | | 1 | T |
| indianwheat, woolly | Plantago patagonica | | | 1 | T |
| tall annual willowherb | Epilobium brachycarpum | | | 2 | 1 |
| mariposa lily | Calochortus macrocarpus | | | 1 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| sagebrush, basin big | Artemisia tridentata | 3 | 5 | 0 | 0 |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | 7 | 3 | 10 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 2 | T | 0 | 0 |
| snakeweed | Gutierrezia sarothrae | | | 3 | 2 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 56 | xxx | 72 |
| **Perennial Cover:** | | xxx | 35 | xxx | 67 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 200 | | 215 | |
| Shrubs: | | 0 | | 0 | |
| | | | | | |
| **Apparent vigor (key species):** | | | | | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | H | | H | |
| bluegrass, Sandberg | Poa secunda | H | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 15 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:**: Silty Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B16. Data collected on range monitoring plot 16 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/7/87 | | DATE: 5/14/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 7 | xxx | 15 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 12 |
| Mosses & Lichens | | | 30 | | 25 |
| | | | | | |
| **Grasses** | | | | | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 3 | 2 | 4 | 10 |
| needle-and-thread | Hesperostipa comata | 5 | 7 | 5 | 15 |
| bluegrass, Sandberg | Poa secunda | 3 | 30 | 3 | 20 |
| cheatgrass | Bromus tectorum | 3 | 10 | 3 | 8 |
| Fescue sp. | Vulpia sp. | | | 1 | T |
| squirreltail | Elymus elymoides | | | 1 | T |
| | | | | | |
| **Forbs** | | | | | |
| indianwheat, woolly | Plantago patagonica | 3- | 1 | 3 | 2 |
| filaree | Erodium cicutarium | 3 | 3 | 2 | 1 |
| phlox, spreading | Phlox longifolia | 3 | 5 | 3 | 6 |
| lettuce, prickly | Lactuca serriola | 1 | T | 0 | 0 |
| penstemon | Penstemon acuminatus | 1 | T | 0 | 0 |
| Lomatium (gray carrot leaf) | Lomatium macrocarpum | 2 | T | 1 | T |
| fleabane, woolly | Erigeron pumilus | 1 | T | 1 | T |
| mariposa | Calochortus macrocarpus | 1 | T | 1 | T |
| pussytoes | Antennaria dimorpha | | | 1 | T |
| fiddleneck | Amsinkia sp. | | | 1 | T |
| mustard, Jim Hill | Sisymbrium altissimum | | | 1 | T |
| aster, hoary | Machaeranthera canescens | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| sagebrush, basin big | Artemisia tridentata | 3 | T | 4 | 18 |
| snakeweed | Gutierrezia sarothrae | 2 | T | 3 | 1 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 1 | T | 0 | 0 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 53 | xxx | 82 |
| **Perennial Cover:** | | xxx | 44 | xxx | 71 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 150 | | 255 | |
| Shrubs: | | 0 | | 0 | |
| | | | | | |
| **Apparent vigor (key species):** | | | | | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | H | | H | |
| needle-and-thread | Hesperostipa comata | H | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 16 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** Light Loamy Terrace | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B17. Data collected on range monitoring plot 17 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/7/87 | | DATE: 5/14/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 75 | xxx | 20 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 10 | xxx | 10 |
| Mosses & Lichens | | 1 | T | | 1 |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 5 | 15 | 5 | 25 |
| bluegrass, Sandberg | Poa secunda | 3 | 3 | 3 | 10 |
| Fescue, six weeks | Vulpia sp. | 3 | 2 | 3 | 5 |
| cheatgrass | Bromus tectorum | 3 | 3 | 4 | 30 |
| ricegrass, Indian | Achnatherum hymenoides | 1 | T | 2 | T |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 3- | 1 | 2 | T |
| **Forbs** | | | | | |
| indianwheat, woolly | Plantago patagonica | 3 | 1 | 3 | 3 |
| phlox, longleaf | Phlox longifolia | 3 | 2 | 3 | 1 |
| Aster? | Aster sp. | 2 | T | 0 | 0 |
| fiddleneck | Amsinkia sp. | 2 | T | 3 | T |
| mustard, Jim Hill | Sisymbrium altissimum | 2 | T | 2 | T |
| mariposa | Calochortus macrocarpus | 2 | T | 1 | T |
| sandverbena, white | Abronia mellifera | 1 | T | 0 | 0 |
| pussytoes | Antennaria dimorpha | 2 | T | 1 | T |
| milkvetch, stalkpod | Astralagus sclerocarpus | 1 | T | 0 | 0 |
| lettuce, prickly | Lactuca serriola | 2 | T | 0 | 0 |
| prickly pear | Opuntia polyacantha | 2 | T | 2 | T |
| scurfpea | Psoralidium lanceolatum | 2 | T | 3 | 1 |
| milkvetch, Columbia | Astralagus succumbens | 1 | T | 0 | 0 |
| desert parsley, Chimaya | Pteryxia terebinthina var. terebinthina | 2 | T | 1 | T |
| salsify | Tragopogon dubius | 1 | T | 0 | 0 |
| filaree | Erodium cicutarium | | | 2 | 1 |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 3 | 1 |
| tall annual willowherb | Epilobium brachycarpum | | | 1 | T |
| diffuse knapweed | Centaurea diffusa | | | 1 | T |
| false yarrow | Chaenactis douglasii var. achilleifolia | | | 1 | T |
| balsamroot, Carey | Balsamorhiza careyana | | | 3 | T |
| yarrow | Achillea millifolium | | | 1 | T |
| fleabane, cushion | Erigeron filifolius | | | 1 | T |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 1 | T | 3 | T |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 1 | T | 1 | T |
| snakeweed | Gutierrezia sarothrae | | | 1 | T |
| **Total Cover:** | | xxx | 30 | xxx | 80 |
| **Perennial Cover:** | | xxx | 22 | xxx | 41 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 250 | | 165 | |
| Shrubs: | | 0 | | 0 | |
| **Apparent vigor (key species):** | | | | | |
| needle-and-thread | Hesperostipa comata | H | | H | |
| bluegrass, Sandberg | Poa secunda | | | H | |
| **Seedlings:** | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 17 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | **ECOL. SITE:** | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | | | | |

## Table B18. Data collected on range monitoring plot 18 in 1987 and 2008 at NWSTF Boardman.

| ITEM & SPECIES | SCIENTIFIC NAME | DATE: 5/7/87 | | DATE: 5/15/08 | |
|---|---|---|---|---|---|
| | | DOMI-NANCE | CANOPY COVER | DOMI-NANCE | CANOPY COVER |
| Bare Ground | | xxx | 40 | xxx | 8 |
| Gravel & Stones | | xxx | 0 | xxx | 0 |
| Litter & Mulch | | xxx | 20 | xxx | 12 |
| Mosses & Lichens | | 2 | 3 | | 8 |
| | | | | | |
| **Grasses** | | | | | |
| needle-and-thread | Hesperostipa comata | 5 | 15 | 5 | 35 |
| bluegrass, Sandberg | Poa secunda | 3 | 15 | 3 | 15 |
| cheatgrass | Bromus tectorum | 4 | 10 | 3 | 15 |
| wheatgrass, bluebunch | Pseudoroegneria spicata | 3- | T | 3 | 5 |
| squirreltail | Elymus elymoides | 1 | T | 0 | 0 |
| | | | | | |
| **Forbs** | | | | | |
| Aster? | Aster sp. | 2 | T | 0 | 0 |
| indianwheat, woolly | Plantago patagonica | 3 | 1 | 1 | T |
| salisfy | Tragopogon dubius | 1 | T | 0 | 0 |
| mustard, Jim Hill | Sisymbrium altissimum | 1 | T | 2 | T |
| lettuce, prickly | Lactuca serriola | 1 | T | 1 | T |
| filaree | Erodium cicutarium | 1 | T | 0 | 0 |
| mariposa | Calochortus macrocarpus | 1 | T | 0 | 0 |
| phlox, longleaf | Phlox longifolia | 1 | T | 2 | T |
| loco, woolly pod | Astragalus purshii | 1 | T | 0 | 0 |
| aster, hoary | Machaeranthera canescens | | | 2 | 1 |
| Lomatium (gray carrot leaf) | Lomatium macrocarpum | | | 1 | T |
| fiddleneck | Amsinkia sp. | | | 1 | T |
| hairy false golden aster | Heterotheca villosa var. villosa | | | 1 | T |
| skeleton weed | Stephanomeria paniculata | | | 1 | T |
| weakstem cryptantha | Cryptantha flaccida | | | 1 | T |
| | | | | | |
| **Shrubs** | | | | | |
| rabbitbrush, rubber | Ericameria nauseosa | 3 | 2 | 4 | 8 |
| rabbitbrush, Douglas green | Chrysothamnus viscidiflorus | 3 | T | 3 | 3 |
| | | | | | |
| | | | | | |
| **Total Cover:** | | xxx | 49 | xxx | 84 |
| **Perennial Cover:** | | xxx | 32 | xxx | 68 |
| **Growing season this year:** | | AbAv | | | |
| Est. Lbs/acre air dry: Per. Grass&Forbs: | | 150 | | 245 | |
| Shrubs: | | 0 | | 0 | |
| | | | | | |
| **Apparent vigor (key species):** | | | | | |
| needle and thread | Hesperostipa comata | H | | H | |
| bluegrass, Sandberg | Poa secunda | H | | M | |
| wheatgrass, bluebunch | Pseudoroegneria spicata | | | H | |
| | | | | | |
| **Seedlings:** | | | | | |
| | | | | | |
| | | | | | |
| **RANCH OR UNIT:** Boardman Bomb Range | | **BY:** McClelland and Anderson (1987); Elseroad and Emery (2008) | | | **PLOT:** 18 |
| **ECOL. PROVINCE:** Columbia Basin - Oregon | | | | | |
| **PHOTO/MAP:** | **PLOT LOCATION:** | **ECOL. SITE:** Light Loamy Terrace | | | |

**Appendix C: Range monitoring plot photos for NWSTF Boardman in 1987 and 2008**

**1987**

**2008**

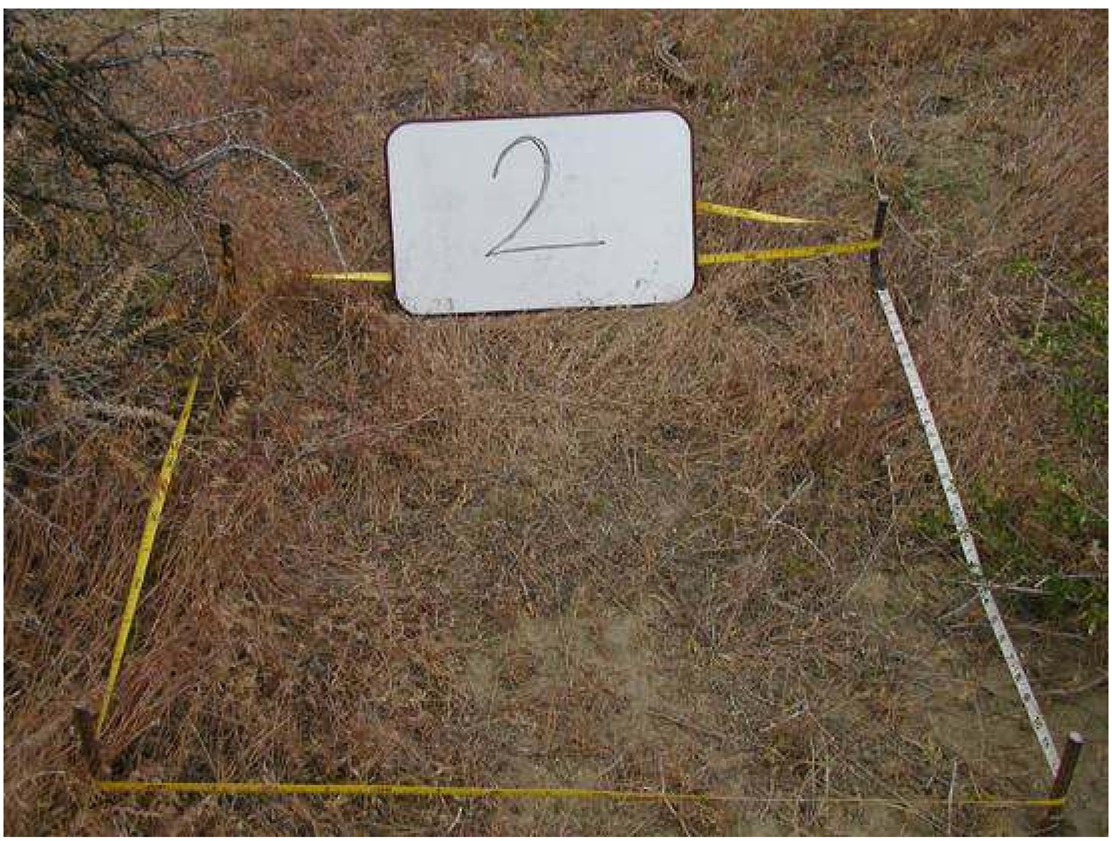
**Figure C1. Range monitoring plot 1 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**


**2008**

**Figure C2. Range monitoring plot 1 at NWSTF Boardman in 1987 and 2008- Aspect photo**

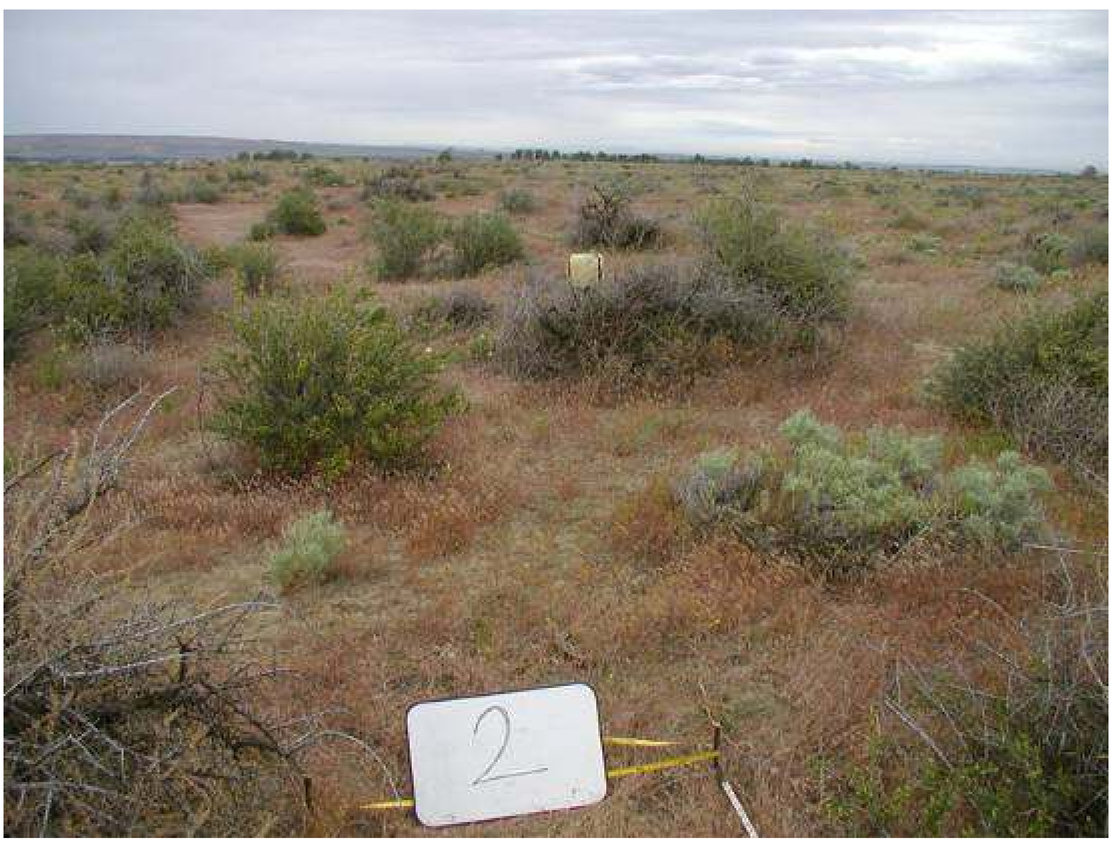

**1987**




**2008**

**Figure C3. Range monitoring plot 2 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**




**2008**

**Figure C4. Range monitoring plot 2 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C5. Range monitoring plot 3 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**


**2008**

**Figure C6. Range monitoring plot 3 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C7. Range monitoring plot 4 at NWSTF Boardman in 1987 and 2008- Close-up photo**

**1987**

**2008**

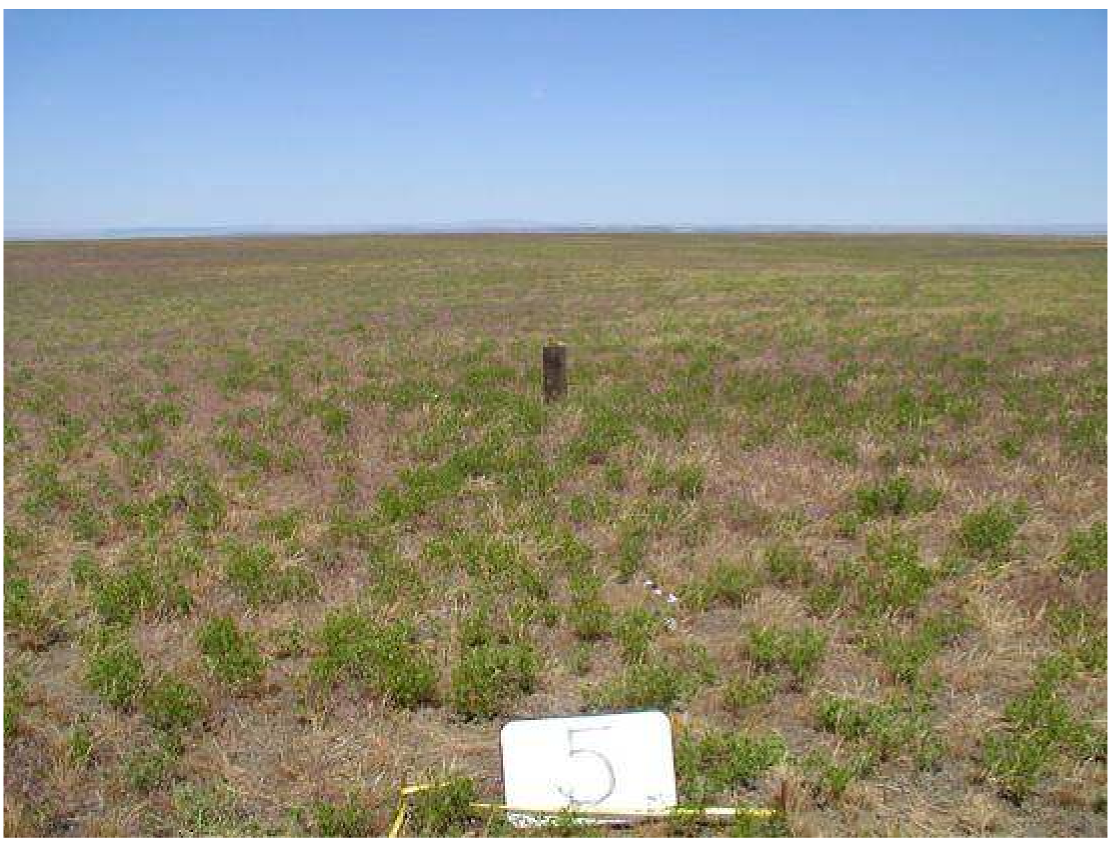
**Figure C8. Range monitoring plot 4 at NWSTF Boardman in 1987 and 2008- Aspect photo**


1987


2008

**Figure C9. Range monitoring plot 5 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**



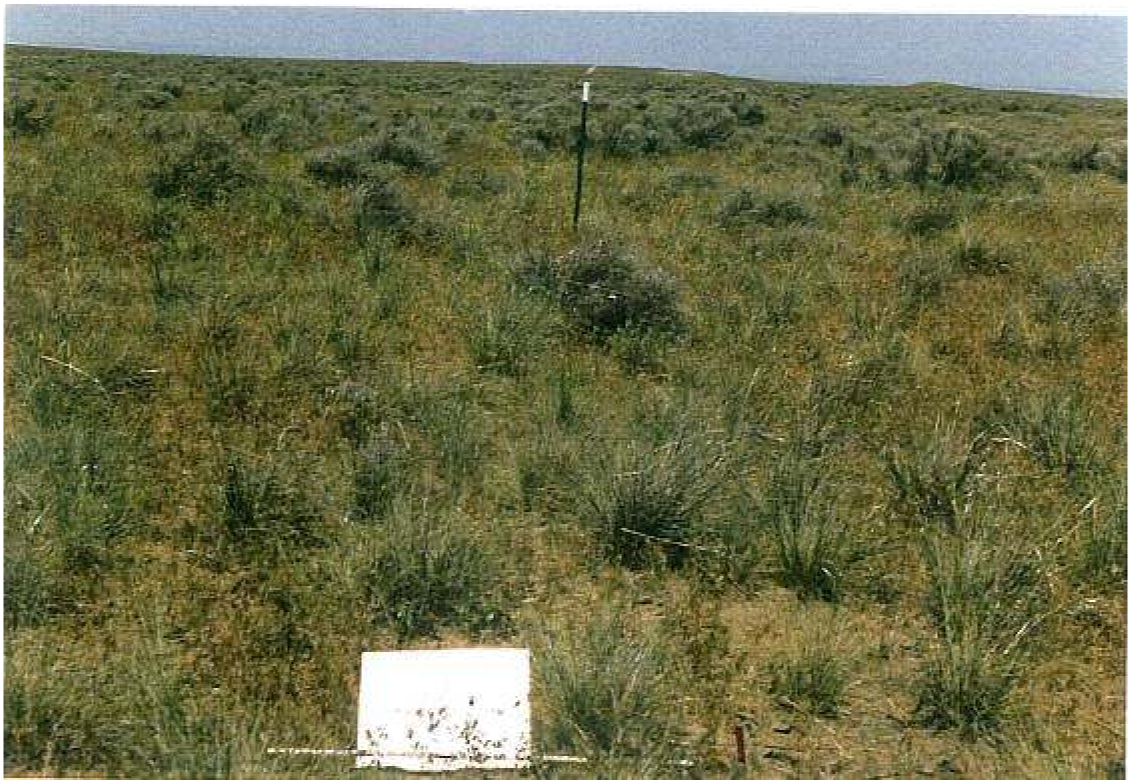

**2008**

**Figure C10. Range monitoring plot 5 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C11. Range monitoring plot 6 at NWSTF Boardman in 1987 and 2008- Close-up photo**

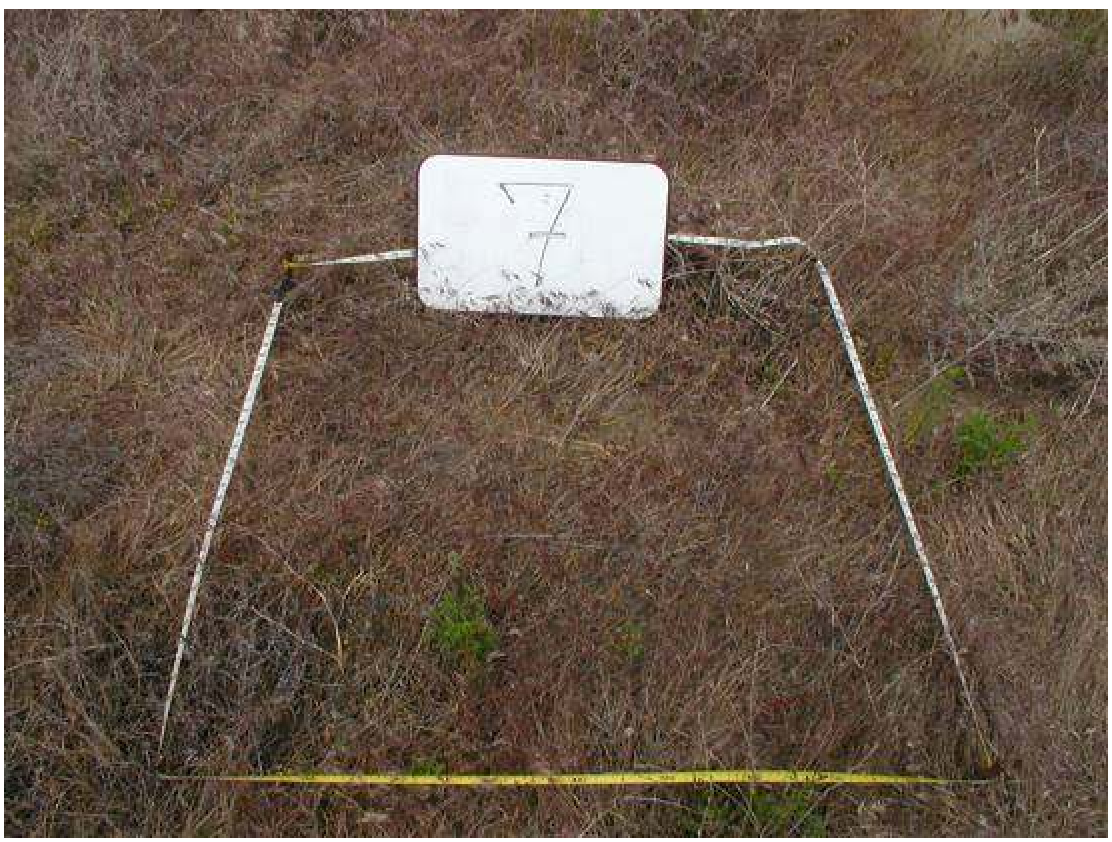


**1987**


**2008**

**Figure C12. Range monitoring plot 6 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**




**2008**

**Figure C13. Range monitoring plot 7 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**


**2008**

**Figure C14. Range monitoring plot 7 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C15. Range monitoring plot 8 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**

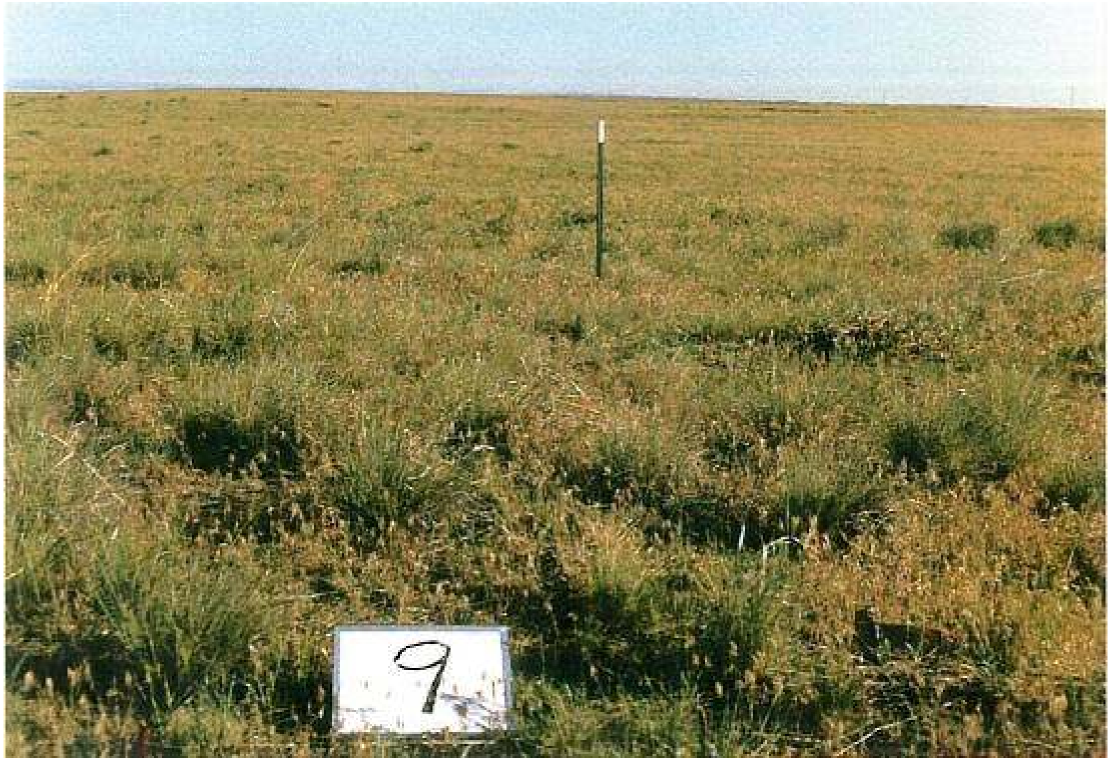

**2008**

**Figure C16. Range monitoring plot 8 at NWSTF Boardman in 1987 and 2008- Aspect photo**


1987


2008

**Figure C17. Range monitoring plot 9 at NWSTF Boardman in 1987 and 2008- Close-up photo**

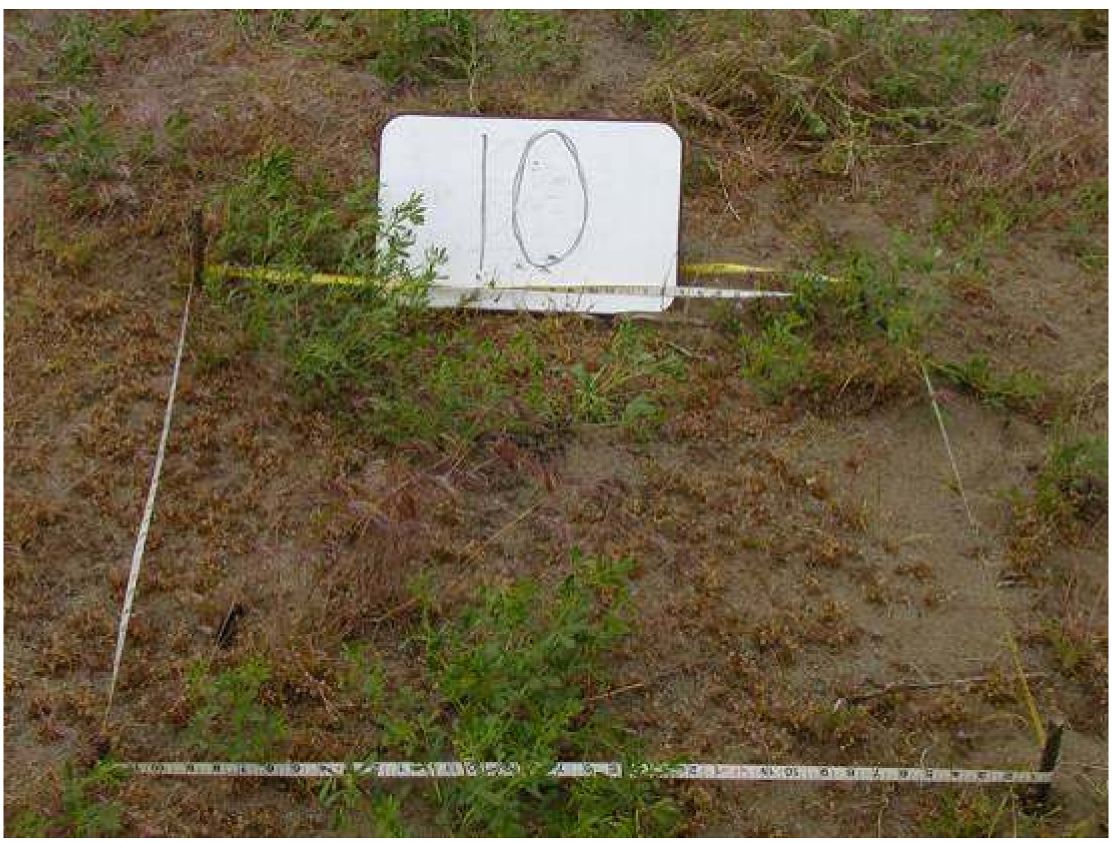



**1987**


**2008**

**Figure C18. Range monitoring plot 9 at NWSTF Boardman in 1987 and 2008- Aspect photo**


1987




2008

**Figure C19. Range monitoring plot 10 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**

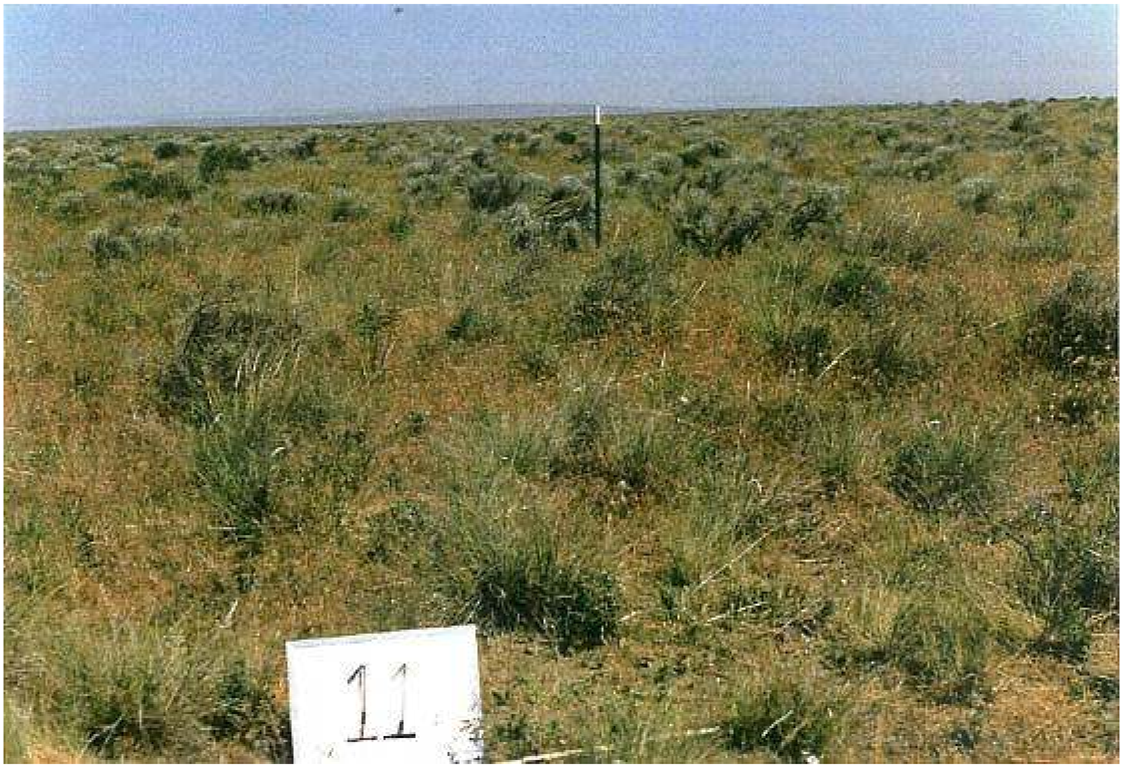

**2008**

**Figure C20. Range monitoring plot 10 at NWSTF Boardman in 1987 and 2008- Aspect photo**

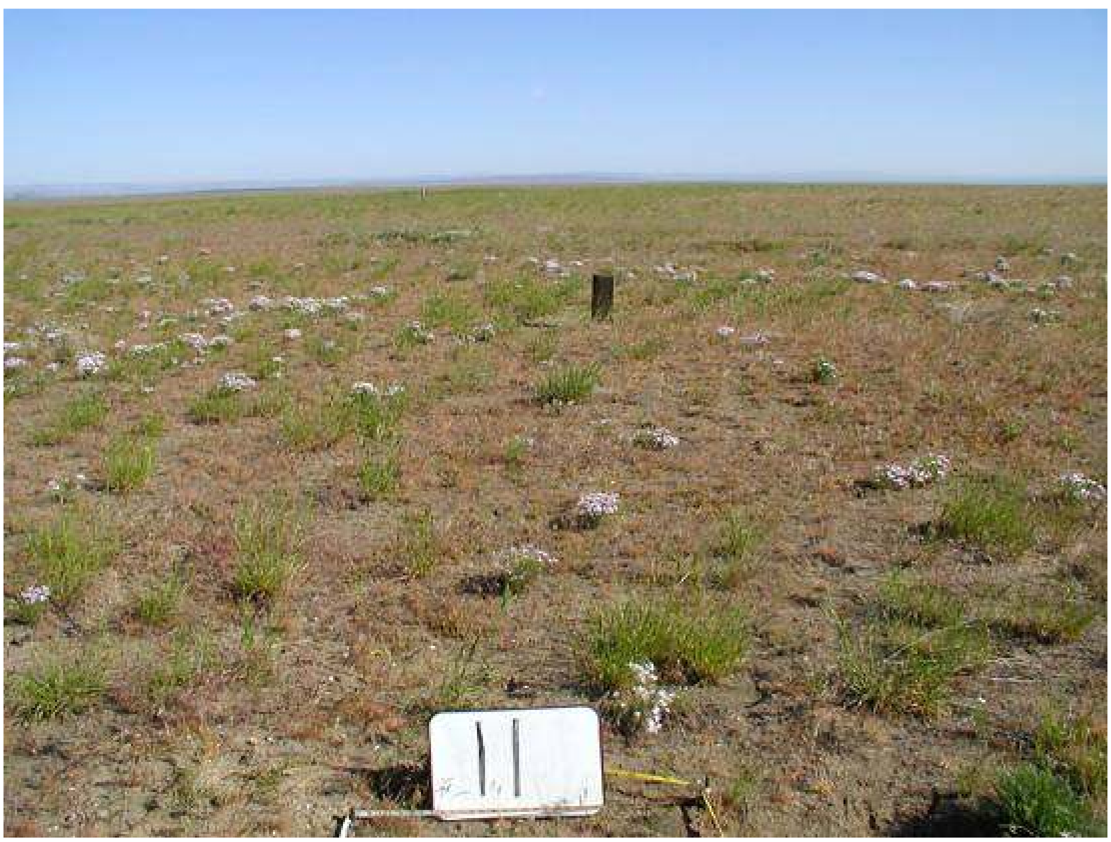

**1987**


**2008**

**Figure C21. Range monitoring plot 11 at NWSTF Boardman in 1987 and 2008- Close-up photo**



1987



2008

**Figure C22. Range monitoring plot 11 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C23. Range monitoring plot 12 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**


**2008**

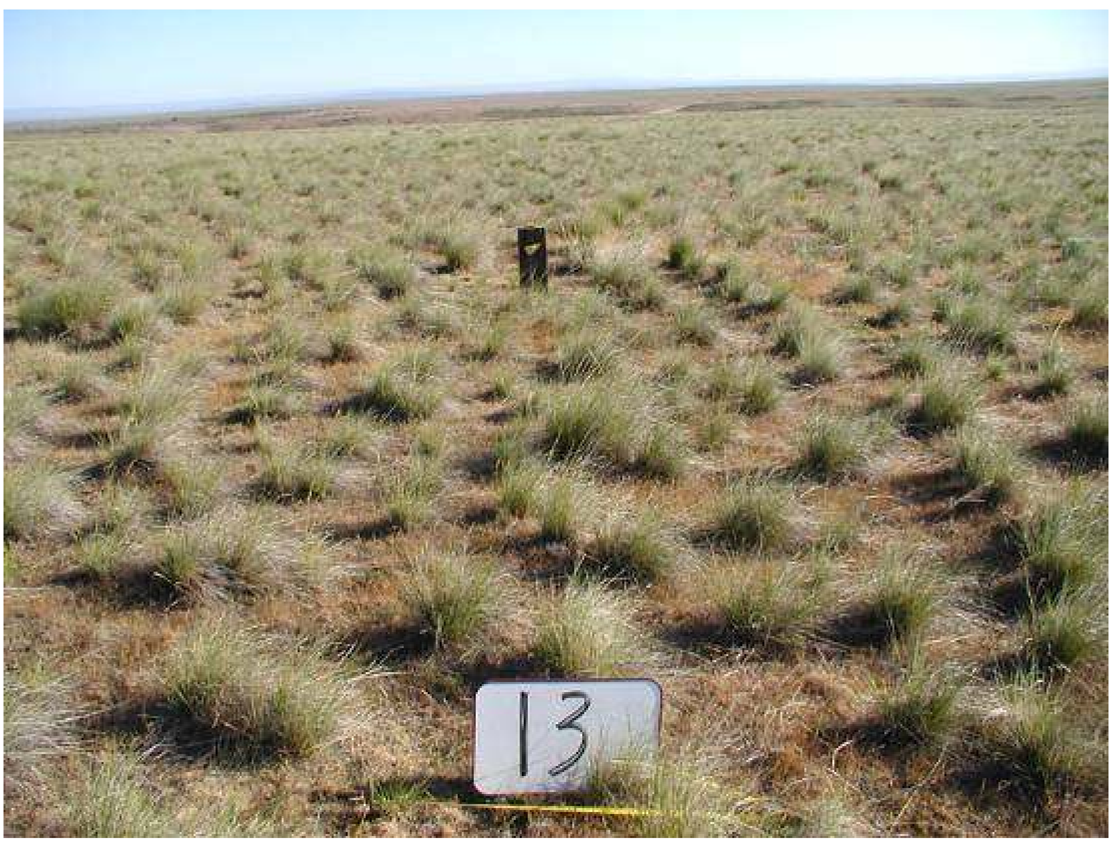
**Figure C24. Range monitoring plot 12 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C25. Range monitoring plot 13 at NWSTF Boardman in 1987 and 2008- Close-up photo**


1987




2008

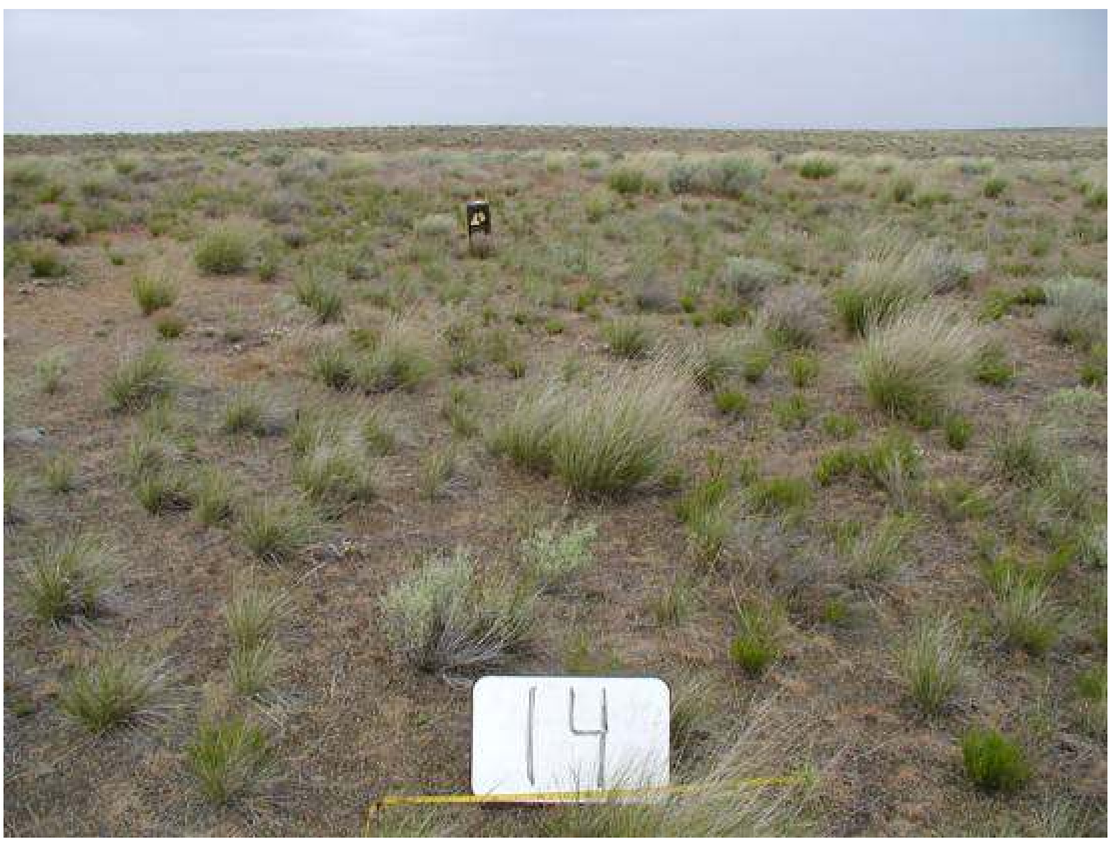
**Figure C26. Range monitoring plot 13 at NWSTF Boardman in 1987 and 2008- Aspect photo**

**1987**


**2008**

**Figure C27. Range monitoring plot 14 at NWSTF Boardman in 1987 and 2008- Close-up photo**

1987




2008

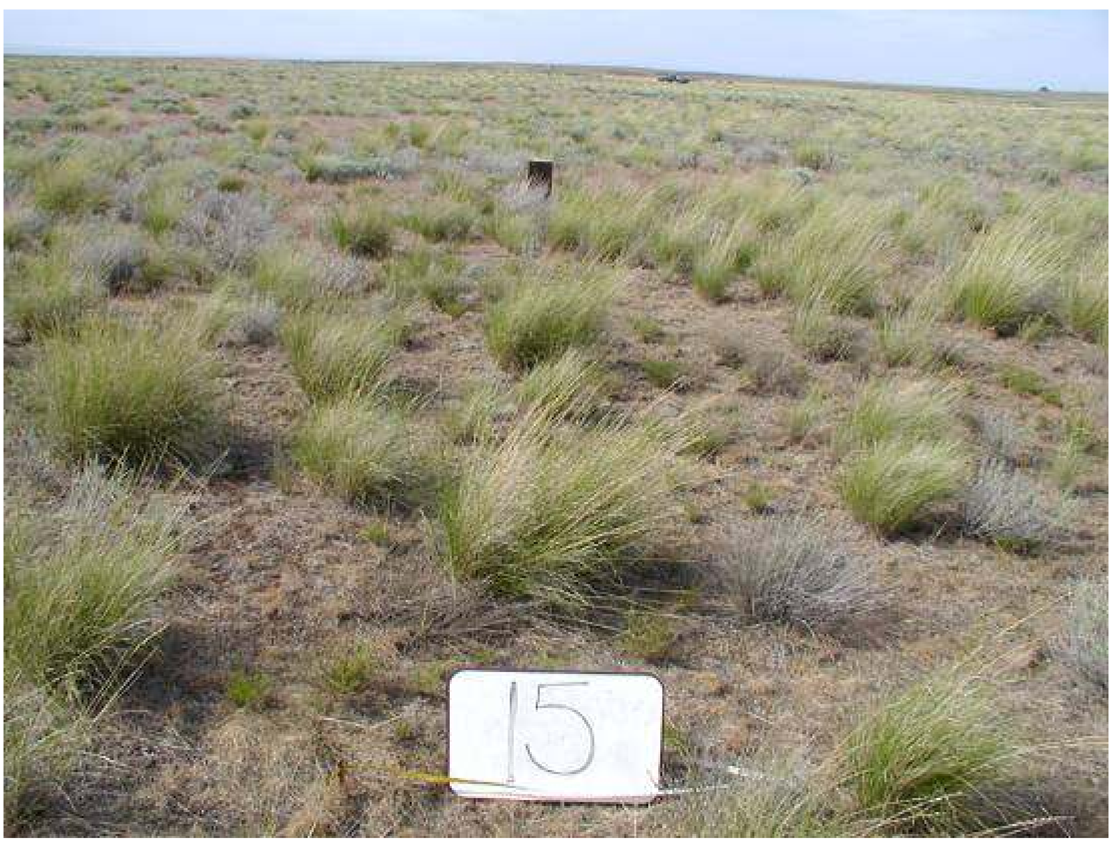
**Figure C28. Range monitoring plot 14 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C29. Range monitoring plot 15 at NWSTF Boardman in 1987 and 2008- Close-up photo**


1987




2008

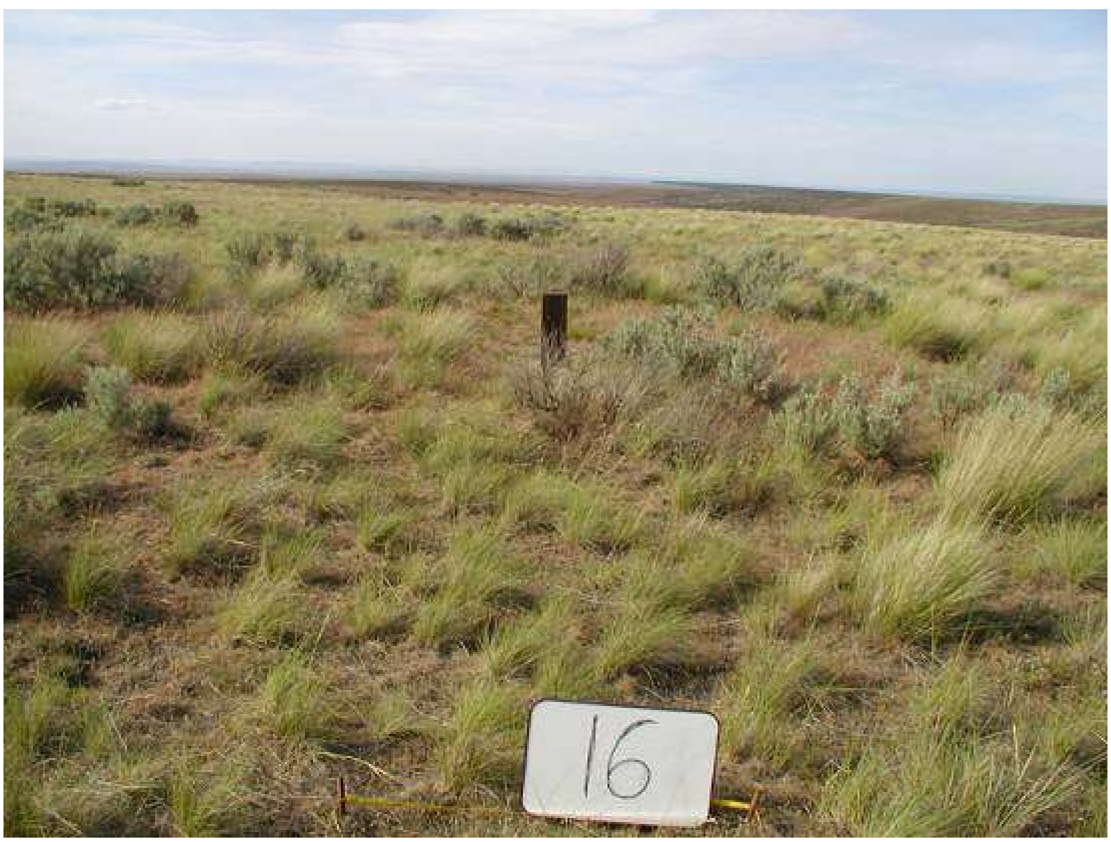
**Figure C30. Range monitoring plot 15 at NWSTF Boardman in 1987 and 2008- Aspect photo**

**1987**


**2008**

**Figure C31. Range monitoring plot 16 at NWSTF Boardman in 1987 and 2008- Close-up photo**

**1987**




**2008**

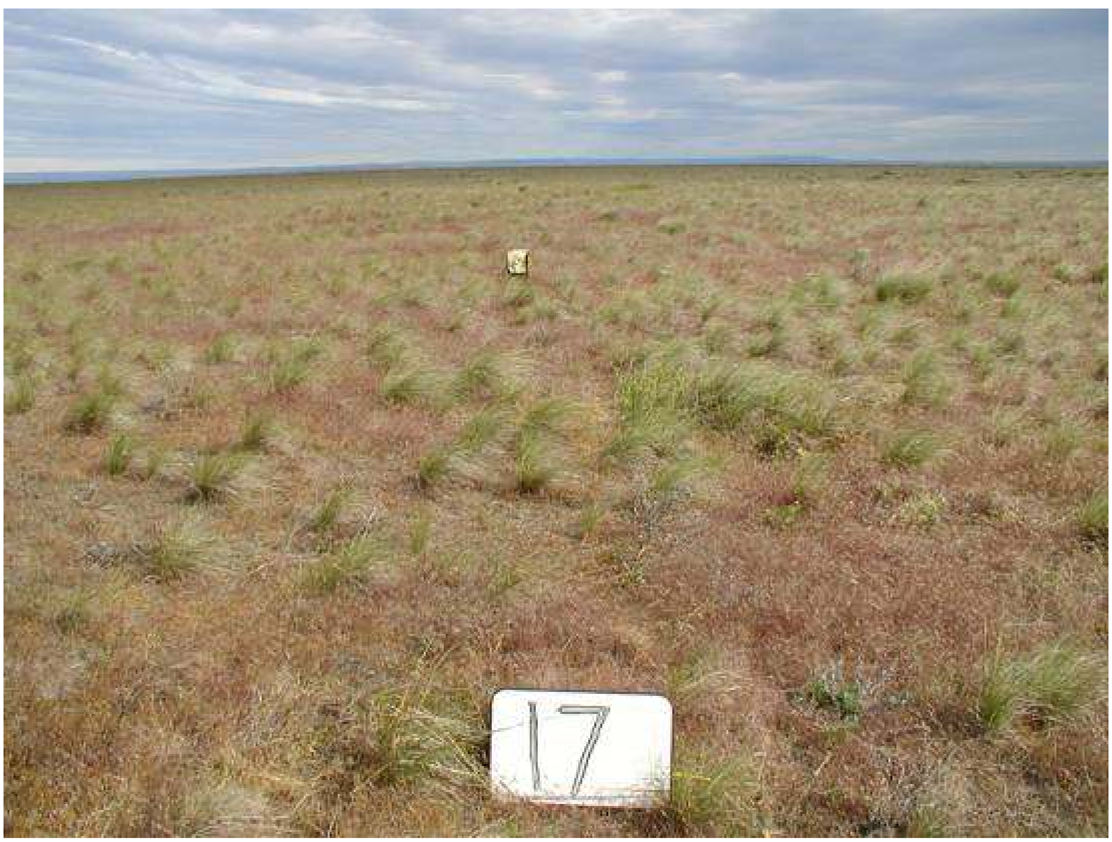
**Figure C32. Range monitoring plot 16 at NWSTF Boardman in 1987 and 2008- Aspect photo**


**1987**


**2008**

**Figure C33. Range monitoring plot 17 at NWSTF Boardman in 1987 and 2008- Close-up photo**


**1987**



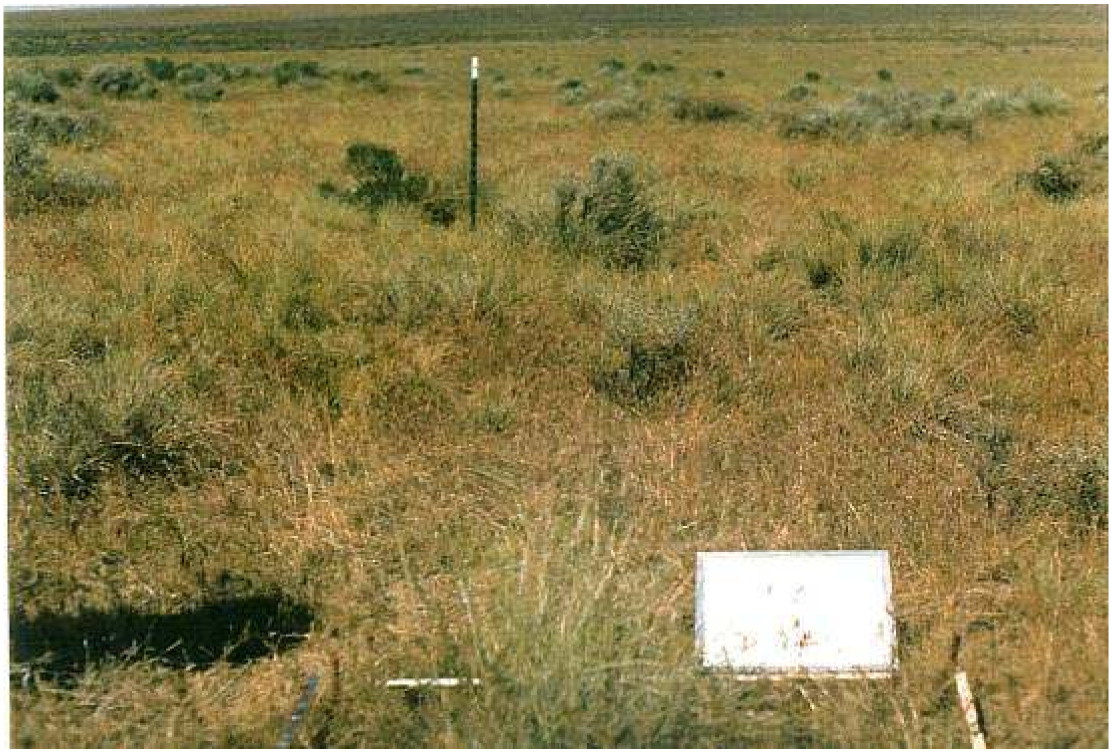

**2008**

**Figure C34. Range monitoring plot 17 at NWSTF Boardman in 1987 and 2008- Aspect photo**

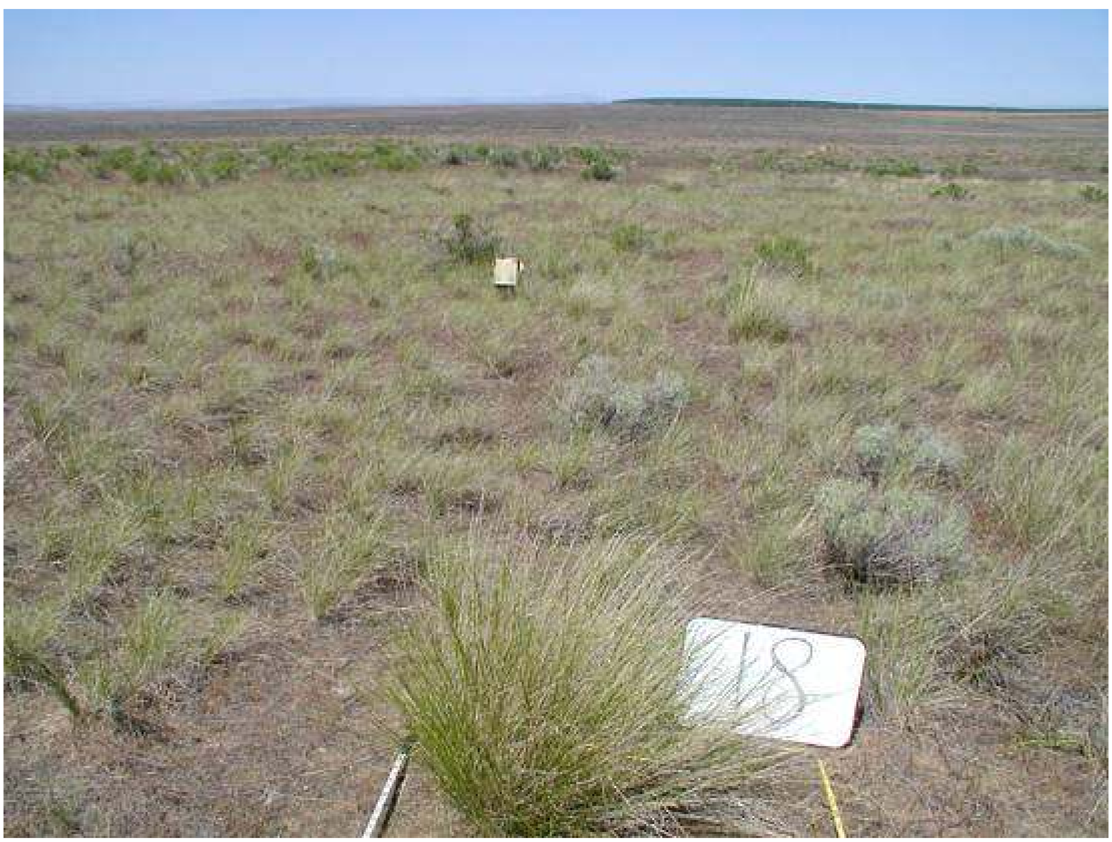
1987


2008

**Figure C35. Range monitoring plot 18 at NWSTF Boardman in 1987 and 2008- Close-up photo**



**1987**




**2008**

**Figure C36. Range monitoring plot 18 at NWSTF Boardman in 1987 and 2008- Aspect photo**

# Summary of Shrub-steppe Restoration Efforts and Monitoring for 2016-2019

## Naval Weapons Systems Training Facility Boardman

## Cooperative Agreement N44255-16-2-0008


Prepared by

Kelly Wallis and Jen Langevin

The Nature Conservancy, Oregon

821 SE 14th Ave. Portland Oregon


March 2019

# Table of Contents

# 1. INTRODUCTION

The Naval Weapons Systems Training Facility Boardman (NWSTF) is a 47,400-acre Naval installation located in north-central Oregon and is one of the largest remaining parcels of native shrub-steppe vegetation in that part of the state. Wildfires affected the property in 2007 and 2008, which together burned over 41,000 acres (86% of the property). The 2012 NWSTF Integrated Natural Resources Management Plan (INRMP) section 4.3 states, in part, that after wildfires "[a]reas that are not recovering naturally back to the desired pre-fire habitat types will be assessed for restoration success and priority ranked for potential restoration measures." (Navy 2012).

The Nature Conservancy (The Conservancy, TNC) has entered into a cooperative agreement (CA) N44255-16-2-008 with the United States Navy (Navy 2016) to conduct burrowing owl surveys, vegetation plot monitoring and post-fire habitat enhancement/restoration on the Boardman Naval Weapons Systems Training Facility (NWSTF Boardman) from September 2016 through March 2019. This document is provided as a final report on activities related to post-fire habitat enhancement/ restoration which include planning, conducting, and monitoring restoration on 100-150 Acres of areas burned during previous wildfire events at NWSTF Boardman, Oregon. Also included in this report are final monitoring results from plantings from the previous CA N44255-14-2-008.

# 2. Methods

In 2015, three areas known as Enhancement areas (EA) were selected at the NWSTF Boardman for range enhancement to help restore native plant communities following the effects of wildfires in 2007 and 2008 (a). Enhancement/restoration efforts were carried out by TNC staff and contractors. Enhancement/restoration activities under this CA were carried out over 1 planting season for EA1 and 2 planting seasons for EA2. This includes herbicide application to control introduced vegetation, range drill seeding of native perennial grass species, planting native shrub seedlings, and/or planting native forb plugs.

## 2.1 Post- fire habitat enhancement/restoration plantings

In total, we seed-drilled and planted plugs on approximately 215 acres of degraded grassland.

### Native Grass Seeding

Native grass seed was planted in EA2 using three species of native perennial bunchgrass – bluebunch wheatgrass (*Pseudoroegneria spicata*), bottlebrush squirreltail (*Elymus elymoides*), and Sandberg bluegrass (*Poa secunda*). Native seed came from local stock and was increased by BFI Native Seeds LLC (Moses Lake, WA). We calculated seeding ratios for each site. For planting, bluebunch wheatgrass and bottlebrush squirreltail seed were mixed together in the same bin of a Truax range drill and drill-seeded; Sandberg bluegrass was placed in a separate bin and broadcast-seeded simultaneously.

## *Native* Forb and Shrub Plug Planting

Due to the risk of unexploded ordinances on the property, we confined plug plantings to flagged plots that were systematically dispersed across the enhancement areas. Prior to planting, TNC staff investigated all plug planting sites with metal detectors to reduce the potential hazard of unexploded ordinance. We created planting plans of native forb and shrub plugs for each enhancement area. Plugs were grown out by Plantworks LLC (Cove, OR) from local seed stock and were planted by Wildlands, Inc. (Richland, WA) under TNC supervision.

## Enhancement Areas

### *Enhancement Area 1*

EA1 was affected by a July 2007 wildfire that burned 10,250 acres across the central and northeastern portions of the property. Prior to the wildfire, EA1 was an antelope bitterbrush stand (*Purshia tridentata*) mixed with needle-and-thread grass (*Hesperostipa comata*) and Sandberg bluegrass (*Poa secunda*) grasslands. Nearly all the bitterbrush was removed by wildfire, however large patches of healthy grassland persisted, though cheatgrass (*Bromus tectorum*) is common and in places forms near-monocultures. The site is very sandy overall (Quincy loamy fine sands), with old dune relief along the northern edge.

*Winter 2017-18 (Season 2)*

In the western half of the enhancement area 1 (EA1) a 41-acre area was planted with shrubs. On December 5th, 2017 contract crews planted 950 bitterbrush (*Purshia tridentata*) plugs. This effort resulted in approximately 23 plants per acre (Figure 2).

### *Enhancement Area 2*

EA2 was affected by the July 2008 wildfire that burned over 30,000 acres across the southern two-thirds of the property. Prior to the wildfire, the site supported large mature sagebrush, though the understory was likely dominated by non-native species, especially cheatgrass. The site was again burned in the June 2015 wildfire. Soils at the site are Royal loamy fine sands. There was no meaningful sagebrush cover following the wildfire, and regenerating vegetation appeared to be almost exclusively non-native, including cheatgrass, tumble mustard, bulbous bluegrass, and a number of other weed species.

*Winter 2016-17 (Season 1)*

In mid-November 2016 the NW portion of Enhancement Area #2 was aerially treated with 16 oz/acre of glyphosate to reduce competition from non-native annual grasses.

In early December 2016, contract planters installed approximately 2,880 sagebrush (*Artemisia tridentata*) seedlings at 48 planting locations in the NW portion of Enhancement Area #2 over 34 Acres. Harsh winter conditions from mid-December through February delayed further planting. In March of 2017, contract planters installed an additional 4,020 sagebrush shrubs at approximately 67 planting sites in the NW portion of Enhancement Area #2 across 50 Acres. This resulted in approximately 93 plants/ Acre across 74 Acres.

*Winter 2017-18 (Season 2)*

In October 2017, a wildfire burned several hundred acres of the NWSTF. The burned area was primarily north of enhancement area 2 (EA2) in Juniper Canyon but included the northern 12 acres of EA2. This presented an ideal opportunity to revegetate this area, which historically was sagebrush and bunchgrass but prior to the 2017 wildfire was dominated by cheatgrass and non-native cover. The decision was made to complete restoration activities in the 12 acres of EA2 which burned, as well as an additional 88 burned acres outside of the northern boundary. The standing sagebrush within the planting area were heavily damaged by the fire and no longer viable.

The restoration efforts in EA2 consisted of planting native forb plugs and drill-seeding native grass seed. TNC drill seeded the 3 species of grasses from November 27th, 2017 to December 20th, and the total seeded area was 100 acres. Due to the rough terrain and limitations of the range drill, the seeded areas were not one contiguous area but had some gaps where the terrain was not suitable for drill-seeding (Figure 3).

On December 5th, 2017 contractors began planting a total of 7,371 native forb plugs. All plugs were planted within a 25-acre area in EA2, the southern part of the seeding area (Fig. 3). Species planted included 3,420 plugs of yarrow (*Achillea millefolium*), followed by 2,680 plugs of hairy golden aster (*Heterotheca canescens*), 551 plugs of long leaf phlox (*Phlox longifolia*), 360 plugs of hoary aster (*Machaeranthera villosa*) and 2 plugs of Astragalus sp. Additionally, 360 plugs of big sagebrush (*Artemisia tridentata*) were planted in areas which formerly supported sagebrush prior to the fire. This resulted in approximately 295 plants per acre. There was a slight delay in planting due to winter weather and the last plants were installed on December 20th, 2017.

#### *Enhancement Area 3*

No planting occurred in Enhancement Area 3 (EA3). Figure 4 depicts seeding and planting efforts from previous cooperative agreement N44255-14-2-008. TNC continues to monitor the success of the plantings in EA3 and new data is presented in this report.

## 2.2 Post- fire habitat enhancement/restoration monitoring

### Native Grass Seed Monitoring

Grass seed monitoring events were performed for seedings that occurred under the previous cooperative agreement (N44255-14-2-0008) in EA2 and/ or EA3 planted in December 2015 and November 2016.

TNC field staff monitored selected species' frequency along transects for each seeding location. Staff used nested frequency frames and recorded the presence of each selected species in each frame using the number (1, 2, 3, or 4) that corresponded to the smallest nested section containing any basal area of any individual. Species found in a given frame were assumed to be present in all larger frames (e.g. a plant found in "2" is assumed present in "3" and "4"). The best fit frame for each species will be the one with a frequency closest to 50%. A full description of the protocol is available in Appendix A.

### Native Forb and Shrub Plug Monitoring

Forb and shrub plug monitoring was performed for plantings from the previous cooperative agreement (N44255-14-2-0008), as well as the first planting season of the current CA (N44255-16-2-0008). The results for the second planting season will be presented in its entirety in the next CA (N44255-17-2-0004).

The intent of forb and shrub monitoring is to track initial establishment of the plants. After each restoration event forbs will be monitored 3 times; March, May, and again in March of the following year. Shrubs will be monitored 4 times, adding an additional fall monitoring; March, May, October, and again in March of the following year. A full description of the protocol is available in Appendix B.

# 3. Results

This report covers monitoring events from N44255-14-2-0008 and N44255-16-2-0008.

## 3.1 Enhancement Area 1 – 1 mile north of Headquarters

### Native Forb and Shrub Plug Planting

**Results from plantings under CA N44255-14-2-0008**

Planting occurred over 2 seasons under the previous cooperative agreement (N44255-14-2-0008).

Restoration at EA1 consisted of planting 3,000 bitterbrush plugs in February 2016 and 5,000 bitterbrush plugs in December 2016, for a total of 8,000 bitterbrush plugs over about 308 acres for a density of 26 plants per acre (Figure 2).

For the first planting, we monitored in March, May, October 2016, and March 2017. At the start of the first growing season, about one-month post-planting, 99% ±<1% of bitterbrush plugs were alive (Figure 5) after visiting all 59 monitoring plots. Unfortunately, the May 2016 dataset was lost, though the survivorship at that time was approximately 25%. By October, monitoring found only two live plugs. Estimated survivorship in October was <1% ±1% after visiting 11 randomly chosen monitoring plots. Estimated survivorship in March 2017 was 1% survivorship after visiting 12 randomly chosen monitoring plots.

For the second planting, we monitored in March 2017, May 2017 and March 2018 (Figure 6). This planting also resulted in negligible survivorship. As a result of the failure of both of these plantings, it was decided to replant EA1 for the 3rd time under the next CA (N44255-17-2-0004).

## 3.2 Enhancement Area 2 – Lower Juniper Canyon

### Native Grass Seeding

**Results from plantings under CA N44255-14-2-0008**

TNC staff monitored grass seeding survivorship in EA2 from 2015 and 2016 plantings under CA N44255-14-2-008. A total of 107 Acres were planted with PSSP = *Pseudoroegneria spicata* (bluebunch wheatgrass), POSE = *Poa secunda* (Sandberg bluegrass), ELEL = Elymus elmoides (bottlebrush squirreltail) on the SE side of the road (Figure 3). We considered both the spatial distribution of the seeded species (Figure 7) as well as the frequency of occurrence (Figures 8-10). In Figure 7, grasses varied spatially and success was also varied based on year planted with minimal survival/distribution in the section planted in November 2016. In the 2015 planting, Sandberg bluegrass fared better. Figure 8 shows the results for the frequency of occurrence of native seeded species. In general, the detection of seeded species was low for EA2, except for Sandberg bluegrass planted in 2015. It was previously thought that detection and identification was hampered by the small stature of the seedlings for the earlier monitoring post planting and that the exceptionally low frequencies observed in EA2 (2016 planting) likely reflect a combination of low abundance and low detection rates. However, based on similar timings in EA3 which had higher detection rates, this may not be the full explanation for the low numbers in EA2.  Regardless, future monitoring efforts should occur at least two growing seasons post seeding to further minimize this issue.

The seeded areas were also monitored for non-native annual grasses (Figure 9).  As is typical in burned and/or in degraded grasslands, cheatgrass (BRTE) dominates the landscape with at or close to 100% frequency in both EA units.  *Poa bulbosa* (POBU) is also an aggressive annual that is difficult for natives to out compete with percent frequency of the 2018 monitorings at 69% for the 2015 planting of EA2 and 94% for the 2016 planting.

Introduced annual forb percent frequency was monitored in 2017 and 2018 for the 2015 and 2016 native grass planting for EA2 (Figure 10).  EA2 had over 70% frequency for SIAL= Tumble mustard (Sisymbrium altissimum), TRDU= Yellow Salsify (Tragopogon dubius), and LACE= Prickly Lettuce (Lactuca serriola) for the 2015 planting of EA2.  The 2016 planting had over 80% frequency for SIAL and LACE, but only 25% for TRDU.

## Native Forb and Shrub Plug Planting

**Results from plantings under CA N44255-14-2-0008**

In February 2016, contractors planted 2,000 sagebrush plugs in the 107-acre seeded area of EA2 on the SE portion of Juniper Canyon Rd. In December 2016, an additional 3,500 sagebrush plugs were planted, as well as forb plugs, including 8,930 yarrow, 2,230 shaggy daisy, 1,420 Lewis' flax, 200 threadleaf fleabane, and 140 longleaf phlox. Harsh winter weather delayed planting of the remainder of the plugs until late March 2017 when 1,620 yarrow and 300 threadleaf fleabane were planted (Figure 3).

We monitored initial plantings (February 2016) in March, May, and October 2016, and March 2017. At the start of the first growing season, about one-month post-planting, 78% of sagebrush plugs were alive (Figure 5.) after visiting all 48 monitoring plots. Unfortunately, the May 2016 dataset was lost, though the survivorship at that time was approximately 75%.  Percent Survival was 70% for October 2016 67% for March 2017.

The forb percent survival for EA2 planted in December 2016 is shown in Figure 11.  Essentially common yarrow (ACMI) was the only successful species with a final result of 75% survival by April 2018.  All others dropped to near 0%.

Like the sagebrush planted in March 2017, the forbs also were in poor to dead condition upon planting and therefore the March 2017 monitoring is percent alive at planting.  ACMI once again was the most successful species with 58% survival by April 2018.  Shaggy fleabane (ERPU) numbers were combined with the planting done in EA2 and EA3, which dropped to 10.5% by the April 2018 monitoring (Figure 12).

**Results from plantings under CA N44255-16-2-0008**

The sagebrush planted in December 2016 and March 2017 described in the "Enhancement/restoration planting" section of this report, had a relatively low survivorship overall for 2 different reasons.  In Figure 13, the sagebrush planted in December 2016 had a low survivorship after the harsh winter with percent survivals of 14% in March 2017, 7% for May 2017, and 7% for March 2018.  The sagebrush planted in March 2017 had been in storage for several months and many of the plants were in poor to dead condition.  The March 17 monitoring of 31% "survival" was probably more like the percent alive at planting. The declining numbers from May 2017 of 22% and March 2018 of 8% were most likely due to poor plant condition upon planting as well as the late timing of planting.

## 3.3 Enhancement Area 3 – Lower Juniper Canyon

### Native Grass Seeding

Results from plantings under CA N44255-14-2-0008

TNC staff monitored grass seeding success from plantings in EA3 in 2015 under CA N44255-14-2-0008 (Figure 4). A total of 45 Acres were planted with PSSP = *Pseudoroegneria spicata* (bluebunch wheatgrass), POSE = *Poa secunda* (Sandberg bluegrass), ELEL = *Elymus elmoides* (bottlebrush squirreltail). See Appendix A for monitoring protocol. We considered both the spatial distribution of the seeded species (Figures 14) as well as the frequency of occurrence (Figures 8-10). In Figure 14, grasses varied spatially and success was also varied based on species with Sandberg bluegrass having the widest distribution. Figure 8 shows the results for the frequency of occurrence of native seeded species. The percent frequency for EA3 was much better than EA2 with upward trends of frequency between the 2nd year after planting and the 3rd year after planting. The 3rd year after planting resulted in 31% bluebunch wheatgrass, 45% bottlebrush squirrel tail, and 82% Sandberg bluegrass.

The seeded areas were also monitored for non-native annual grasses (Figure 9). Similar to EA2, cheatgrass (BRTE) was close to 100% frequency in EA3. *Poa bulbosa* (POBU) was at 51% frequency for the 2018 monitoring.

EA3 was monitored for introduced annual forb percent frequency in 2017 and 2018 for the 2015 native grass planting (Figure 10). EA3 had fewer introduced annual forbs than EA2, which could possibly be a contributing factor for the higher success of the native seed establishment. SIAL had a 10% frequency, TRDU 41%, and LACE 73% for the 2018 monitoring.

### Native Forb and Shrub Plug Planting

In February 2016, contractors planted forb plugs, including 6,000 yarrow and 120 threadleaf fleabane. Winter weather delayed planting of the remainder of the plugs until late March 2017 when 780 Lewis' flax, 100 threadleaf fleabane, 260 longleaf phlox and 40 Carey's balsamroot were planted (Figure 4).

We monitored initial plantings (February 2016) in May 2016, October 2016, and March 2017. We skipped the March 2016 monitoring because the plantings had not been flagged and were too small to find for accurate monitoring. Unfortunately, the May 2016 dataset was lost. In October, 95% of yarrow plugs found were alive and 97% in March 2017 after visiting all 48 monitoring plots (Figure 5.)

We monitored initial plantings (March 2017) in March 2017, May 2017, and April 2018 (Figure 12). October 2017 was skipped because most forbs are too senesced to assess accurately. Due to the aforementioned prolonged storage of the forbs, many plants were in poor to dead condition upon planting and therefore the March 2017 monitoring is probably best to consider as percent alive at planting. All of the forbs in EA3 were reduced to <= 10% by the April 2018 monitoring.

# 4. Discussion

## 4.1 Native Grass Seeding

EA2 has not been as successful at establishing native grasses compared to EA3 with bluebunch wheatgrass and bottlebrush squirreltail dropping to near 0% for both planting years. There was some relatively good success for Sandberg bluegrass for the 2015 planting at 57% survival (Figure 8). Reasons for this may be because EA2 had much higher introduced annual forbs with tumble mustard over 70% and yellow salsify over 70% for the 2015 planting and prickly lettuce over 80%. Compare this to EA3 of tumble mustard under 20%, yellow salsify under 40% and prickly lettuce under 80% (Figure 10). EA3 had a higher percent frequency for all species partially due to the lower weed competition. There is probably a soil type effect as well as EA3 soils are Warden silt loam and EA2 are Royal loamy fine sands.

Another potential for low percent frequency for all but the Sandberg bluegrass could be the range drill itself. Bluebunch wheatgrass and bottlebrush squirreltail are drill seeded, whereas Sandberg bluegrass is broadcast seeded. The Truax range drill plants at a depth of ¾" to 1" which is deeper than the optimal planting depth of ¼ to ½" for most native seeds. As the Sandberg bluegrass is broadcast it remains closer to the surface and this may be the reason that it has been the most successful species. We plan to modify the planters to reduce the depth for future seeding efforts.

## 4.2 Native Forb and Shrub Plug Planting

After one growing season, plug survival varied dramatically by species. Practically no bitterbrush plugs survived one growing season. Monitoring data suggests bitterbrush plugs survived initial transplanting shock but began to rapidly die during the growing season (April-May), potentially because of competition with cheatgrass. Increased site preparation, including soil scalping and herbicide treatment to control cheatgrass may improve plug survival.

Sagebrush plugs largely survived one growing season after the February 2016 planting. Sagebrush mortality appeared to slow drastically after initial transplanting, and appears somewhat stable at around 67% on the final March 2017 evaluation. In December 2016/ March 2017 planting, many sagebrush plugs were already withered from mold attack, suggesting initial sagebrush mortality may be driven by plugs largely succumbing to mold before being planted. The harsh winter amplified the low survival and by March 2018 percent survival was around 8%.

Yarrow plug establishment was very successful. However, initially locating monitored yarrow plugs was difficult because the plugs were flagged well after planting. In most yarrow plots, between 75-90% of monitored plugs were found. Depending on the fate of the missing plugs (i.e. already dead, alive but not found, or never planted), practically all yarrow plugs may have survived one growing season, though even the low survival estimate was higher than bitterbrush or sagebrush. Previous plug planting on the Boardman Conservation Area also found high levels of success for yarrow plugs (Cahill 2016). Because yarrow plugs are so successful, it may be worth investigating how successfully yarrow germinates from seed.

## 4.3 Summary

Although the areas were treated with a glyphosate treatment prior to planting, this is not enough to maintain good weed control post planting. The practice of seeding and planting forbs over the seeded area the same season, makes weed control difficult since herbicides can no longer be used without injuring or killing the newly planted forbs. Future restoration effort may involve establishing the grass seed first for at least 1 year or longer depending on weed control. Then once the native grasses have become established, planting the forbs. This would potentially involve longer cycles for the cooperative agreements, as it is difficult to have successful restoration in 2 years. If weeds are not controlled, restoration is likely to fail.

The most successful species were Sandberg bluegrass, common yarrow, and sagebrush. Antelope bitterbrush remains to be the most challenging to establish. This is consistent to previous restoration efforts.

## 5. Literature Cited

Cahill, M.C. (2016) 10 Year Comprehensive Report of McIntyre Holding and The Field Restoration Efforts at the Boardman Conservation Area: 2006-2016. *Unpublished report.*

U.S. Navy (2014) Cooperative Agreement between the U.S. Department of the Navy and The Nature Conservancy. C.A. N44255-14-2-0008

U.S. Navy (2016) Cooperative Agreement between the U.S. Department of the Navy and The Nature Conservancy. C.A. N44255-16-2-0008

U.S. Navy (2012) Integrated Natural Resources Management Plan for Naval Weapons Systems Training Facility Boardman.

## Figures

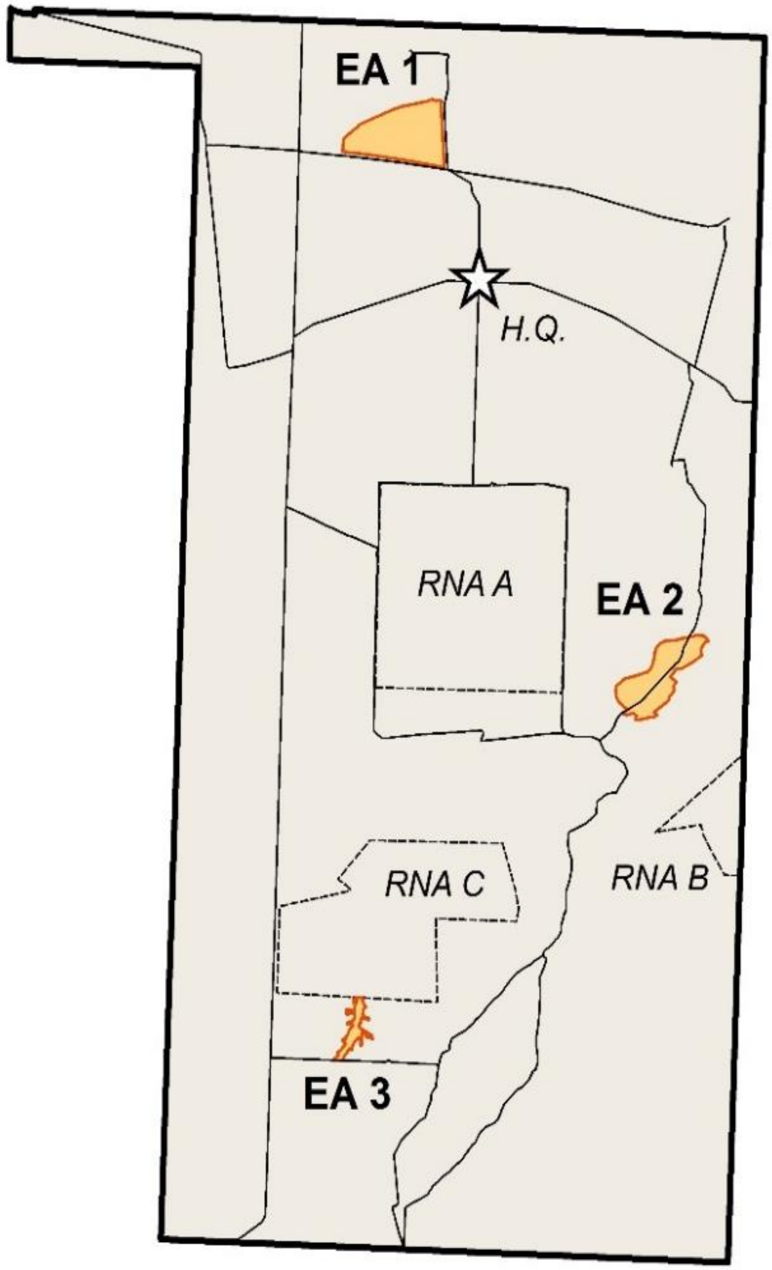



Figure 1. Location of enhancement areas (EA), research natural areas (RNA), and headquarters (H.Q.) on NWSTF.

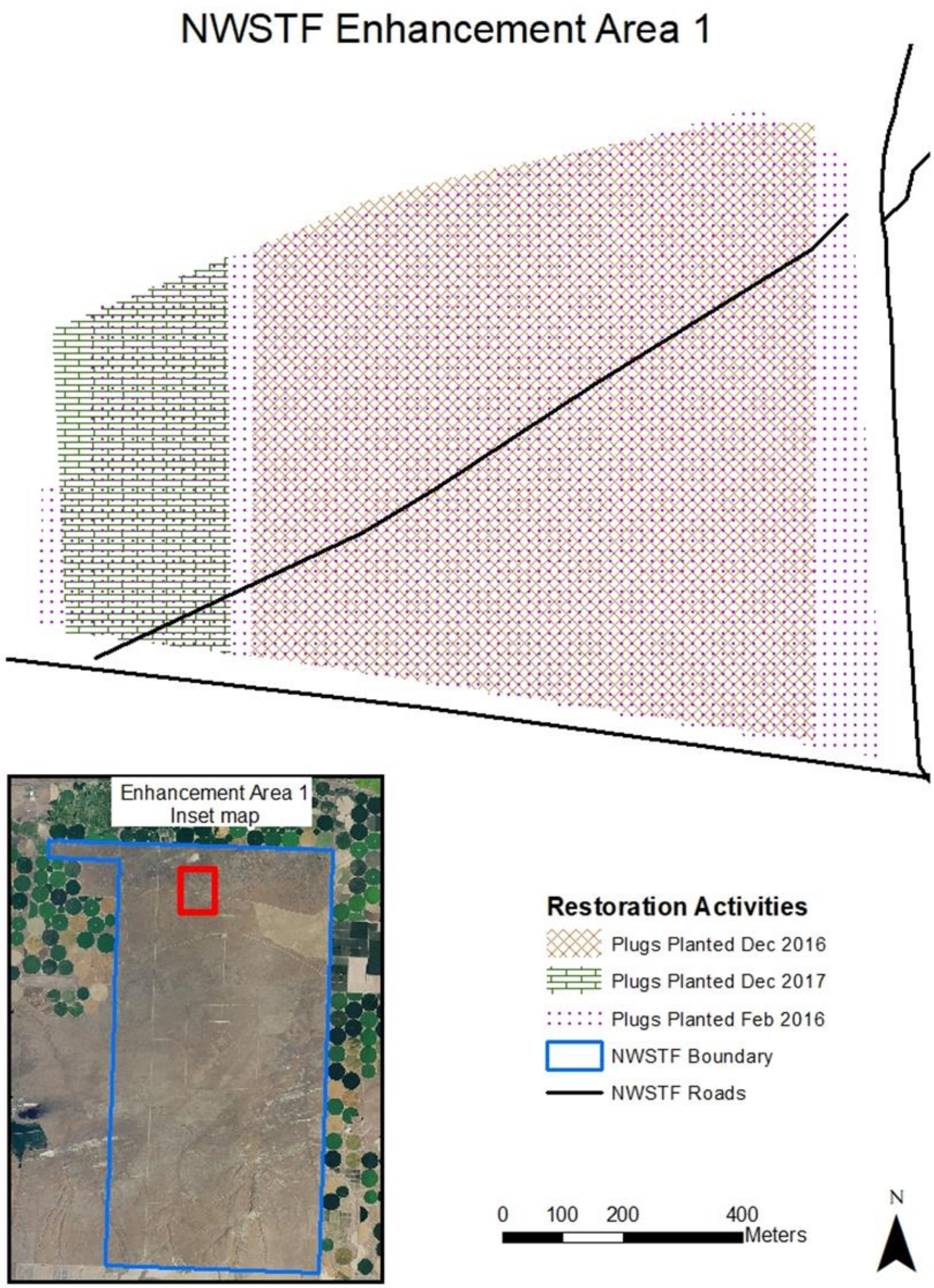



Figure 2. Restoration Activities for Enhancement Area 1. In 2017, 950 bitterbrush plugs were planted in the western portion. Planting areas are overlapped due to the low observed survival in the initial planting (February 2016).

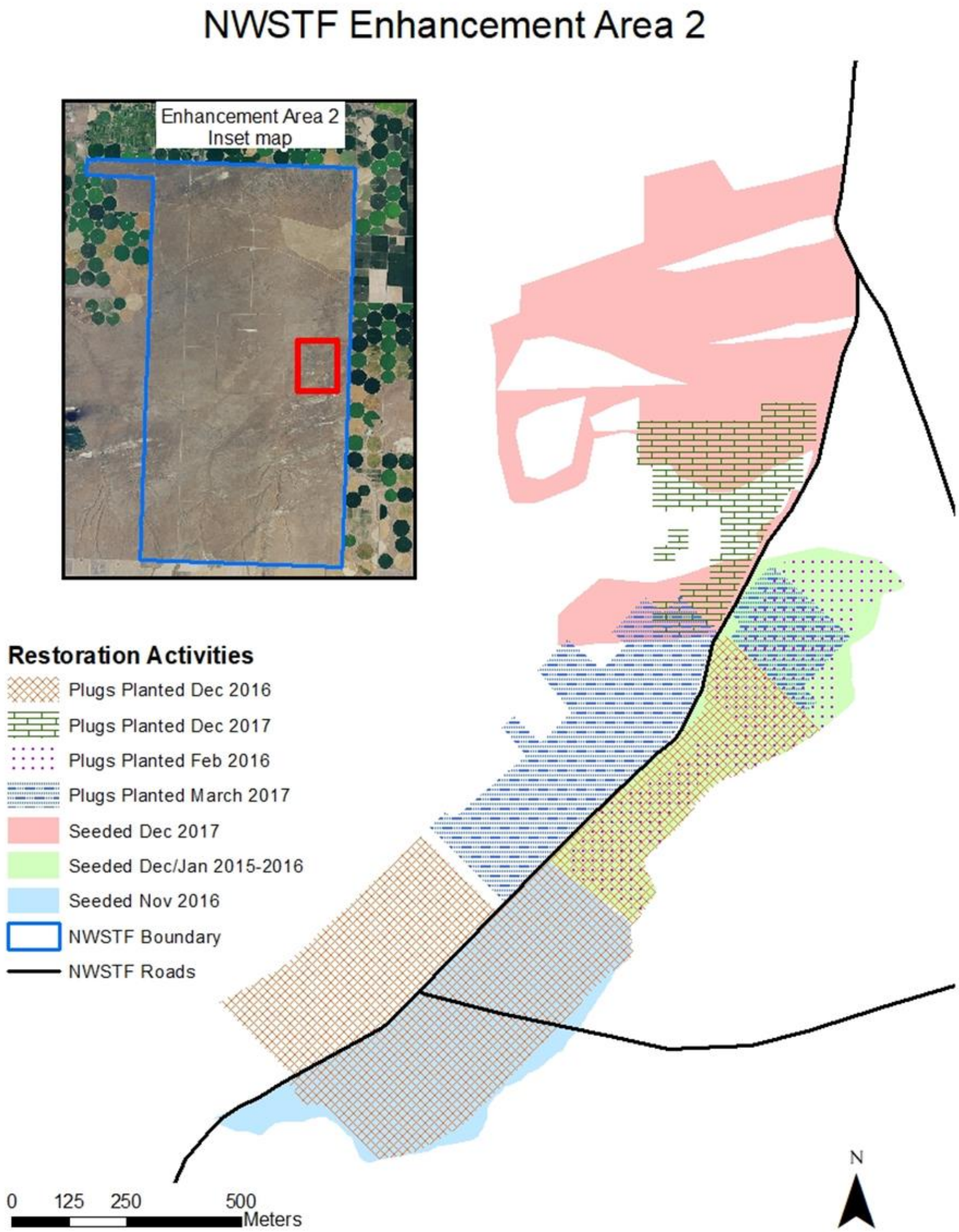



Figure 3. Restoration Activities for Enhancement Area 2. Habitat enhancement plantings, including both seeding and forb and shrub plug planting, occurred to the north of prior year planting efforts in Enhancement Area 2. This area was affected by the October 2017 wildfire. The 2017 seeding area is discontinuous due to the hummocky terrain and limitations of the rangeland drill. All restoration activity Northwest of the road is covered under this agreement.

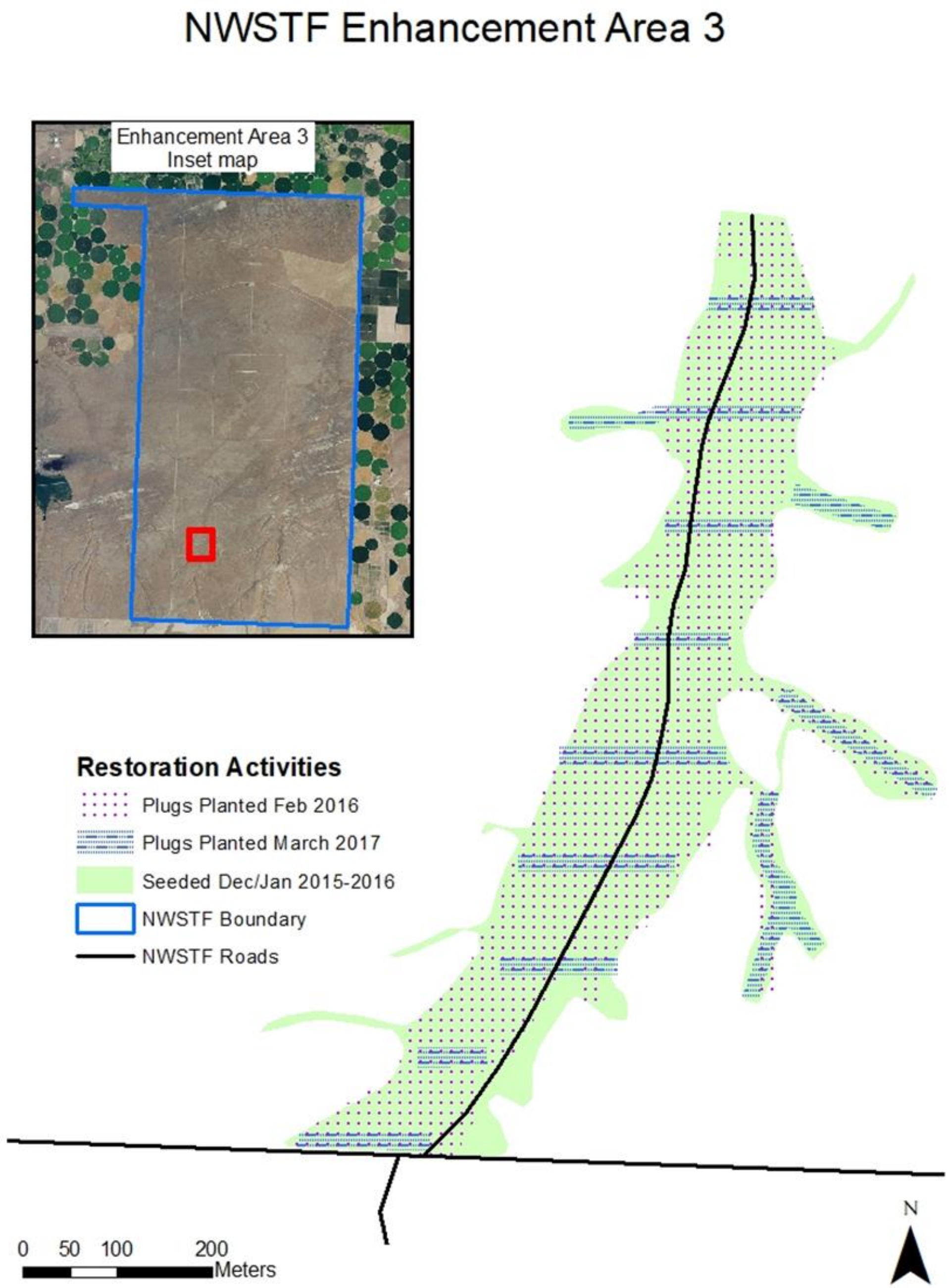



Figure 4. Restoration Activities for Enhancement Area 3. No planting occurred in EA 3 in December of 2017, however monitoring of seeded areas were completed.

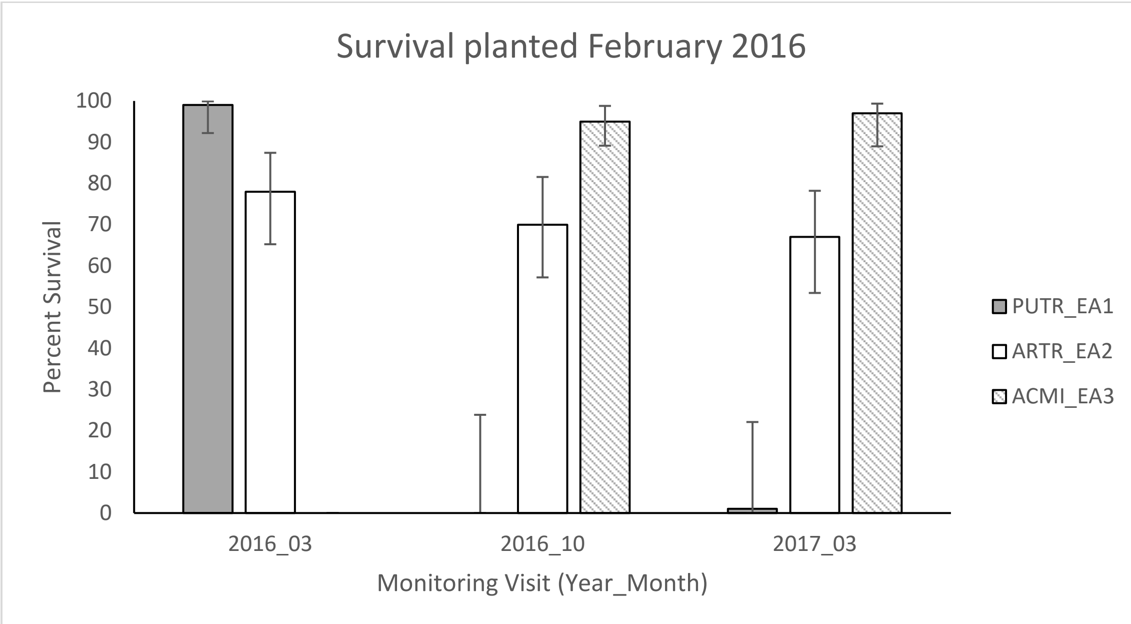



Figure 5. Survivorship of monitored shrub and forb plugs planted in February 2016 under CA N44255-14-2-0008 in various EA units. EA=enhancement area (planting site), PUTR = *Purshia tridentata*/ antelope bitterbrush, ARTR = *Artemisia tridentata*/ sagebrush, ACMI = *Achillea millefolium*/ common yarrow. Error bars represent 90% CI.

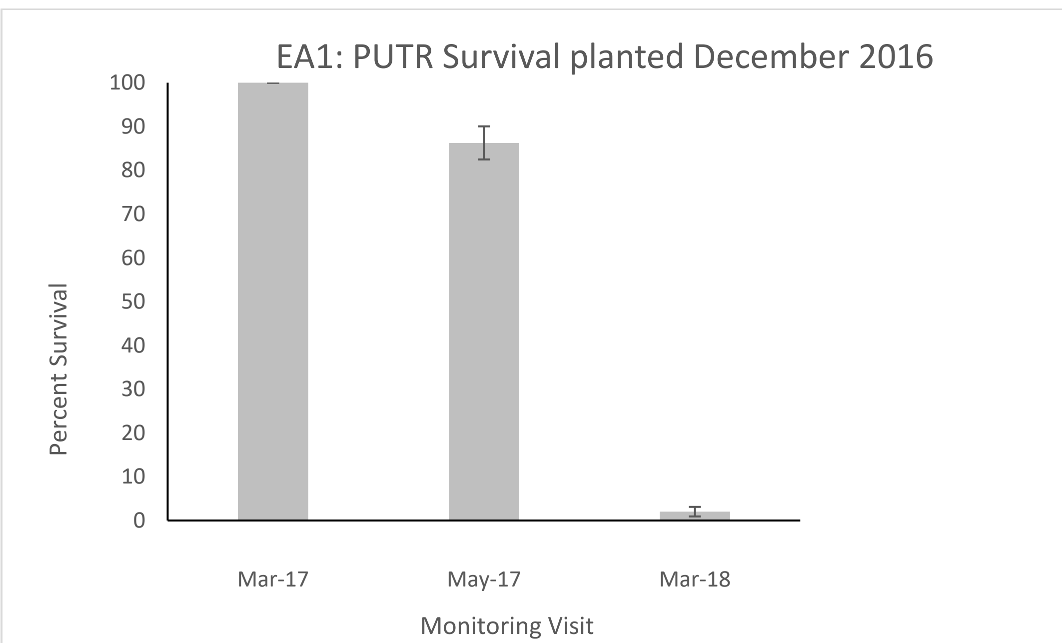



Figure 6. Survivorship of PUTR= *Purshia tridentata* / antelope bitterbrush planted December 2016 in EA1 under CA N44255-14-2-0008. The October 2017 visit was not completed. Error bars represent 90% CI.

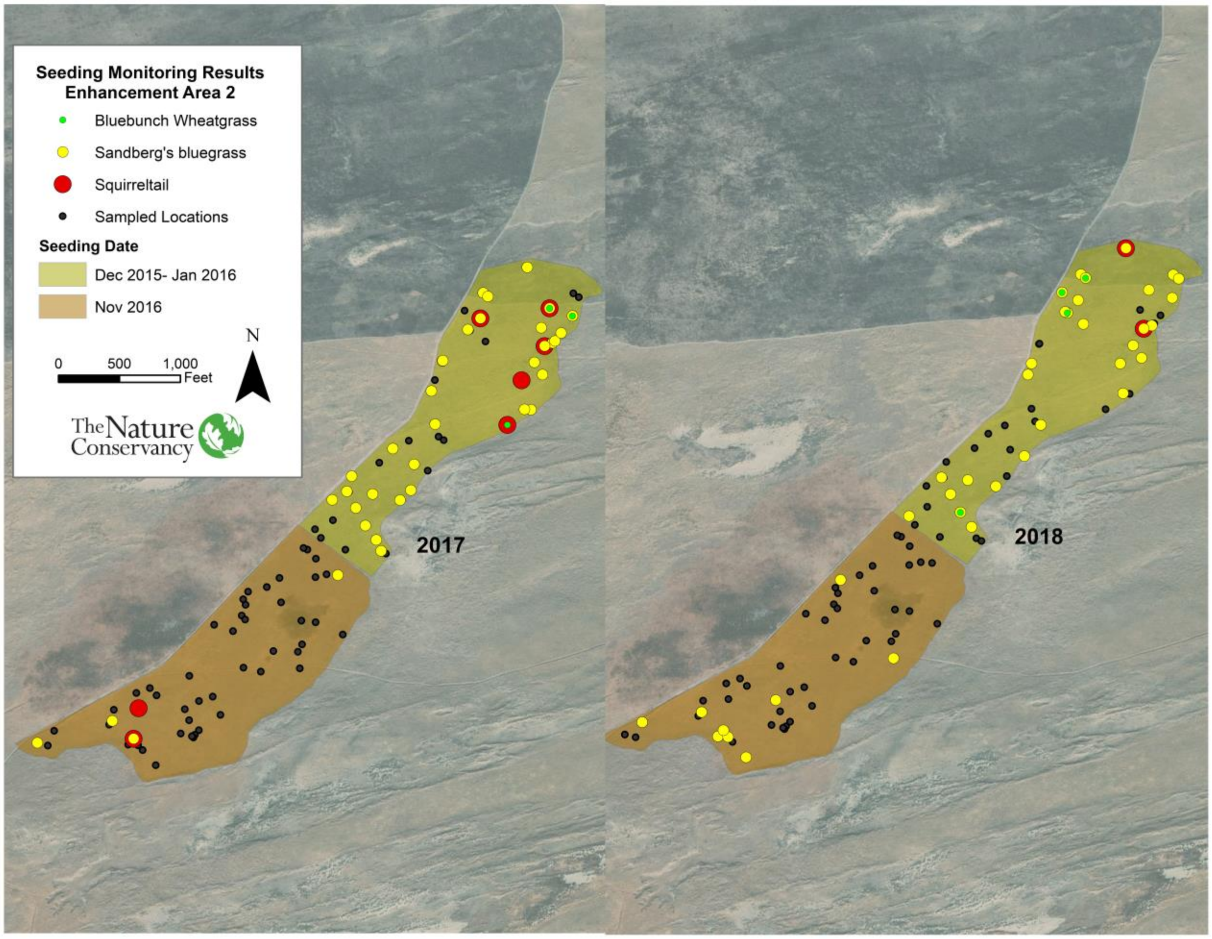



Figure 7. Grass seed monitoring results for Enhancement Area 2. Grass seeding effectiveness varied spatially and by species within each planting site. Detection and identification may have been hampered by the small stature of the seedlings for the 2017 monitoring effort. However, even the 2nd season monitoring in 2018 resulted in a low distribution of Bluebunch wheatgrass and squirreltail. Sandberg bluegrass was widespread throughout the December 2015 planting in EA2.

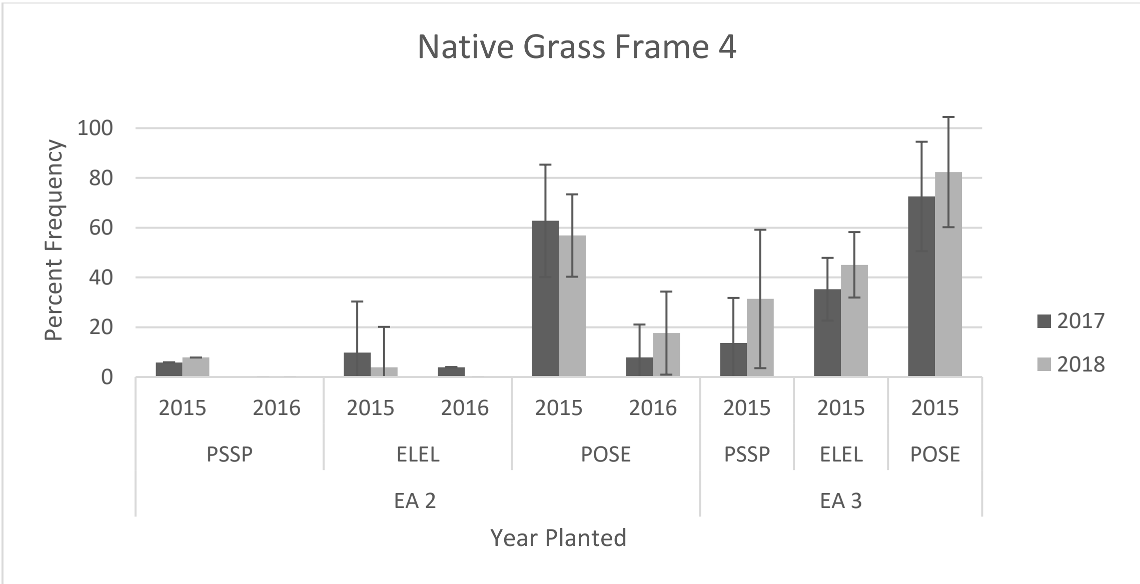



Figure 8. Percent Frequency of Native Grass in EA2 and EA3. Grass seeding effectiveness varied among sites, species, and planting dates. Sandberg bluegrass was well represented in both enhancement areas two years post planting. Frame size = nested frequency sampling frame. PSSP = *Pseudoroegneria spicata*/ bluebunch wheatgrass, POSE = *Poa secunda*/ Sandberg bluegrass, ELEL = *Elymus elymoides*/ bottlebrush squirreltail. Error bars represent 90% CI.

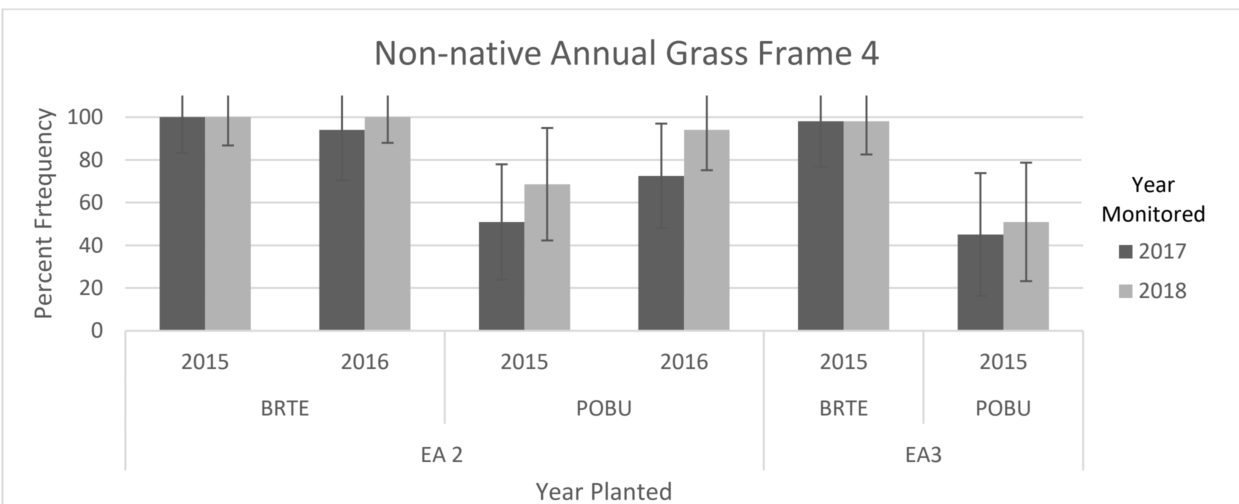



Figure 9. Percent frequency of non-native annual grasses in EA 2 and EA3. Year planted is the year native grasses were planted. Frame size = nested frequency sampling frame. Enhancement Area (EA), BRTE= *Bromus tectorum*/ cheatgrass, POBU= *Poa bulbosa/* bulbous bluegrass. Error bars represent 90% CI.

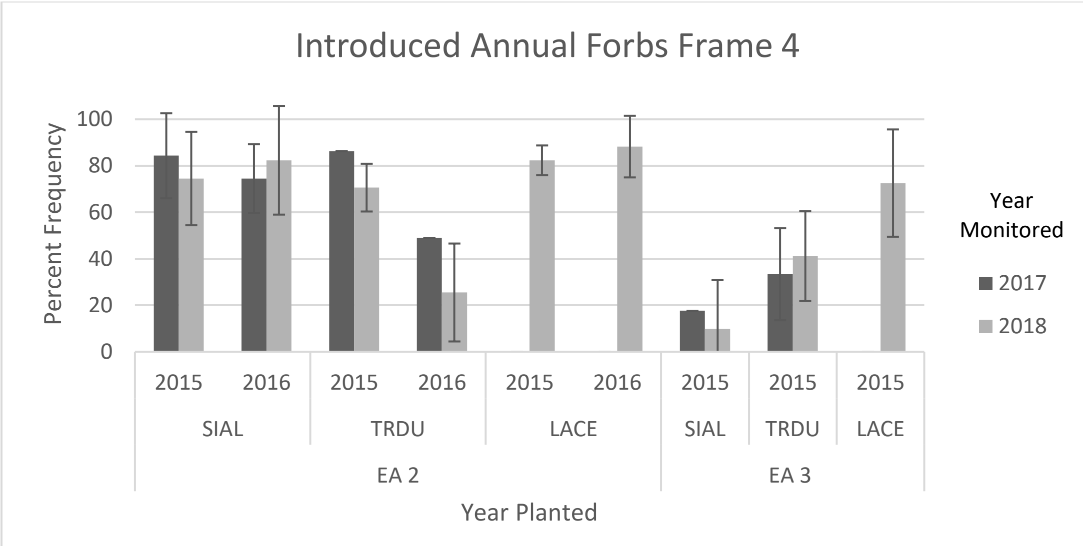



Figure 10. Percent frequency of introduced annual forbs in EA2 and EA3. Year planted is the year native grasses were planted. Frame size = nested frequency sampling frame. SIAL= Sisymbrium altissimum/ Tumble mustard, TRDU= *Tragopogon dubius* /Yellow Salsify, LACE= *Lactuca serriola*/ Prickly Lettuce. Error bars represent 90% CI.

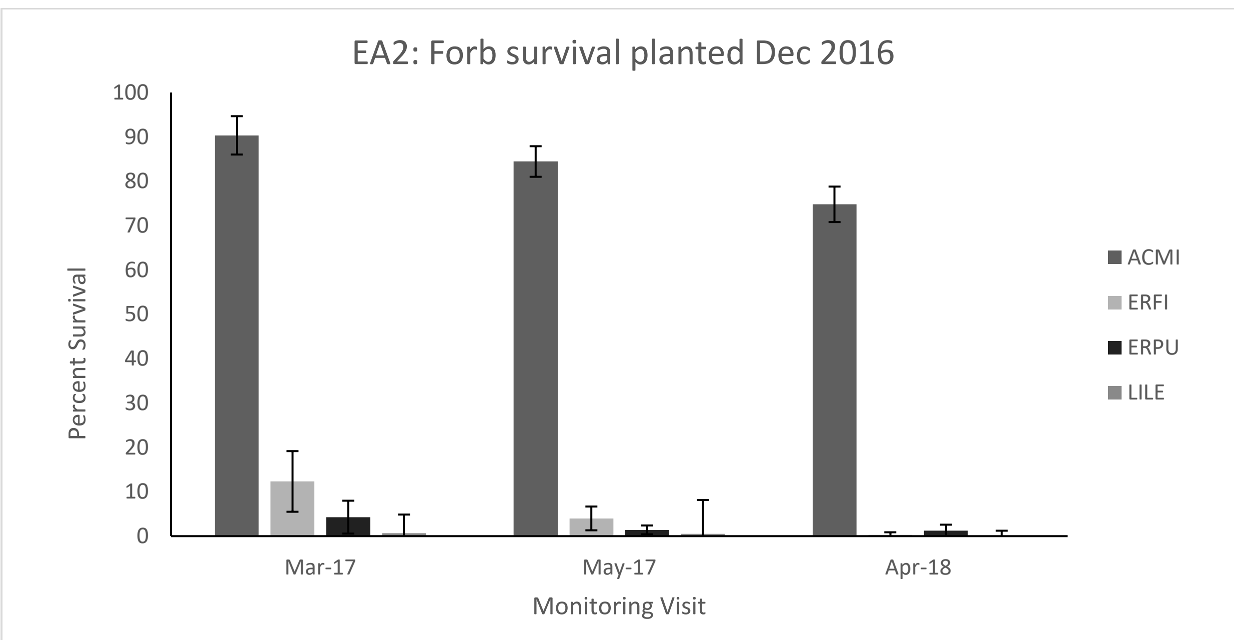



Figure 11. Forb survival for EA2 planted December 2016 for various species.
EA=enhancement area (planting site), ACMI = *Achillea millefolium*/ common yarrow, ERFI = *Erigeron filifolius*/ threadleaf fleabane, ERPU = *Erigeron pumilus*/ shaggy fleabane, LILE = *Linum lewisii*/ Lewis flax. Error bars represent 90% CI.

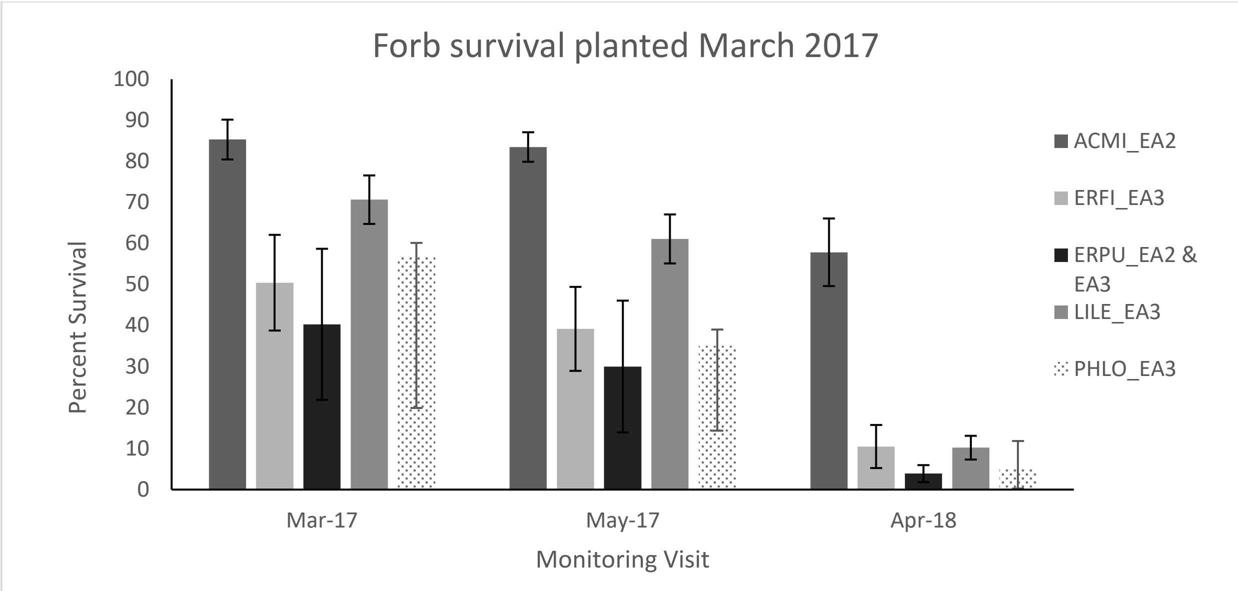



Figure 12. Forb survival planted March 2017 for various species in EA2 and EA3. ERPU are the combined results from EA2 and EA3. EA=enhancement area (planting site), ACMI = *Achillea millefolium*/ common yarrow, ERFI = *Erigeron filifolius*/ threadleaf fleabane, ERPU = *Erigeron pumilus*/ shaggy fleabane, LILE = *Linum lewisii*/ Lewis flax. Error bars represent 90% CI.

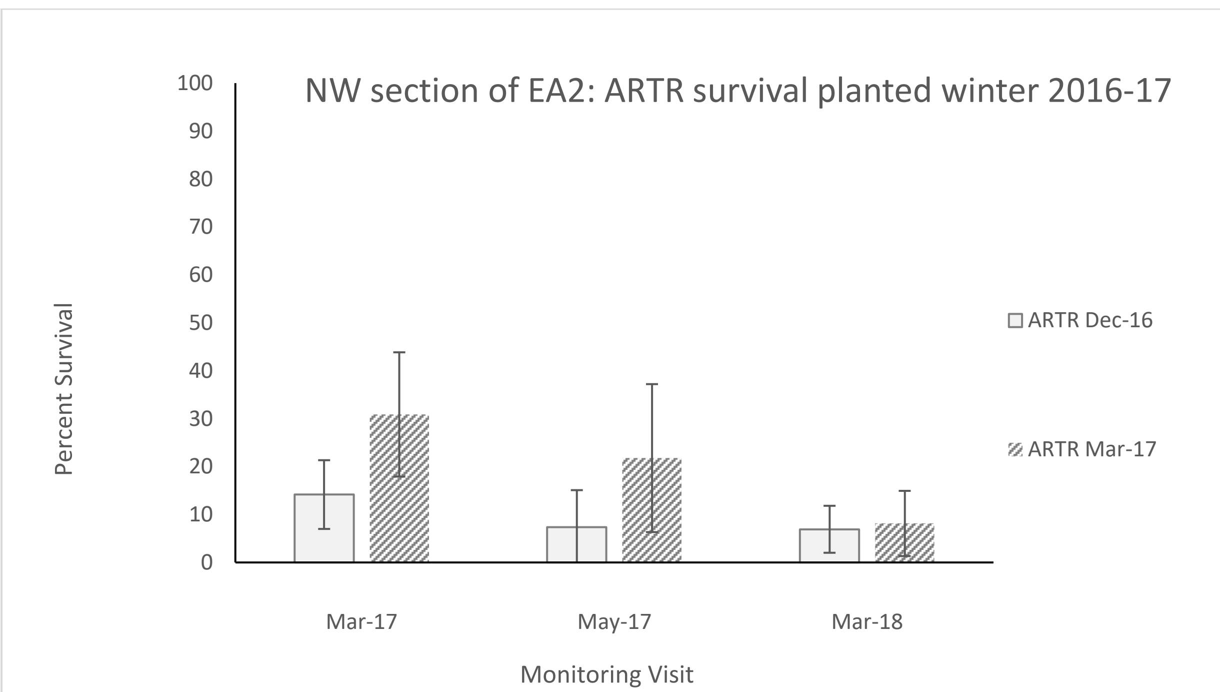



Figure 13. Survivorship of ARTR = *Artemisia tridentata*/ big sagebrush in EA2 for N44255-16-2-0008. 2800 ARTR were planted in December 2016 and then due to harsh weather delaying planting, 4020 ARTR were planted in March 2017. Error bars represent 90% CI.

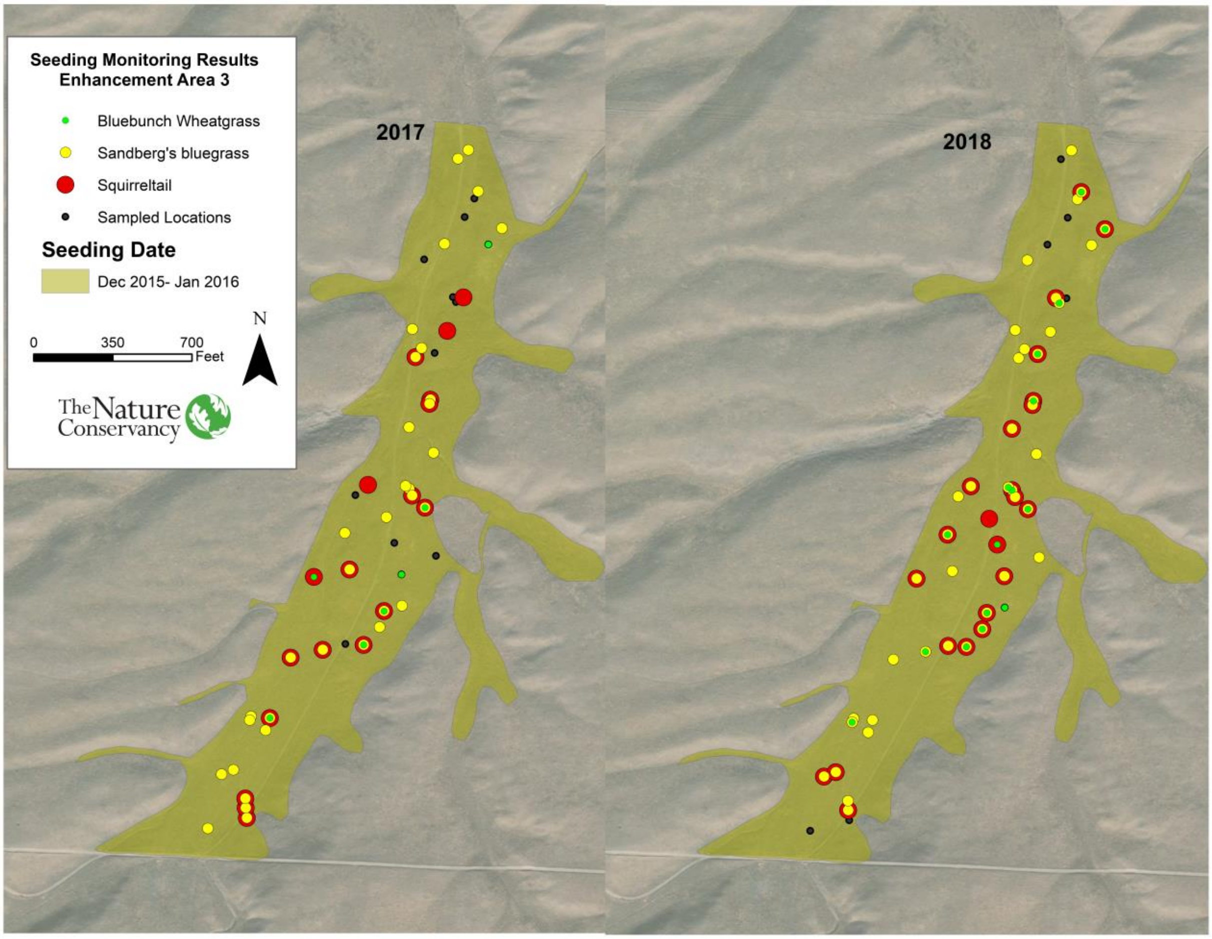



Figure 14 Grass seed monitoring results for Enhancement Area 3. In EA3, 2 and 3 growing seasons post planting, Sandberg bluegrass and bottlebrush squirreltail were distributed throughout the planting area during both 2017 and 2018. However, bluebunch wheatgrass was not widespread in 2017 but increased distribution by 2018.

# Appendices

## Appendix A

**NWSTF Native Grass Seeding Monitoring Protocols**

**Objective:** Evaluate frequency of established seedlings in three different seeded areas on NWSTF Boardman.

**Equipment:**

- 50m metric field measuring tapes (at least 2).
- iPad with relevant Excel field datasheet downloaded (1 per person).
- Nested frequency frame with $1m^2$, $1/10^{th}m^2$, $1/100^{th}m^2$, $1/1000^{th}m^2$ sections (1 per person)
- Compass (1 per person)
- Flexiglass poles (for sighting transects)
- Personal field equipment (Food, water, sunscreen, sunglasses, etc.)

**Protocol:**

*General Survey Protocol:* TNC field staff will monitor selected species' frequency along transects for each seeding location. Staff will use nested frequency frames and record the presence of each selected species in each frame using the number (1, 2, 3, or 4) that corresponds to the smallest nested section containing any basal area of any individual. Assign 1 for the $1/1000^{th}m^2$ section, 2 for the $1/100^{th}m^2$ section, 3 for the $1/10^{th}m^2$ section and 4 for the $1m^2$ section. Species found in a given frame are assumed to be present in all larger frames (e.g. a plant found in "2" is assumed present in "3" and "4"). The best fit frame for each species will be the one with a frequency closest to 50%.

Sampled species include:

Bluebunch Wheatgrass (*Pseudoroegneria spicata*)
Bottlebrush Squirreltail (*Elymus elymoides*)
Sandberg Bluegrass (*Poa secunda*)
Cheatgrass (*Bromus tectorum*)
Bulbous Bluegrass (*Poa bulbosa*)
Tumblemustard (Sisymbrium altissimum)
Yellow Salsify (Tragopogon dubius)
Prickly Lettuce (Lactuca serriola)
Russian Thistle (Salsola tragus)

Sampling Literature Guidance:

1. Heywood, J.S. & M.D. Debacker, (2007) *Optimal sampling designs for monitoring plant frequency.* Journal of Rangeland Ecology and Management. 60:426-434

"For managers who wish to include frequency plots in their monitoring protocol, 3 recommendations for maximizing statistical efficiency emerge from this study: 1) a plot size that returns a mean frequency close to 50% is nearly optimal over a broad range of values for the magnitude of spatial structure; 2) frequency plots within the same site (often located along transects) should be dispersed over as large an area as possible; and 3) study sites, but not individual frequency plots, should be permanently marked and resampled over time."

**EA2 – Lower Juniper Canyon**

*Grass Seeding Monitoring Locations*

In both the first (Dec. 15) and second (Nov. 16) seeding areas at EA2, 51 randomly located monitoring points need to be visited and the same frequency data recorded. To locate the points, use the ArcGIS Online Map called "NWSTF_Grass_Seeding_Monitoring" and then enter data in the excel sheet "NWSTF_Monitoring_GrassSeeding_Datasheet" under the "Seeding_Areas" tab. In total, 102 sites need to be visited, 51 for each seeding. There are enough monitoring sites to construct a 90% C.I. +/-10%.

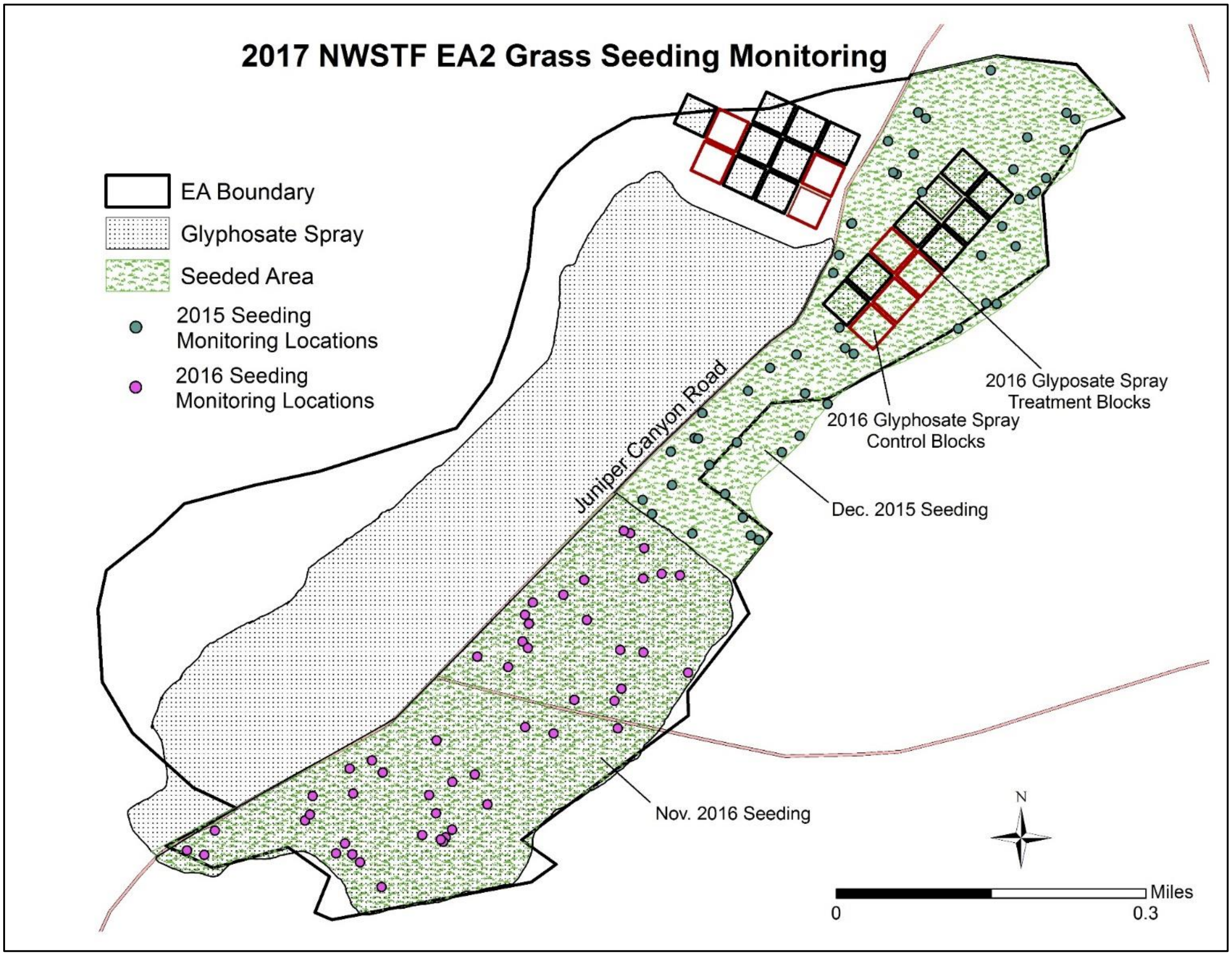
At each random point, blindly throw a pin flag straight up into the air. Where the pin flag lands is where you should put the corner of the frequency frame with the nested portions, and the direction of the frame should follow the pin flag shaft.

**EA3**

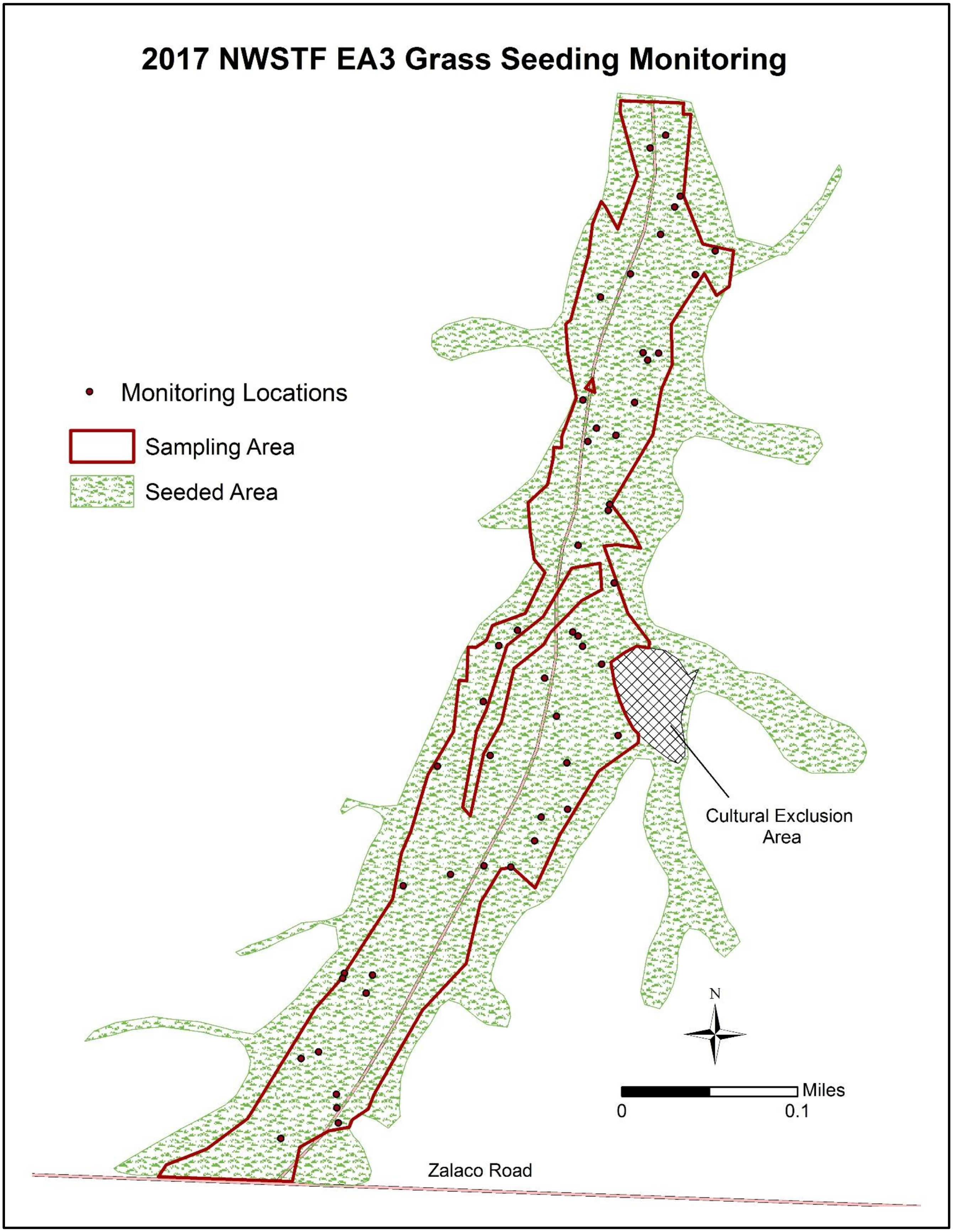
*Grass Seeding Monitoring Locations*

As with the grass seeding monitoring on EA2, there are 51 randomly located monitoring points that need to be visited and the same frequency data recorded. To locate the points, use the ArcGIS Online Map called "NWSTF_Grass_Seeding_Monitoring" and then enter data in the excel sheet "NWSTF_Monitoring_GrassSeeding_Datasheet" under the "Seeding_Areas" tab. The sampling area for EA3 was restricted to all seeded areas with less than a 2% slope and at least 3m from a road to have a homogenous sampling area. There are enough monitoring sites to construct a 90% C.I. +/-10%.

At each random point, blindly throw a pin flag straight up into the air. Where the pin flag lands is where you should put the corner of the frequency frame with the nested portions, and the direction of the frame should follow the pin flag shaft.



2017 NWSTF EA2 Grass Seeding Monitoring
EA Boundary
Glyphosate Spray
Seeded Area
2015 Seeding Monitoring Locations
2016 Seeding Monitoring Locations
Juniper Canyon Road
2016 Glyposate Spray Treatment Blocks
2016 Glyphosate Spray Control Blocks
Dec. 2015 Seeding
Nov. 2016 Seeding
N
Miles
0
0.3


2017 NWSTF EA3 Grass Seeding Monitoring
Monitoring Locations
Sampling Area
Seeded Area
Cultural Exclusion Area
N
Miles
0
0.1
Zalaco Road

## Appendix B

**<u>NWSTF Shrub and Forb Plug Monitoring Protocol</u>**

**Purpose**: Steps for monitoring the NWSTF restoration shrub and forb plug plantings.

**Equipment**: 1 Trimble GPS (each person)

1 Hand counter (each person)

1 Can of spray paint (each person)

1 Set of printed EA maps (each Crew Member, optional for Crew Lead)

1 Extra bundle of 20 pin flags, preferably blue (each person, as needed for replacements flags)

1 Cell phone w/ service and/or hand-held radio for communication (each person)

Extra charged Trimble batteries, relevant car-charging cables

Personal supplies of food, water, sunscreen, sunglasses, relevant clothing, etc.

**Office Prep: Confirm the appropriate maps are downloaded on the Juno's and they are fully Charged.**

*General Monitoring Protocol:*

The intent of restoration monitoring is to track initial establishment of the plants. After each restoration event forbs will be monitored 3 times; March, May, and again in March of the following year. Shrubs will be monitored 4 times, adding an additional fall monitoring; March, May, October, and again in March of the following year.

For each planting (species and year) at each enhancement area, crew members will visit a certain number of randomly selected monitoring plots. The monitoring plots have already been selected before planting took place. At each plot, count the number of flags (ideally there should be 20 in 5x5m plots and 60 in 10x10m plots) and the number of live plants.

For forb species, also count the number in flower or showing signs of flowering in the current growing season. Results and comments from the previous monitoring round are included in each layer for reference. The hand counter and spray paint are to help you keep track of counting, which can be difficult especially in the 10x10m plots with 60 plants. Use them as works best for you. Only count plants that are flagged. If the flag is severely weathered (or missing but the plant is obviously a planted plug, not a natural recruit) please replace the flag, but only for plugs that will be monitored again the following year.

Enter the number of live plants found into the appropriate field, typically named "*Y201#_Alive*". Make a note in the comment field if the total number of plants found (dead + live) differs from the number that was to be planted, i.e. 60. For example, if it is a 10x10 plot and was supposed to have 60 plugs but you count 50 alive and 55 total flagged plugs then make a note "found 55" in the comment field for the corresponding year.

When all the plots are finished save and close the map. Make sure one person is responsible for uploading the data back at the office and confirming all the necessary plots were monitored.

# Appendix A

**NWSTF Native Grass Seeding Monitoring Protocols**

**Objective:** Evaluate frequency of established seedlings in three different seeded areas on NWSTF Boardman.

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**Protocol:**

General Survey Protocol: TNC field staff will monitor selected species' frequency along transects for each seeding location. Staff will use nested frequency frames and record the presence of each selected species in each frame using the number (1, 2, 3, or 4) that corresponds to the smallest nested section containing any basal area of any individual. Assign 1 for the $1/1000^{th}m^2$ section, 2 for the $1/100^{th}m^2$ section, 3 for the $1/10^{th}m^2$ section and 4 for the $1m^2$ section. Species found in a given frame are assumed to be present in all larger frames (e.g. a plant found in "2" is assumed present in "3" and "4"). The best fit frame for each species will be the one with a frequency closest to 50%.

Sampled species include:

Bluebunch Wheatgrass (Pseudoroegneria spicata)
Bottlebrush Squirreltail (Elymus elymoides)
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Cheatgrass (Bromus tectorum)
Bulbous Bluegrass (Poa bulbosa)
Tumblemustard (Sisymbrium altissimum)
Yellow Salsify (Tragopogon dubius)
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Russian Thistle (Salsola tragus)

Sampling Literature Guidance:

1. Heywood, J.S. & M.D. Debacker, (2007) *Optimal sampling designs for monitoring plant frequency.* Journal of Rangeland Ecology and Management. 60:426-434

"For managers who wish to include frequency plots in their monitoring protocol, 3 recommendations for maximizing statistical efficiency emerge from this study: 1) a plot size that returns a mean frequency close to 50% is nearly optimal over a broad range of values for the magnitude of spatial structure; 2) frequency plots within the same site (often located along transects) should be dispersed over as large an area as possible; and 3) study sites, but not individual frequency plots, should be permanently marked and resampled over time."

**EA2 – Lower Juniper Canyon**

*Grass Seeding Monitoring Locations*

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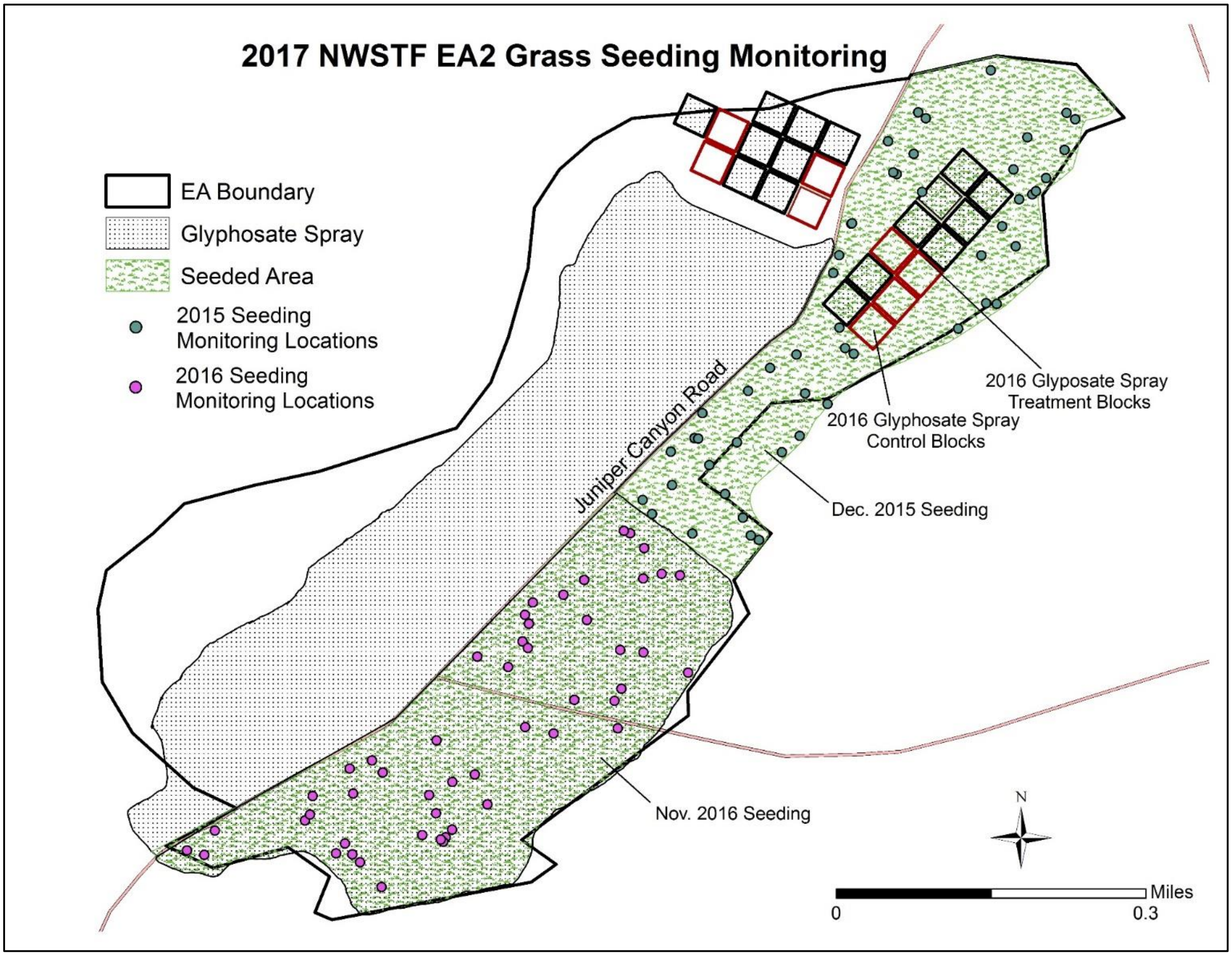
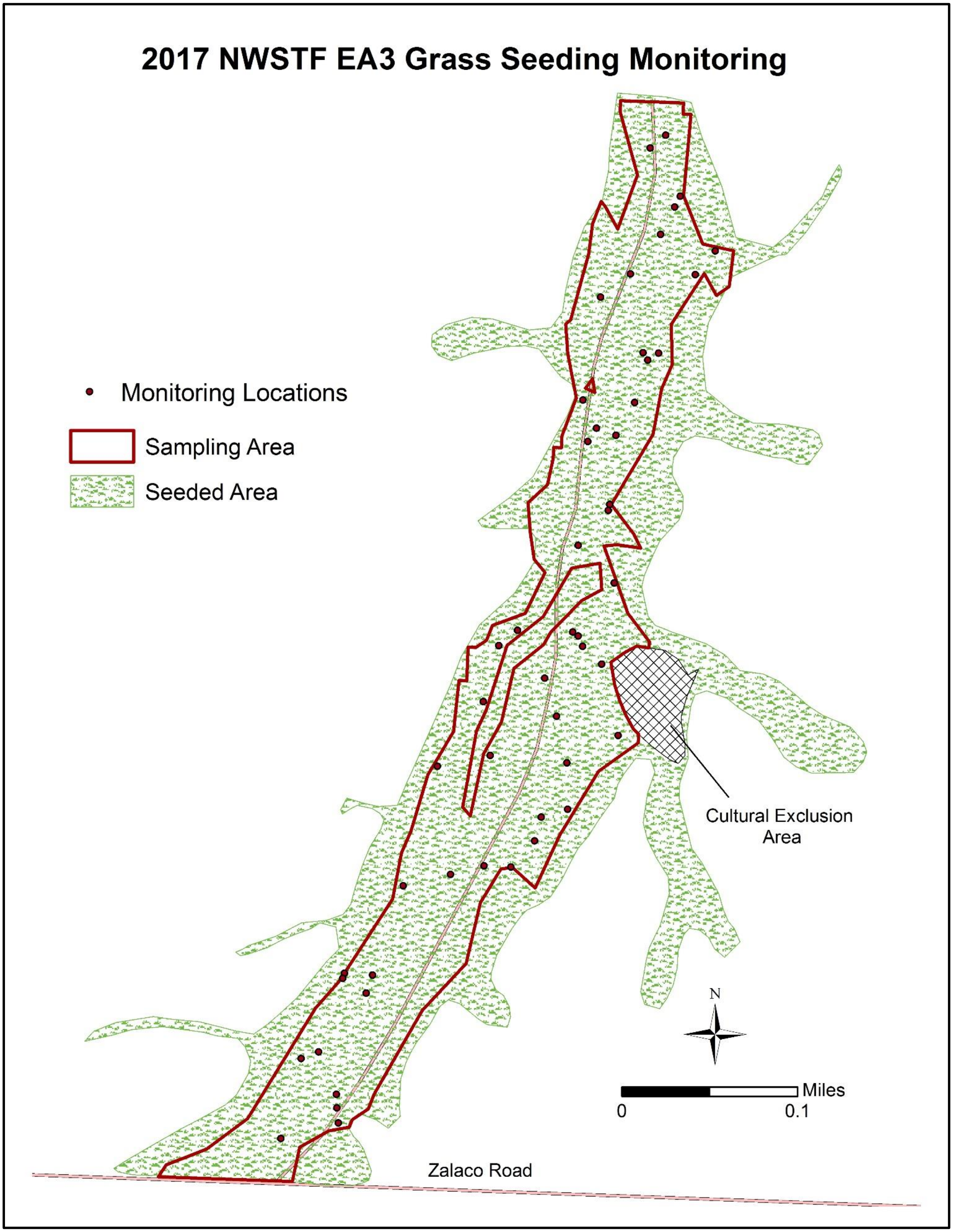
**EA3**

*Grass Seeding Monitoring Locations*

As with the grass seeding monitoring on EA2, there are 51 randomly located monitoring points that need to be visited and the same frequency data recorded. To locate the points, use the ArcGIS Online Map called "NWSTF_Grass_Seeding_Monitoring" and then enter data in the excel sheet "NWSTF_Monitoring_GrassSeeding_Datasheet" under the "Seeding_Areas" tab. The sampling area for EA3 was restricted to all seeded areas with less than a 2% slope and at least 3m from a road to have a homogenous sampling area. There are enough monitoring sites to construct a 90% C.I. +/-10%.

At each random point, blindly throw a pin flag straight up into the air. Where the pin flag lands is where you should put the corner of the frequency frame with the nested portions, and the direction of the frame should follow the pin flag shaft.


2017 NWSTF EA2 Grass Seeding Monitoring
EA Boundary
Glyphosate Spray
Seeded Area
2015 Seeding Monitoring Locations
2016 Seeding Monitoring Locations
Juniper Canyon Road
2016 Glyposate Spray Treatment Blocks
2016 Glyphosate Spray Control Blocks
Dec. 2015 Seeding
Nov. 2016 Seeding
N
Miles
0
0.3


2017 NWSTF EA3 Grass Seeding Monitoring
Monitoring Locations
Sampling Area
Seeded Area
Cultural Exclusion Area
N
Miles
0
0.1
Zalaco Road

## Appendix B

**NWSTF Shrub and Forb Plug Monitoring Protocol**

**Purpose**: Steps for monitoring the NWSTF restoration shrub and forb plug plantings.

**Equipment**: 1 Trimble GPS (each person)

1 Hand counter (each person)

1 Can of spray paint (each person)

1 Set of printed EA maps (each Crew Member, optional for Crew Lead)

1 Extra bundle of 20 pin flags, preferably blue (each person, as needed for replacements flags)

1 Cell phone w/ service and/or hand-held radio for communication (each person)

Extra charged Trimble batteries, relevant car-charging cables

Personal supplies of food, water, sunscreen, sunglasses, relevant clothing, etc.

**Office Prep: Confirm the appropriate maps are downloaded on the Juno's and they are fully Charged.**

*General Monitoring Protocol:*

The intent of restoration monitoring is to track initial establishment of the plants. After each restoration event forbs will be monitored 3 times; March, May, and again in March of the following year. Shrubs will be monitored 4 times, adding an additional fall monitoring; March, May, October, and again in March of the following year.

For each planting (species and year) at each enhancement area, crew members will visit a certain number of randomly selected monitoring plots. The monitoring plots have already been selected before planting took place. At each plot, count the number of flags (ideally there should be 20 in 5x5m plots and 60 in 10x10m plots) and the number of live plants.

For forb species, also count the number in flower or showing signs of flowering in the current growing season. Results and comments from the previous monitoring round are included in each layer for reference. The hand counter and spray paint are to help you keep track of counting, which can be difficult especially in the 10x10m plots with 60 plants. Use them as works best for you. Only count plants that are flagged. If the flag is severely weathered (or missing but the plant is obviously a planted plug, not a natural recruit) please replace the flag, but only for plugs that will be monitored again the following year.

Enter the number of live plants found into the appropriate field, typically named "*Y201#_Alive*". Make a note in the comment field if the total number of plants found (dead + live) differs from the number that was to be planted, i.e. 60. For example, if it is a 10x10 plot and was supposed to have 60 plugs but you count 50 alive and 55 total flagged plugs then make a note "found 55" in the comment field for the corresponding year.

When all the plots are finished save and close the map. Make sure one person is responsible for uploading the data back at the office and confirming all the necessary plots were monitored.

# Final Report

# Survey of Endangered / Threatened Plant Species

# Naval Weapons Special Training Facility

***Astragalus succumbens***

### Submitted to:

Engineering Field Activity, Northwest
Naval Facilities Engineering Command (EFANW)
19917 7th Ave NE
Poulsbo, WA 98370-7570

### Submitted by:

Vision Air Research, Inc.
904 East Washington Street
Boise, Idaho 83712
(208) 841-9566

**AUGUST 4, 2004**

**Final Report**

# Survey of Endangered / Threatened Plant Species

## Survey of Endangered and Threatened Plant Species at Naval Weapons Special Training Facility

***Astragalus sclerocarpus***

## *Submitted to:*

Engineering Field Activity, Northwest
Naval Facilities Engineering Command (EFANW)
19917 7th Ave NE
Poulsbo, WA 98370-7570

## *Submitted by:*

***Vision Air Research, Inc.***
904 East Washington Street
Boise, Idaho 83712
(208) 841-9566
Susan Bernatas, President
Federal ID # 82-0527663
DUNS # 118736292

**August 4, 2004**

# Survey of Endangered / Threatened Plant Species
# Naval Weapons Special Training Facility

## PROJECT SUMMARY

**Vision Air Research, Inc.** was retained to conduct a biological field survey of the Naval Weapons System Training Facility (NWSTF) located near Boardman, Oregon. The survey of this 45,000-acre facility was conducted to update information on all Endangered and Threatened plant species also referred to as special status plant species to meet needs in the Endangered Species Act, Sikes Act and any Cooperative Agreement obligations. We established a list of plant species to search for on the NWSTF by comparing habitat required by the plants listed in the Navy's Request for Proposal and other special status plants tracked by the Oregon Natural Heritage Program (ONHP) with available habitat found on NWSTF. This list was developed and presented in the "Plant Survey Schedule, Scientific Protocol, and Sampling Techniques" work document developed and supplied by Vision Air Research, Inc., and dated November 17, 2002.

Field surveys were conducted in April 17 to May 29, 2003 with additional field surveys conducted June 2 – 4, 2004 to confirm habitat quality in small portions of the NWSTF. Transects were established 0.25 miles or roughly 400 meters apart providing 1 – 5 % coverage of NWSTF. Field biologists walked along the transect meandering as needed to search appropriate habitat for plant species on the list. Course along the transect were tracked using GPS and data loggers. Information on the habitat quality was sampled along the transect by sampling at approximately 3-minute intervals. Vegetation quality of the plot was classified into one of 5 habitat conditions:

- L — Low – Area entirely comprised of exotic species
- ML — Medium Low – Exotic species dominate with native plant species evident
- M — Medium – Area a mix of native plant species and exotic species
- MH — Medium High – Native species dominate but few exotic species present
- H — High – A full component of native grasses with no exotic species present

Since conditions can change within a short distance we used a visual 3 meter radius "plot" for the classification.

Two rare plants, *Astragalus sclerocarpus* (Dalles milkvetch) and *A. succumbens* (crouching milkvetch) were found throughout NWSTF. These plants are on the ONHP List 4 which contains taxa which are of conservation concern but are not currently threatened or endangered. This includes taxa which are very rare but are currently secure, as well as taxa which are declining in numbers. Each of these two rare plant species was handled as a single population because of their distribution. Any attempt to define subpopulations would be largely arbitrary and lacking biologically significance. Two other notable occurrences are *Hymenopappus filifolius filifolius* (Columbia Cut-Leaf) which was reclassified as common during the 2001 Oregon rare plant review has no special plant status, and *Astragalus carcinus* (Jones) Barneby (Buckwheat milkvetch). Although *A. carcinus* is not a rare plant it is a notable collection because it was previously not known from the Oregon side of the Columbia River as indicated by Aarron Liston, Department of Botany & Plant Pathology, Oregon State University, Corvallis.

The vegetation quality on the NWSTF varies from low to high quality based on past disturbance. Although the special status plants located across the NWSTF are found within a continuum of vegetation quality their densities appeared to be lower in habitat classified as low than in habitat classified as high. Fire and subsequent invasion by exotic species reduces habitat quality by reducing the number of native species and the density of those native species. Although most grassland communities evolved with fire, the abundance of exotic species makes fires less desirable today. Fire control and aggressive weed control is recommended particularly after fire. Ground disturbance should be limited. Livestock grazing in this area would require development of water sources. Development of livestock water sources, the salt / supplement blocks, and water tank location would result in large areas of disturbance where additional source of exotic noxious weeds could establish. This would provide an additional seed source of exotic species.

Provided as a result of this survey include:

- Map in jpg format of the rare plant distribution
- Map in jpg format of the habitat quality
- Photos of the two rare plants found on the range in jpg format
- ONHP Element Occurrence form for *Astragalus sclerocarpus* (Dalles milkvetch) and *A. succumbens* (crouching milkvetch). One Oregon Natural Heritage Information Center Rare Plant Field Survey Form is provided for each plant species.
- Excel spreadsheets of plants and geographic positions. Also included on the spreadsheet are the habitat quality data.

## ➢ INTRODUCTION

**Vision Air Research, Inc.** was retained to conduct a biological field survey of the Naval Weapons System Training Facility (NWSTF) near Boardman, Oregon containing 45,000 acres. The project purpose was to update location information for the federal and state threatened and endangered (T/E) and Oregon species of concern occurring within the NWSTF. Special status plants include those defined by the U.S. Fish and Wildlife Service, State of Oregon, Bureau of Land Management or by the Oregon Natural Heritage Program. Categories of special status plants include Endangered, Threatened, Sensitive, and Species of Concern. Quality Threatened and Endangered (T/E) plant surveys are required to meet in needs in the Endangered Species Act, Sikes Act and Cooperative Agreement obligations.

## STUDY AREA

The NWSFT is also referred to as the Boardman Bombing Range on local topographic maps. The NWSFT is located in eastern OR approximately 150 nm southeast of Seattle, 40 nm west of Pendelton, OR, and 20 nm southwest of Hermiston, OR. Elevation is roughly 650 ft. msl. Terrain can be described as gently rolling. Few canyons or draws are found on the NWSTF margins. Juniper Canyon is located in the southeastern corner of the NWSTF. This canyon forms a relatively broad, flat basin with few narrow tributary canyons.

The NWSTF is largely surrounded by areas developed for various agricultural uses. The Boardman Conservation Area is located southwest of Boardman, in northern Morrow County, Oregon, on properties currently under lease by Threemile Canyon Farms from the State of Oregon. The Conservation Area lies within the Palouse Prairie Section of the Columbia Plateau Ecoregion. The Palouse Prairie Section is dominated by sagebrush steppe and Palouse grassland and has undergone extensive changes over the last 150 years. Today more than 55% of grassland habitat and 87% of shrub-steppe habitat in the Section has been lost to agricultural conversion, inundation from hydroelectric development, or urban and industrial development. Habitat loss and fragmentation combined with the reduction in the quality of habitats through introduction of non-native plant species and altered fire regimes threaten the remaining native habitats and species in the region.

The NWSFT has one of the largest stands of Columbia Basin shrub steppe habitat in Oregon. Although the grassland plant communities within the NWSTF are rare, potential for finding T/ E plants are low based on fieldwork conducted on the NWSTF by The Nature Conservancy for the National Natural

Landmark evaluation and years of stewardship activity on the Boardman Conservation Area. The management plan for the Boardman Conservation Area provides:

> *"Together with the Naval Weapons Systems Training Facility, Willow Creek Wildlife Management Area, Horn Butte Curlew Area of Critical Environmental Concern, and private lands to the west, the Boardman Conservation Area is the only remaining significant block of shrub-steppe and Palouse grassland habitat in the Oregon portion of the Palouse Prairie Section of the Columbia Plateau Ecoregion (Saul 2001). Totaling over 70,000 acres, this continuous block of undeveloped habitat supports populations of shrub steppe plants and animals that have been extirpated from or significantly reduced in other areas in the Palouse Section (Ward et al. 2001; Saul et al. 2001) including Washington Ground squirrel, Ferruginous hawks, loggerhead shrike, sage sparrow, burrowing owl, long-billed curlew, and grasshopper sparrow."*

## METHODS

We developed a species list, search protocols and then conducted walking field surveys to search for rare plants having potential to occur on the NWSTF. Data was entered into a GIS for spatial distribution of the species and occurrence by habitat quality.

<u>Species List</u>

We developed a list of rare plants to be surveyed based on review of the list provided in the RFQ/Q, consultation with agency personnel, literature review, and personal experience in the study area (Table 1). Literature included taxonomic keys and the NWSTF conservation plans, species list, and vegetation map. Species status, habitat requirements, description and identifying characteristics, phenology are provided.

Four species were identified as having potential or are known to occur on the NWSTF: *Astragalus collinus var. larentii, A. sclerocarpus, A. succumbens* and *Hymenopappus filifolius filifolius* (refer to Table 1). These plants occupy the *Poa secunda / Stipa comata* community which comprised 40-50% of the NWSTF. Four additional species were included as species to watch for but are highly unlikely to be found on the NWSTF. Four species noted in the RFQ/Q were not included in the list of species to search for because they were determined common during the 2001 rare plant review conducted by the Oregon Natural Heritage Program. In addition, they are not likely found here. These include *Astragalus misellus, A. reventus reventus, Swertia albicalus* , and *Frasaria albicalus*). Although *Hymenopappas filifolius filifolius* is now considered common, this species is known from NWSTF and is rare on the NWSTF. Other species included in the RFQ/Q are not likely found on the NWSTF

***Table 1. Rare plants to be surveyed for on the Naval Weapons Special Training Facility, near Boardman, Oregon. Those likely to occur on the Range are in bold.***

| *Scientific Name* | **Common Name** | **Status *** | **Habitat Requirements** | **Phenology** |
|---|---|---|---|---|
| ***Astragalus collinus var. laurentii*** | Lawerence Milkvetch | SoC/LT/T | Open grassland of the Columbia Basin ecoregion. Rolling hills with deep loess soils. Not sandy soils. Associated species bluebunch wheatgrass, Fescue. Not sagebrush. | Blooms late May to early June. Seed sets begins mid to late June. |
| ***Astragalus sclerocarpus*** | Dalles Milkvetch | na /na / 4 | Sagebrush-steppe from Washington to northeast Oregon along both sides of the Columbia River. Sandy barrens, dunes, dry sites in sagebrush-steppe and lower montane zones of Ponderosa pine. | Blooms April to June<br>Fruits late June-July (?) |
| ***Astragalus succumbens*** | Crouching Milkvetch | na /na / 4 | Sagebrush desert to lower foothills. Drier dunes and sandy soils. Umatilla and Gilliam Counties in Oregon. Found across the NWSTF. | Blooms April to May.<br>Seed set late May to June. |
| ***Hymenopappas filifolius filifolius*** | Columbia Cut-Leaf | None | Found at NWSTF on sandy soils associated with STCO\POSA globally rare plant community. | Flowers in May. |
| *Lupinus oreganus kincaidii (L. sulphureus kincadii)* | Kincaid's Sulfur Lupine | T / T/ 1 | Native upland prairies & open oak woodlands. Willamette Valley with a disjunct population in Lewis Co., Washington. Mesic to slightly xeric soils. | Flowers April - June. Seed set May-July. |
| *Mirabilis macfarlanei* | MacFarlane's Four-O'Clock | LT / LE / 1 | Snake and Imnaha River canyons. Dry open native grassland sites or with scattered shrubs. Steep river canyon slopes to nearly flat. Soils vary from sandy to rocky. | Flowering early May-mid June. Seeds dispersed from mid-June to Mid July. |
| *Stephanomeria malheurensis* | Malheur wire lettuce | LE/ LE/ 1 | Only known from one site in Malheur County. Broad dry hill, on a soil derived from volcanic tuff layered with some limestone. Numbers vary hugely based on precipitation. | Blooms July – Aug; flowers open early morning & close when sun strikes. Seed set is August-Sept. |
| *Sidalcea nelsoniana* | Nelson's Wild Hollyhock<br>Nelson's Checker Mallow | LT / LT/ 1 | Western Hemlock Zone, along streams, meadows & other relatively open areas where prairie or grassland remnants exist, i.e., field edges or fence rows. Associated species: tall fescue, common velvet grass, common rush, oxeye daisy and Canada thistle. | Flowering mid-May through September.<br>Fruits as early as mid-June and as late as mid-October. |

* Federal / Oregon Agricultural Department / Oregon Natural Heritage Program. See Appendix A for definitions.

because their required habitat is not found here. Two (*Erigeron decumbens decumbens* and *Lomatium bradshawii*) are known from the Willamette Valley. Both the *Erigeron* and *Lomatium* require wet, heavy soils. *Thelypodium howellii spectabilis* is known from moist alkaline meadows. *Sidalcea nelsoniana* is known from the Western Hemlock Zone along streams and meadows, and other relatively open areas where prairie or grassland remnants persist.

Field Survey

Field surveys were conducted April 17 to May 29, 2003 with additional selected habitat quality confirmation conducted in June 2-4 2004. Surveys were conducted to provide for optimal plant phenological condition to locate and identify species.

The RFQ/Q suggested that an appropriate sampling strategy provide for a 1 – 5% survey of the 45,000-acre NWSTF. This level of effort was supported by work conducted in the area on the potential for rare plants and previous surveys and stewardship activities. Survey transects were established roughly every 0.25 miles considering access. Transect orientation was based on access from roads, fence lines, terrain, habitat, and unexploded ordinance. Along transects, rare plants were searched for by identifying appropriate habitat to support the species and then searching for the species itself. Once appropriate habitat was identified, a meandering walk along the transect provided for good visual coverage of 200 ft. in width. The 200 ft. belt transect allowed for sufficient ability to detect even diminutive rare plant within these grassland plant communities. Transects of this nature take roughly an hour to cover1.5 miles providing searching and documentation time. Because of phenological difference between species development the area was surveyed at different times to obtain flowers and pods to verify species. The survey was conducted using information and guidelines detailed in the US Fish and Wildlife Service's *Rare Plant Inventory Guidelines*. The survey was conducted to search the entire 45,000-acres using belt transect described above. This strategy provided for economy of time and money while meeting regulatory guidelines. Transects walked were tracked using a GPS unit. A GIS was used to confirmed sufficient search effort was applied. Rare plant occurrences or other interesting features were recorded with GPS coordinates.

We conducted a reconnaissance survey by driving around the NWSTF roads prior to commencing the walking transects. Both *A. sclerocarpus* and *A. succumbens* were common and widespread across the NWSTF. As such, it was impractical to attempt to delineate individual populations meaningfully. As such, we recorded presence / absence of these two species at intervals based on time or distance.

***Astragalus sclerocarpus* pods**

We also recorded the vegetation quality based on five habitat conditions:

- L		Low – Area entirely comprised of exotic species
- ML		Medium Low – Exotic species dominate with native plant species evident
- M		Medium – Area a mix of native plant species and exotic species
- MH		Medium High – Native species dominate but few exotic species present
- H		High – A full component of native grasses with no exotic species present

Since conditions can change within a short distance we used a visual 3 meter radius "plot" for the classification. All rare plant occurrences and other interesting features were photographed.

Special consideration: The NWSTF is a military range and could have unexploded ordinance (UXO). We coordinated access to the NWSTF on a daily basis with Navy personnel. No ground breaking or digging was conducted under this contract. Some areas where skirted to avoid a high density of unexploded ordinance and other debris.

## RESULTS AND DISCUSSION

A total of two rare plant species were found across the NWSTF: *Astragalus sclerocarpus* and *A. succumbens.* Distribution maps of these species occurrences are found in Appendix A.

A. sclerocarpus and *A. succumbens* were found across the NWSTF. A*. succumbens* was very abundant found in large patches of several hundred individuals in some areas. In some small areas or patches in the northwestern part of the NWSTF it was the dominant species. This species is notable from the east side of the RNA and the very northeastern part of the NWSTF. A. *sclerocarpus* distribution is slightly narrower across the NWSTF. It was typically found in low densities of between 1 – 10 plants per plot.

The distribution is slightly notable by habitat quality with *A. sclerocarpus* found in slightly lower habitat quality than *A. succumbens* (Table 1a) was more likely found in lower higher quality habitat using the five habitat condition categories developed for this project. *A. sclerocarpus* was found 52% time in low or medium low quality habitat, 30 % in medium quality, and 18% in medium or high quality habitat. *A. succumbens* was found in slightly higher quality habitat with 34% of occurrences found in low or medium low quality habitat, 42% in medium quality habitat, and 23% in medium high or high quality habitat. In our sample, 51% of the NWSTF has low and medium low habitat quality, 31% medium, and 18% in medium high and high habitat condition (Table 1b).

*Table 1. Distribution of plant species and habitat habitat quality located during the threatened and endangered plant survey conducted in 2003 on the Naval Weapons Special Training Facility, near Boardman, OR.*

*Table 1a. Number of plots with A. succumbans (ASSU), A. sclerocarpus (ASSC), both ASSU and ASSC, Hymenopappus filifolius filifolius (HIFI) and A. caricinus (ASCA) by vegetation habitat quality.*

| **Species** | **L** | **ML** | **M** | **MH** | **H** | **Unknown** | **Totals** |
|---|---|---|---|---|---|---|---|
| **ASCA** | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| **ASSC** | 116 | 155 | 154 | 82 | 10 | 3 | 520 |
| **ASSU ASSC *** | 3 | 8 | 35 | 9 | 3 | 0 | 58 |
| **ASSU** | 64 | 102 | 201 | 96 | 13 | 1 | 477 |
| **HYFI** | 0 | 0 | 5 | 0 | 0 | 0 | 5 |
| **Totals** | 183 | 265 | 397 | 187 | 26 | 4 | 1062 |

* sites with both species

L Low – Area entirely comprised of exotic species.
ML Medium Low – Exotic species dominate with native plant species evident
M Medium – Area a mix of native plant species and exotic species
MH Medium High – Native species dominate but few exotic species present
H High – A full component of native grasses with no exotic species present

*Table 1b. Number of plots located with each vegetation habitat quality category on the NWSTF.*

| **Habitat Quality** | **L** | **ML** | **M** | **MH** | **H** |
|---|---|---|---|---|---|
| **Samples** | 608 | 788 | 845 | 407 | 71 |

In addition, two other notable observation included *Hymenopappus filifolius filifolius* and *A. caricinus* (Jones) Barneby. *Hymenopappus filifolius filifolius* is not a rare plant species. Although this is not a rare plant it is a notable collection as indicated by Aarron Liston, Department of Botany & Plant Pathology, Oregon State University, Corvallis. He notes this species was treated in Peck as A. lyallii s.l., and Hitchcock called it A. lyallii var. caricinus, although the differences between the two are small. He indicates he follows Barneby in recognizing both as species and further indicates that *A. caricinus* has been collected at Patterson in Benton Co., WA, but never before on the Oregon side of the Columbia.

***Astragalus caricinus***

## MANAGEMENT RECOMMENDATIONS

The NWSTF has one of the largest stands of Columbia Basin shrub steppe habitat in Oregon. Although the grassland plant communities within the NWSTF are rare the plants are not. There are no plants found on NWSTF which are listed by the US Fish and Wildlife Service or Oregon Department of Agriculture as threatened or endangered. Two rare plants were found on the NWSTF: *A. sclerocarpus* and *A. succumbens*. These two plants are on the ONHP List 4 which contains taxa which are of conservation concern but are not currently threatened or endangered. This includes taxa which are very rare but are currently secure, as well as taxa which are declining in numbers**.** These two plants are common across the NWSTF with subtle differences in distribution pattern.

Analysis of the distribution of these species against the plant community map and soils type using a GIS may elucidate information about habitat affiliations. We sampled across the NWSTF using distance (transect spacing) and time (3-minute interval along the transect) as a means to randomly collect data on the distribution of these two species. These samples can not be construed as separate or individual populations because the species may have been continuous between the sample locations. We consider the occurrence of these species as one population for each species for management purposes.

Two other plant species, *Hymenopappus filifolius filifolius* and *A. caricinus,* found on NWSTF are not listed as rare plants but their occurrence here is ecologically significant. Position data and vegetation quality data was collected for these two observations as well.

The Navy's maintainance of a native grassland plant community type within this ecoregion has high ecological importance. This significance is recognized by the Navy with its establishment and maintainance of 3 Research Natural Areas (RNS) within the boundary of the NWSTF. Protecting the RNAs and other areas we identified as having medium to high ecological condition from disturbance should be a goal within the Integrated Natural Resources Management Plan. Fire and subsequent invasion by exotic species reduces biological diversity through degradation of habitat and a reduction in the number of native species and the density of those native species. Although most grassland communities evolved with fire, the abundance of exotic species today makes fires less desirable. Fire control is recommended. Aggressive weed control is recommended particularly after fire. Caution should be used in broadcast application of herbicide with native vegetation. Ground disturbance should be limited in scope. Any ground disturbance will result in encroachment of exotic annuals. Livestock grazing in this area would require development of water sources. Both the development of livestock water sources and the salt / supplement block and water tank location would result in large areas of disturbance where additional source of exotic noxious weeds could establish. This would provide an additional source of exotic species. Exotic annuals increase the rate of a fire's spread and can decrease the period between fires causing a downward spiral of ecological condition.

## Appendix A Status Definitions
## ( Oregon Natural Heritage Program.  2001)

Endangered taxa are those which are in danger of becoming extinct within the foreseeable future throughout all or a significant portion of their range.

Threatened taxa are those likely to become endangered within the foreseeable future.

LE = Listed Endangered. Taxa listed by the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) as Endangered under the Endangered Species Act (ESA), or by the Oregon Departments of Agriculture (ODA) and Fish and Wildlife (ODFW) of the state of Oregon under the Oregon Endangered Species Act of 1987 (OESA).

LT = Listed Threatened. Taxa listed by the USFWS, NMFS, ODA, or ODFW as Threatened.

SoC = Species of Concern. Former C2 candidates which need additional information in order to propose as Threatened or Endangered under the ESA. These are species which USFWS is reviewing for consideration as Candidates for listing under the ESA.

The criteria for the Heritage Program lists are as follows:

List 1 contains taxa that are threatened with extinction or presumed to be extinct throughout their entire range.

List 2 contains taxa that are threatened with extirpation or presumed to be extirpated from the state of Oregon. These are often peripheral or disjunct species which are of concern when considering species diversity within Oregon's borders. They can be very significant when protecting the genetic diversity of a taxon. ORNHP regards extreme rarity as a significant threat and has included species which are very rare in Oregon on this list.

List 3 contains species for which more information is needed before status can be determined, but which may be threatened or endangered in Oregon or throughout their range.

List 4 contains taxa which are of conservation concern but are not currently threatened or endangered. This includes taxa which are very rare but are currently secure, as well as taxa which are declining in numbers.

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# National Weapons Special Training Facility

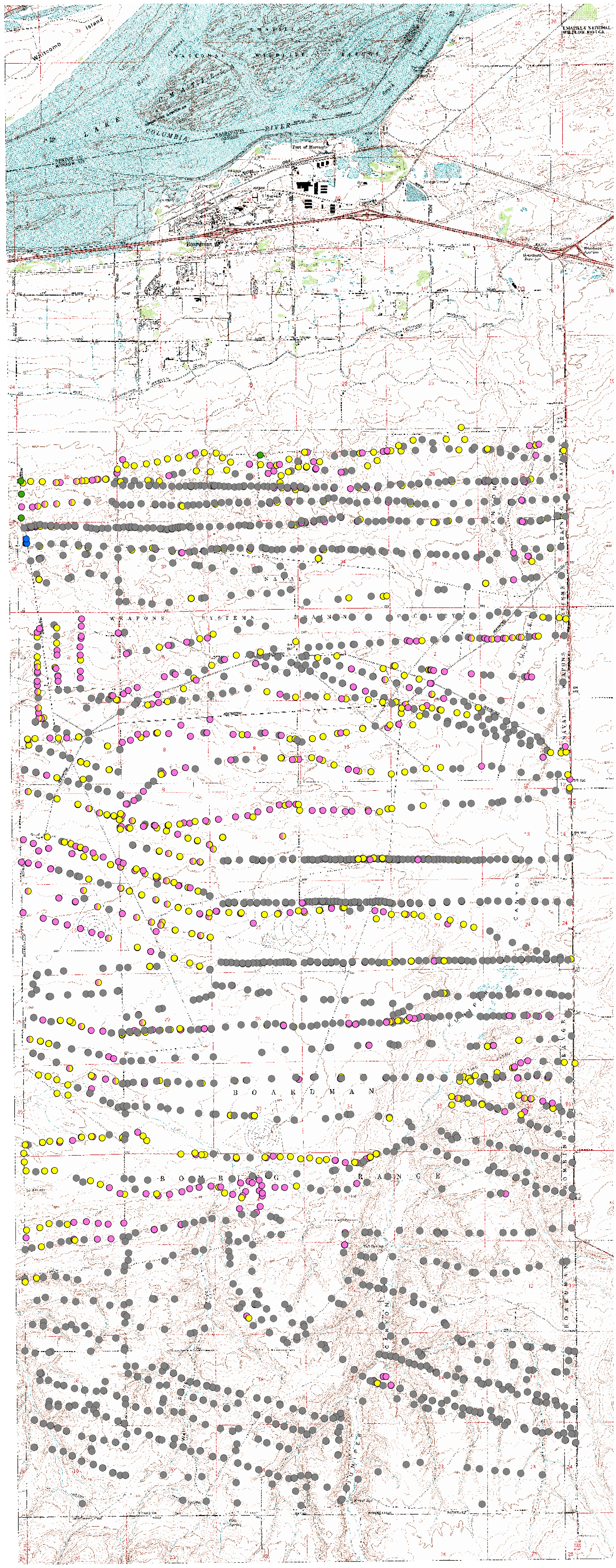
## Plant Species

- Astragalus succembens
- Astragalus sclerocarpus
- A. succembens and A. sclerocarpus
- Astragalus caricinus
- Hymenopappus filifolia
- None

Feet

0 1,500 3,000 6,000

N



VISION AIR RESEARCH

SPATIAL DYNAMICS

# National Weapons Special Training Facility

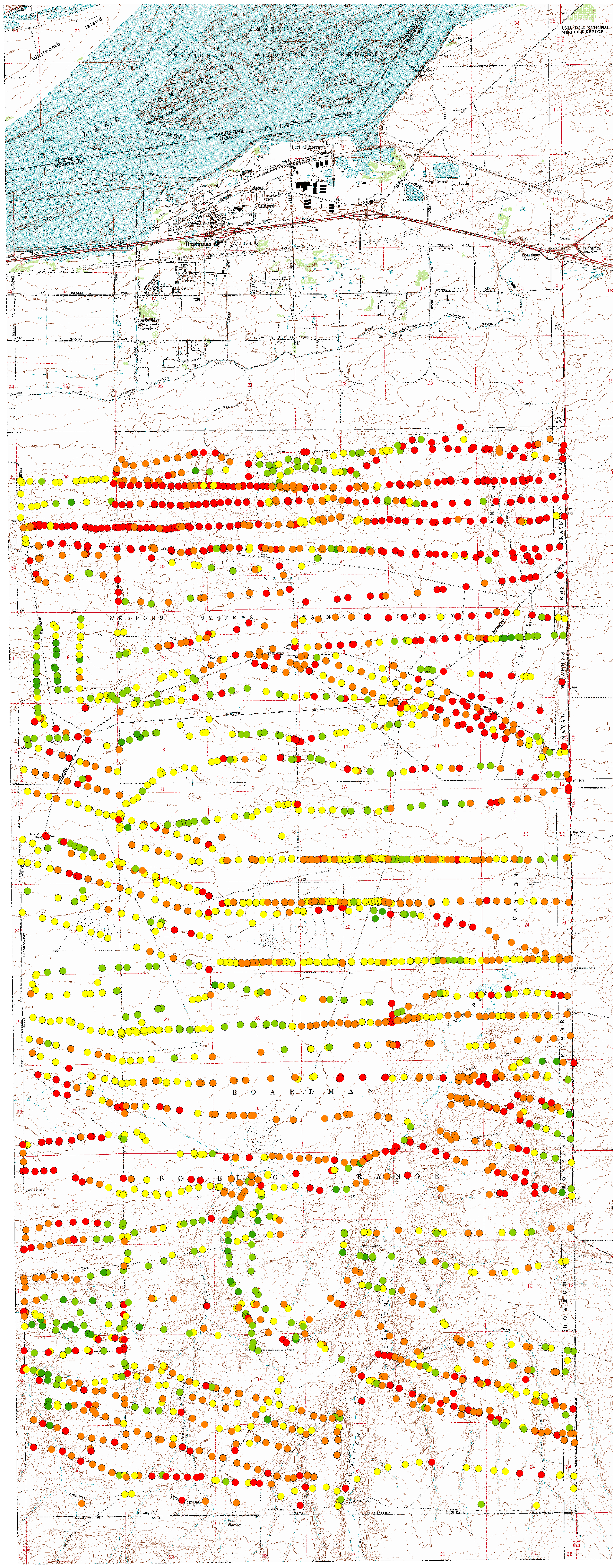
## Habitat Quality

- High
- Medium High
- Medium
- Medium Low
- Low

Feet

0 1,500 3,000 6,000

N



# NAVAL WEAPONS SYSTEMS TRAINING FACILITY NOXIOUS WEED INVENTORY AND MAPPING PROJECT

Report to Naval Air Station, Whidbey Island from The Nature Conservancy of Oregon

## INTRODUCTION

The Nature Conservancy of Oregon (The Conservancy, TNC) was awarded a contract by the Department of Defense, US Navy to complete a noxious weed inventory for the Naval Weapons Systems Training Facility (NWSTF) at Boardman, Oregon. Since 1979, The Nature Conservancy has cooperatively managed a portion of the Facility as three Research Natural Areas (RNA A, B, and C). Controlling noxious weeds in the RNA's has become a daunting task for the Conservancy. Using an integrated management approach, staff and volunteers spend over 250 hours each year fighting weed invasions.

The Navy's 73 sq. mi. Training Facility at Boardman is the largest remnant of shrub steppe habitat remaining in the Columbia Basin of Oregon. Therefore the area is extremely important to wildlife and vegetation native to the Basin. The Navy and The Nature Conservancy recognize noxious weeds as one of the greatest threats to the naturally functioning ecosystem and have undertaken this inventory as a first step in developing a noxious weed management plan for NWSTF.

## METHODS

The Conservancy surveyed the Boardman Training Facility for noxious weeds and other invasive, non-native plants during May, June and July 1997. Prior to beginning field work we prepared a draft map of known weed locations using information from all pertinent sources and submitted it to the Environmental Affairs Department, Naval Air Station, Whidbey Island.

To locate current weed infestations we drove all of the open roads on the Facility and walked along other roads, boundary and pasture fence lines, buried water lines and flight lines, noting weed populations. We also walked to areas where we had no previous information and areas away from roads. One widely scattered weed, rush skeletonweed, was located using binoculars to scan from good vantage points. This technique was useful only when the plants were full sized and flowering.

The Conservancy used a Trimble GeoExplorer GPS data logger to map specific weed locations and to mark locations of boundaries of large and very large populations. Weed locations were also plotted on orthophoto quads. GPS and orthophoto quad information was combined to define weed infestation polygons and the resulting map was digitized in PC ArcInfo 3.5.1. We calculated acreages of infestation for individual species using ArcInfo. Acreages for smaller infestations are overestimated due to the inability of the system to resolve very small areas.

Acreage calculations for polygons representing one plant and infestations up to 2 acres were overestimated by ArcInfo.

Densities of infestations were also recorded using the following classification.

VL=VERY LOW: very few, small, scattered infestations or individuals, less than 1 patch per 50 acres.
L=LOW: Scattered small infestations up to 25% of the area mapped, knapweed 10-50% cover.
M=MEDIUM: infestation covers 25 to 75% of the area mapped with 25-75% knapweed cover.
H=HIGH: infestation covers 75% or greater of the area mapped with 50-100% knapweed cover.

## RESULTS

TNC located and mapped boundaries and density composition for the following weed species: spikeweed (*Hemizonia pungens*), yellow starthistle (*Centaurea solstitialis*), diffuse knapweed (*Centaurea diffusa*), rush skeletonweed (*Chondrilla juncea*), scotch thistle (*Onopordum acanthium*), cereal rye (*Secale cereale*), perennial pepperweed (*Lepidium latifolium*), and medusahead rye (*Taeniatherum caput-medusae*). We were unable to locate any puncturevine (*Tribulus terrestris*).

These species were chosen for investigation because they were thought to be present on the Range and they were listed on the Morrow County or Oregon State Noxious Weed Classification System. Weeds are either listed as: "A" - weeds of known economic importance which occur in small enough infestations to make eradication/containment possible; "B" - weeds of economic importance which are regionally abundant or of limited distribution in a county and are subject to intensive control or eradication where feasible; "T" - priority noxious weeds designated by the State Weed Board as target weed species on which the Department of Agriculture will implement statewide management plans.

### Diffuse Knapweed

Diffuse knapweed is found on both the Morrow County and Oregon State Noxious Weed List as a "B" weed. It is the most abundant and widely distributed weed on the NWSTF. We discovered that this species could be encountered almost anyplace on the Training Facility. Populations were mapped as high, medium, low and very low density.

We located and mapped approximately 34846 acres (14101 hectares) of knapweed including 1290 acres (522 hectares) of high density, 2470 acres (999 hectares) of medium density, 16016 acres (6481 hectares) of low density and 15070 acres (6099 hectares) of very low density infestations. Examination of the pattern of population densities has helped us understand where the infestations may have begun and how they are spreading.

Several large medium and high density infestations of knapweed occur along the west boundary of the NWSTF. There are also several large medium and high density infestations scattered on the west (Boeing) side of the boundary fence. Knowledge that the prevailing winds are generally from the southwest seems to indicate that knapweed is spreading from west of the boundary onto the NWSTF. Several examples follow to help illustrate this pattern.

A “flight line” (an approach marked with large plywood signs on poles) leading northeast from the boundary in Section 31, T3N, R25E toward the main target area has served as a major corridor for knapweed spread. The soil has been plowed and otherwise disturbed and provides nearly perfect conditions for knapweed establishment. Knapweed has invaded this “flight line” and, with the help of prevailing winds, spread northeast along it.

Pasture fences and the primitive roads associated with them in Sections 7 and 18, T2N, R25E have served the same function as the flight line described above to facilitate the east-west spread of knapweed. Soil disturbance associated with these fences and roads combined with vehicle use has helped to create ideal seed beds for knapweed and has encouraged its spread.

Another high density knapweed infestation is associated with an area near the sand dunes in Section 6, T2N, R25E. As mentioned previously there are large scattered knapweed patches on the west side of the boundary fence. The combination of upwind seed source and disturbed soil has facilitated the spread of knapweed.

The “Interstate” is a north-south running road about one mile east of the west boundary fence. We think that vehicle traffic has helped spread knapweed north and south along this road after the infestations mentioned above moved from the west boundary fence to the “Interstate”. We located several instances where knapweed has spread from roads and developed a plume of infestation downwind, however, spread can occur in any direction from roads.

A similar pattern of weed spread appears to have occurred between the “Cow Camp” in Section 24, T3N, R25E and the east side of the main target area (RNA A). A large high density infestation of knapweed is located near the cow camp. From there a “trail” of knapweed locations leads west along the fence line and associated “road” through Sections 23 and 22 to the boundary of the target area. Knapweed has been spread south along the fence by vehicle traffic to the southeast corner of RNA A. Two infestations, one mapped as medium and one high density, are located east of the RNA fence on the bench in Sections 23 and 26. We think these infestations are the result of plants (seed heads) being blown onto the bench from the east RNA A boundary by prevailing winds. The process of vehicles spreading seeds, seed heads and plants along roads and subsequent dispersal by wind exacerbates an already difficult control problem.

The southeast portion of the NWSTF has relatively little knapweed. The plants we located were usually associated with livestock watering areas or the access roads to these facilities. Most infestations in the southeast were small and isolated. We think vehicle traffic to and from these watering areas is bringing seeds and seedheads into otherwise knapweed-free areas.

The east boundary of the Facility adjacent to the highway has a more or less continuous knapweed infestation. There is knapweed on both sides of the highway right of way. Two other rights of ways, a natural gas pipeline and a high voltage transmission line, parallel the highway on the NWSTF (west) side. The combination of three superimposed rights of way each contributes to the problems in this area. Knapweed is spreading onto the Facility from the these rights of way along the entire length of contact.

Three areas of the Training Facility currently have no known knapweed. Most of the area north of the main east-west road (Page road) is free of knapweed. We think this is primarily a result of less vehicle traffic, lack of a large upwind seed source along the west boundary, and sandier soils.

The Conservancy has been controlling knapweed in RNA B and RNA C since 1987. The majority of these two RNAs are free of knapweed. The west and southwest margins of RNA C are reinvaded each year by wind-blown plants from the adjacent infestations south and west of the RNA. TNC's efforts have been successful in reducing the extent of the infestation over time and keeping knapweed from spreading to other parts of the RNA but the large wind-borne seed source and proximity to the "Interstate" road makes reinvasion particularly vigorous. TNC's control efforts in RNA B have also been successful but as in RNA C there is yearly reinvasion from adjacent infestations. Knapweed invades RNA B from the highway right of way to the east, against the prevailing winds, though strong east and northeast winds occur at times. Weed spread westward on this boundary occurs more slowly than in RNA C where the prevailing winds and vehicle traffic facilitate the invasion.

**Yellow Starthistle**

We located yellow starthistle at several widely scattered locations. A total of less than 10 acres (4 hectares) was found. Most locations were associated with roads or fence lines. A particularly large infestation is located west of the main target area in Section 20, T3N, R25E. There is a stock water tank there and the soil is disturbed by livestock using the area. Additionally, the location was used in 1997 as a dismantling area for M-60 tanks resulting in a great deal of new soil disturbance. A larger infestation can be expected to occur in this location next year. Yellow starthistle is an "A" listed weed in Morrow County and ranked both "B" and "T" for the state of Oregon.

**Spikeweed**

Spikeweed was located on about 309 acres (125 hectares) of the NWSTF. The plant is confined to alkaline soils near the bottom along Juniper Canyon and the playa at Well Spring. The current infestations are high density and there is potential for the species to spread further down Juniper Canyon where there are suitable soils. Spikeweed does not compete as well in other soil types and we would expect limited expansion outside of the alkali areas. Spikeweed is classisfied as an "A" species in Morrow County and "B" on the Oregon State Noxious Weed List.

**Rush Skeletonweed**

Rush skeletonweed is also listed as an "A" noxious weed in Morrow County, but as "B" and "T" on the Oregon State list. This perennial species is widely distributed on the NWSTF but currently has an extremely low density. Consequently it is very difficult to locate. The Conservancy spent many days throughout the season searching for this species with little success. Some locations were discovered using binoculars to examine large areas from good vantage points. Most locations, however, were discovered during the course of general searching for all weed species. No acreage figure was calculated because of the typically very small individual infestations or single plant locations.

**Scotch Thistle**

Approximately 30 acres (12 hectares) of scotch thistle were found at several scattered locations on the Facility. The infestation in Juniper Canyon is associated with the stream channel and is probably being spread when the channel carries water during late winter and spring. The seed source may be from outside the south NWSTF boundary, further upstream in Juniper Canyon. There is no apparent pattern to the distribution of other infestations. This species is most often wind dispersed and could invade nearly anywhere. It is ranked as "A" on the Morrow County weed classification list and "B" for the state as determined by the Oregon Department of Agriculture.

**Cereal rye**

A high density infestation of cereal rye is located along the eastern boundary of the Facility on approximately 5 acres (2 hectares). Mechanical control has kept this population from spreading. This species is considered a serious economic threat to grain crops and is listed as a "B" noxious weed in Morrow County.

**Medusahead Rye**

TNC found scattered medusahead plants over a wide area in the southern part of the Range. We mapped only the largest infestation (0.3 acre, 0.1 hectare) in Section 16, T2N, R25E. This low density location is in an old rangeland seeding area that is currently nearly 100% cheatgrass (*Bromus tectorum*). The medusahead infestation seems to be in the early stage but has the potential to displace even cheatgrass and seriously degrade rangeland quality on the Facility. Medusahead is ranked a "B" noxious weed on the Morrow County and Oregon State Classification System.

**Amsinkia**

We did not locate any large infestations of this species that covered more than 75% of the soil surface. It is scattered in the sandy soils in the northern most part of the Range.

**Perennial pepperweed**

Perennial pepperweed was not on the original list in our contract but is on the State of Oregon "B" list of noxious weeds. We located 48 acres (19 hectares) of this species, most in seasonally wet soils in Juniper Canyon, the north end of Well Spring playa and near the old barn and corrals in Section 20, T2N, R25E. The infestations we located are high density.

## RECOMMENDATIONS FOR AN INTEGRATED WEED CONTROL PROGRAM

### AWARENESS, EDUCATION AND TRAINING

The invasive nature of most noxious weeds makes it imperative that all personnel working in an area be familiar with the most important weed species (Greater Yellowstone Noxious Weed

Management Coordinating Committee 1996) Prevention and early detection are the most effective weed control strategies. We recommend that all on site Navy personnel train in recognition of the 5 most common noxious weeds. Posters, handouts and on-site discussions may be helpful in raising awareness of the damage these weeds cause to rangelands. We believe training would increase the detection rate and make whatever control methods utilized more effective. Perhaps all seasonal users of the Facility should receive training in noxious weeds and be expected to report sightings to the Officer In Charge. Educational programs that could be implemented at NWSTF include; an annual weed tour of the Range for all Navy personnel and others working on the Range, a weed display to be kept on site, and a training program conducted by the Cooperative Extension Service , TNC, or weed control contractors.

PREVENTION AND EARLY DETECTION

Trained personnel and periodic weed inventories are essential for a successful early detection program. Prevention is best accomplished by ensuring that new weed species' seed or vegetative reproductive plant parts are not introduced onto the Training Facility. Eliminating the following common methods of weed seed introduction are important steps in the prevention process:

- Ensure that any seed, feed grain, hay, straw or mulch brought onto the Range be free of weed reproductive parts. Develop NWSTF standards in weed management plan and include implementation of inspections.

  Ensure that equipment machinery or vehicles are free of weed reproductive plant parts prior to movement onto NWSTF or moved from known noxious weed areas on site to uncontaminated areas. Earth-moving and tracked vehicles coming onto the Range should be rinsed with water off-site or steam cleaned on-site before use. Vehicle traffic on the Range has a strong influence on the spread of weeds. Even though vehicle access to the road system is regulated, tire tracks indicate that vehicles use just about every road, track, fence line, water line, etc. on the entire NWSTF. The problem is worst when plants are producing or carrying seeds (June 15-October 30). We believe that all vehicles operated on the Range share responsibility for the spread of weeds. Perhaps a road closure and vehicle inspection policy could be developed in the NWSTF weed management plan.
- Encourage proper management of livestock to slow noxious weed spread. Livestock grazing areas with noxious weeds spread viable seed attached to their hair or wool or in their digestive tract. We suggest that, in the future, permittees receive special training about weed awareness. Permittees should be encouraged to practice weed control on their own property and applicants who have controlled noxious weeds should be given priority.

- Use only gravel, roadfill, or topsoil that is free of noxious weed seed and other vegetative reproductive parts. A policy including some inspection standards could be developed in the NWSTF weed management plan. If it is not possible to use weed free material, these sites should be inspected for at least 3 years and treated if necessary.

- Prevent or minimize any soil disturbances during fire suppression activities. Weeds can be expected to invade areas disturbed by wildfires. Burned areas should be mapped and monitored for 3 years after wildfires. This will assure that weed infestations will be detected and treated early while they are still small.

INVENTORY

This report and map provides a complete baseline inventory from which to begin developing long term prevention and action plans. Periodically repeating the inventory is essential for updating the weed map after control has been applied. This will assist when monitoring and evaluating the program's effectiveness and insuring the earliest possible detection of new infestations.

COOPERATION AND PARTNERING

Cooperation between the Navy and adjacent land owners, managers and partners is essential to achieving effective and economical weed control. Good communication and cooperation can help direct control efforts toward long term solutions instead of individually concentrating energy and resources on "brushfires". The superimposed rights of way along the east boundary present an opportunity to achieve better and more economical control through cooperation. There are currently several uncoordinated control efforts going on that are actually working at cross purposes. For example, scalping (removal of all vegetation) around the bases of the powerline support poles (as was done in 1997) is providing excellent, newly disturbed soil for knapweed seedling establishment Knapweed control along the PGT natural gas pipeline right of way is made all the more difficult in part, because of the control efforts of another right of way user. Since the gas pipeline was installed the entire right of way has been taken over by knapweed. Knapweed infestations on both sides of the highway right of way are constantly reinvading the adjacent private lands and the NWSTF. The knapweed is entering the Navy Range along the entire eastside and moving west from the boundary fence. The State of Oregon/Morrow County must be a part of the control effort along this right of way if there is to be any hope of long term success. All appropriate partners need to develop control strategies. Another example where cooperation and coordination could yield better results is on the west boundary of the Range adjacent to the Boeing tract. Without control of the infestations west of the boundary there can be little hope of effective control on the NWSTF side. Does Boeing have a weed control program on their leased lands.

CONTROL METHODS

Integrated weed management is based on four general categories of management options (cultural, physical, biological, and chemical). All are discussed in our recommendations for the most effective current treatments. Herbicide must be used according to lable directions. Use of any pesticide which does not conform to the current product label is a violation of federal law. If aerial spraying is used, we recommend leaving a 25 meter buffer around RNAs. This will allow TNC the opportunity to use either backpack chemical or manual control in the buffer and protect the plants in the RNAs themselves from overspray damage.

We would like to recommend that once a weed control contractor proves they can accomplish satisfactory control, a 3 to 5 year contract be awarded. Applicators will treat more effectively when they learn the locations of infestations and become familiar with on site conditions (roads, wind, etc.).

**Diffuse knapweed**
Although we would prefer the Navy to use a ground based chemical control program for diffuse knapweed high, medium and low density areas, we recognize the efficacy of aerial application. Past aerial applications have not been effective and may have reduced native forb populations on the Range. It is difficult to recognize your target weed from the air. A ground based program assures chemical will only be applied where you visually locate the infestation. We realize past aerial applications have been applied too late in the season. Knapweed control on NWSTF should occur in April or May. Once the plants flower, chemical application becomes much less effective. On the Range at Boardman knapweed is bolting in June and the window for aerial application is over. Tordon 22K (picloram) at .25lb/acre active ingredient is most effective on rosettes and pre flowering plants. Treatment kills established plants and the residual herbicide prevents knapweed seedlings re-establishment for two to four years. Because seed remains viable in the soil for over 7 years, knapweed cannot be controlled with a single application of Tordon (Economic evaluation of knapweed control using picloram).

The Conservancy's successful integrated control program on the RNAs is ground based. In early to mid-May, while knapweed is in the rosette stage, TNC staff and contractors (with Oregon State applicator licenses) walk the entire infested area applying Tordon 22K (1oz per gallon H2O) with backpack sprayers. One month later, in June, Conservancy staff and volunteers walk the knapweed infestation again pulling the bolted plants that were missed during the chemical application phase. This two step program is effective, but must be continued indefinitely.

Other methods are effective, but may not be feasible for NWSTF. Manual control is effective on small infestations (Youtie 1997). Currently in Oregon four biological control agents are available through the Oregon Department of Agriculture (Urban 1994). Perhaps these insects could be released at NWSTF.

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We strongly recommend against aerial application of the areas mapped as "very low" on the GIS map. Knapweed individuals and very small patches were widely scattered and associated with roads, fence lines or water lines. Chemical control should be associated with visual inspection and conducted with backpack sprayers or a four wheeler with a spray tank. Control could be combined with mapping these small infestations at a finer scale.

Sheep grazing does not seem to be an effective tool for reduction of knapweed. Knapweed seeds are known to be viable after passing through sheep and mule deer (Wallander et al. 1995). Sheep will feed on the plants in the spring, however, the same individuals still flower and seed later in the summer. Actually it is the Conservancy's experience that the plants become more difficult to detect and control if they are grazed. This is due to the smaller stature of the plants not due to a reduction in numbers.

Cattle usually do not graze knapweed leaves if they have good forage available. Recent work at Eastern Oregon University by Mike McInnis and Larry Larson showed that knapweed seeds will not survive after exposure to fluids from cows rumen. (Mike McInis, personal communication). Direct observations of cattle effects on knapweed on the Range seem to reveal that only in areas of extreme overgrazing, such as along fence lines and around watering areas, the cows trample the vegetation to dust leading to knapweed invasion of these sites.

Knapweed seed stalks blow around in the wind and become lodged in canyons and against fence lines and other man-made structures. Wind is a major means of seed dispersal and weed spread. These catchment sites can actually act as a protection mechanism. However, tumble weed (*Salsola kali*) and tumble mustard (*Sisymbrium altissimum*) also blow into these catchment sites filling the available space. Once the windward side of the fence is filled with dried seed stalks any new stalks blow over the fences and seed disperses to the adjacent pasture. If these catchment sites were periodically burned in the spring or fall, the tumbling knapweeds would be trapped and seed spread limited. Since seeds drop in these catchment areas, they also need to be sprayed with Tordon.

**Yellow starthistle**

Populations of yellow starthistle on NWSTF are small. If started soon, intensive ground control over the next several years could lead to the elimination of yellow star. Reinvasion will probably continue to occur via seed dispersal from vehicles and livestock. If a control program is not iminent, yellow starthistle has the capability to spread throughout the entire Range. Tordon 22K applied during the month of May before the plant flowers is the recommended control (Corp and VanWinkle 1990). Biological control agents may be available from the Oregon Department of Agriculture. However, since the infestation is relatively small in area, chemical control may be faster and prevent fewer seeds from spreading. Following initial control, establishment of a healthy stand of perennial grass is desirable (Larson et al. 1994).

**Spikeweed**

Spikeweed occupies the upper end of Juniper Canyon and part of Well Spring playa. There are several other alkali sites on the range where spikeweed could spread if not controlled. TNC has had success controlling spikeweed on our Lindsay Prairie Preserve directly south of the Boardman Facility (Youtie 1997). Tordon 22K (1oz/1gal. H2O) is applied utilizing backpack sprayers in early April. Chemical application is most effective if applied during the seedling stage when the plants are less than 3 inches in diameter (Corp and VanWinkle 1990).

**Rush skeletonweed**

In 1996 a biologist working on the Training Facility identified and reported the presence of this weed species. Morrow County weed specialist, Dave Pranger, located and treated (in 1996) several of the infestations that were identified on the preliminary map. Several new sites were found in 1997 and we do not know whether they were treated this year. All these sites need to be revisited and follow up treatment will be necessary for at least 3 years (Corp and VanWinkle 1990). Corp and VanWinkle recommended high application rates of Tordon 22K for effective control. Hand pulling is not a recommened treatment for this weed species. Biological control insects have been released in other areas and could possibly be utilized on the Range.

**Scotch thistle**

Isolated occurrences of scotch thistle are just beginning to be located on NWSTF. Control is fairly easy in the first year of growth, or early in the second year, prior to bolting. Tordon 22K or Banvel (dicamba) and 2,4-D are effective in early spring (Corp and VanWinkle 1990). The Conservancy has had good success with manual control of this species. Pulling or chopping the stems at ground level is feasible to eliminate small infestations (Youtie 1997).

**Cereal rye**
Cereal rye is a noxious weed in cultivated wheat fields. It is very common on road sides in Morrow County. On NWSTF it has invaded from the highway east of the Facility. The Conservancy has been controlling cereal rye in RNA B for 2 years. In 1996 and 1997 we had the Umatilla Corrections Crew mechanically cutting the rye with weed eaters. This has kept the population from spreading.

**Medusahead rye**
Medusahead rye was found on the Range in low densities associated with converted annual grassland sites. Due to the low densities, it was difficult to locate and map. Not all sites have been identified on the GIS weed map. Medusahead rye has the ability to displace cheatgrass (*Bromus tectorum*) and can potentially dominate a very large portion of the Range. It is essentially unpalatable to domestic and wild ungulates except very early in the growing season. It produces a thick thatch which prevents many natives and desirable species from germinating or establishing (Young 1992, Hilken and Miller 1980, Turner, Poulton and Gould 1963). The Conservancy is experimenting with a combination of burning and chemical ("Round-up" - glyphosate) control on our Lawrence Grasslands Preserve to the southwest of NWSTF (Youtie 1997). Several consecutive years of early spring application of glyphosate is proving fairly successful for controlling medusahead.

**Puncturevine**
Although populations of puncturevine were not discovered in 1997, searching should continue. We pulled and bagged some along the "Interstate" in 1996, but could not relocate the population this season. Two species of weevil have proven to be effective forms of biological control; larvae of *Microlarinus lareynii* attack the seed, and larvae of *M. lypriformis* attack the plant stems (Urban 1994).

**Perennial pepperweed**
This species was not identified on the range prior to the 1997 weed inventory. In fact, Morrow County does not recognize this weed as being in the county. (Therefore it has no official county rank.) However, it is a "B" designated weed listed by Oregon Department of Agriculture. It is a very difficult weed to suppress due to its fast rate of spread, resistance to herbicides, occurrence of creeping rhizomes and adaptation to saline habitats (Young and Turner 1995). There is a large infestation on the Malheur National Wildlife Refuge in Harney County, Oregon. The US Fish and Wildlife Service has an ongoing control program for this weed and should be contacted for advice. Sites are still small on NWSTF and perhaps chemicals should be tried.

MONITORING AND EVALUATION
Most weed management activities require annual monitoring and evaluation for effectiveness after control is applied. Techniques may need modification if monitoring indicates they are ineffective. An adaptive management program is important for successful weed control.

Different levels of monitoring depend on objectives and resources. Setting clear monitoring objectives is a critical first step in the monitoring process. Managers need to specify the population being monitored; identify what will be measured; and the frequency of measurement.

The majority of weed control work causes large scale changes and less intensive monitoring methods may be appropriate.  Low intensity monitoring such as inventory and recording the plant's presence or absence may detect large changes in weed abundance.  The next level of monitoring is qualitative; establishing photo plots, mapping the extent of the infestation or recording visual cover estimates.  Weed research comparing the effectiveness of different chemicals or other control methods requires quantitative measurements utilizing a measure of abundance such as frequency, cover, density or biomass.  It is important to monitor not just the target weed, but how the control method affects the native annual and perennial species and other organisms in the community (Youtie 1997, Greater Yellowstone Noxious Weed Management Coordinating Committee 1996).

We would like to recommend that the Navy assign personnel or hire a civilian employee to conduct the monitoring, evaluation and inspection programs needed on the Training Facility.  As we examine the GIS map and write this report, we realize that one seasonal, on site, person (4 months) is essential to seriously reducing noxious weed populations at NWSTF.  Perhaps this person could also conduct training, inventory and mapping, and control of new infestations immediately following early detection.

## CONCLUSION

In 1987 knapweed was identified in only a few sites on the Range, along the "Interstate" and on the east boundary adjacent to RNA B.  Ten years later it has invaded almost 75% of the Range.  The sporadic control efforts applied thus far have been ineffective and have made no long term progress toward reduction of knapweed.  The population has continued to expand.  However in RNAs B and C, where the Navy has helped fund The Conservancy's control program, knapweed density has been greatly reduced, knapweed free areas have been maintained (see GIS map), and a successful control method has been developed.

Large scale control efforts need to begin immediately on the Boardman Facility.  Intensive methods are necessary in order to prevent further degradation of rangelands.  A program to control knapweed spread and reduce densities is going to be a very long term and costly task.  Presently, populations of several of the other weed species identified on NWSTF are small enough that they may still be controlled fairly easily.  However, if a control program is not initiated, many of these species will spread in a manner similar to knapweed and control will be much more difficult and expensive.

Following weed control, desirable species may not occupy the site without assistance.  If one species of weed is controlled with no change in management practices or revegetation, the site is very often re-infested by the same or another weed species.  Although, the Navy's objectives may vary for different portions of the Range,  a weed control program encompassing the entire Training Facility is a significant step towards maintaining sustainable rangelands  However in the future, the Navy may want to consider a larger scale maintenance and restoration program for the native ecosystem at NWSTF.

The Conservancy recommends that the NWSTF Weed Managenent Plan be written as soon as possible and that implementation begin April 1998. Please notify The Conservancy if we can be of any assistance.

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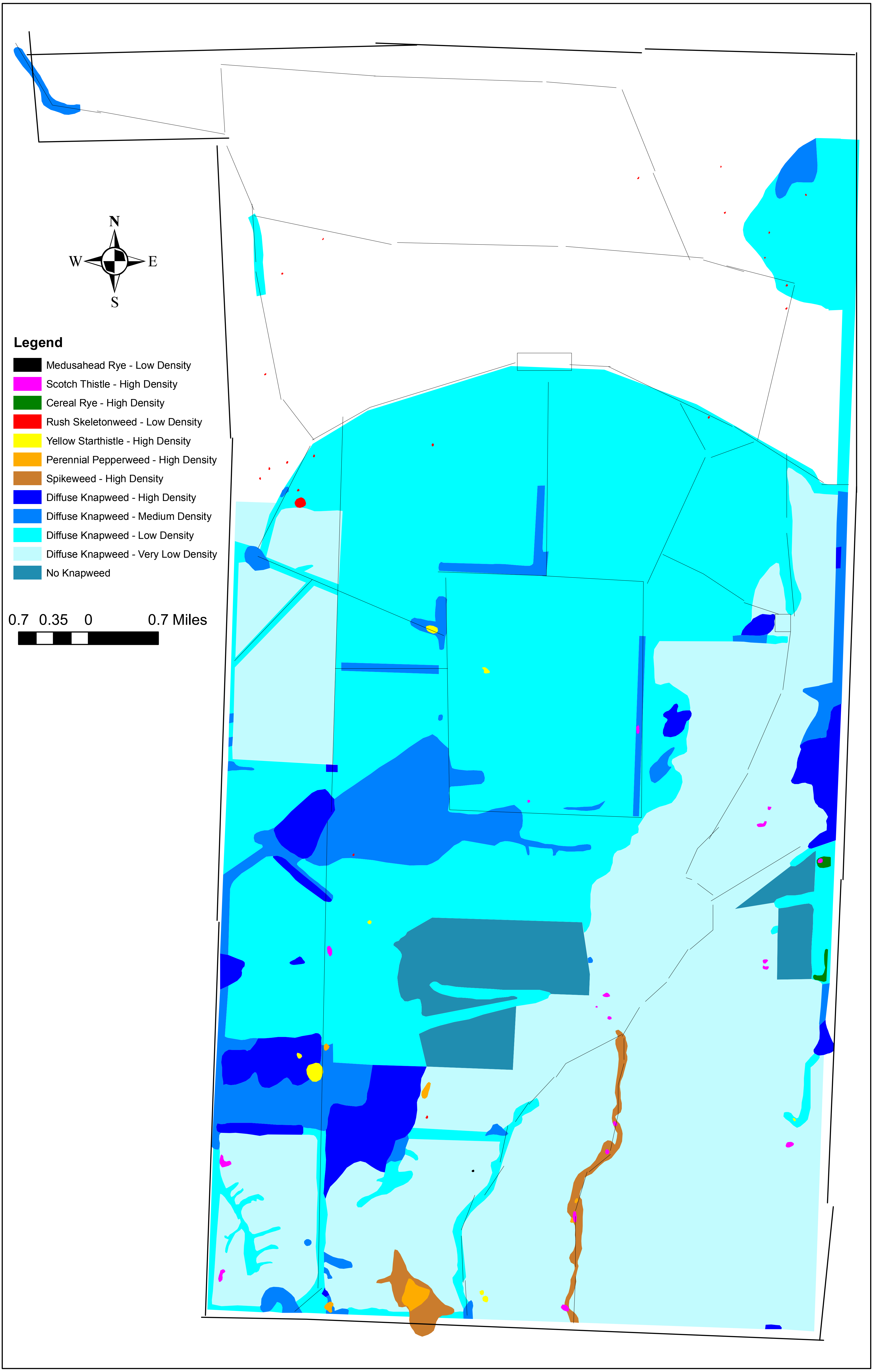
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Scotch Thistle - High Density
Cereal Rye - High Density
Rush Skeletonweed - Low Density
Yellow Starthistle - High Density
Perennial Pepperweed - High Density
Spikeweed - High Density
Diffuse Knapweed - High Density
Diffuse Knapweed - Medium Density
Diffuse Knapweed - Low Density
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# Fire-induced changes in sagebrush steppe habitat and bird populations at Naval Weapons Systems Training Facility Boardman, Oregon

**Diana L. Humple and Aaron L. Holmes, August 2001**

PRBO contribution #969
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# Fire-induced changes in sagebrush steppe habitat and bird populations at Naval Weapons Systems Training Facility Boardman, Oregon

Final Report submitted to the Oregon Department of Fish and Wildlife, Heppner District and NAS Whidbey Island, Environmental Affairs Department

August 2001

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PRBO contribution #969

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## EXECUTIVE SUMMARY

The Umatilla Plateau (Oregon's portion of the Columbia Basin ecoregion) once supported extensive tracts of sagebrush and associated populations of breeding birds (Gabrielson and Jewett 1940). Today it is second among Oregon's ecoregions only to the Willamete Valley in the percentage of landscape converted to non-native habitats (Oregon Biodiversity Project 1998). Remaining sagebrush steppe often occurs in small fragments, or is degraded by livestock grazing, exotic plant invasion and loss of shrub cover to wildfires. Due to concern over population declines and habitat degradation throughout the sagebrush ecosystem, many once common shrubsteppe birds are now listed as species of concern by state and federal agencies (ODFW 1997, USFWS 1995). The Naval Weapons Systems Training Facility (NWSTF) in Boardman contains one of the few remaining patches of basin big sagebrush steppe within the Umatilla Plateau. The Point Reyes Bird Observatory, in collaboration with Oregon Department of Fish and Wildlife (ODFW) and the US Navy, assessed habitat use and reproductive success for many species breeding on the NWSTF as part of a study carried out from 1995-1997 (Holmes and Geupel 1998). In August of 1998, approximately 9,700 ha of grassland and sagebrush habitat burned in a wildfire, resulting in major vegetative changes and greatly reducing the extent of sagebrush on the facility. In 2000 and 2001, aspects of the pre-fire study were repeated to investigate the effects of wildfire on populations of breeding songbirds using the facility. Our objectives were to: 1) evaluate changes in vegetation structure, songbird community composition, and relative abundance of songbirds on 8 sagebrush study plots; 2) evaluate changes in the breeding population size and nest success of Loggerhead Shrikes in sagebrush habitat of the Bombing Range; 3) survey and map locations of Sage Sparrow territories in order to make comparisons with pre-fire distributions and densities; and 4) provide management recommendations based on our results.

Measurements taken before and after the fire demonstrate a 75% decrease in sagebrush cover. Cryptobiotic crust was also severely reduced in areas of high fire intensity, or where it was covered in shifting soil de-stabilized after the fire. There was a corresponding increase in cheatgrass (mean cover on study plots increased from 8% to 44%). Census data indicates substantial changes in the distribution and abundance of breeding songbirds have occurred. The number of Loggerhead Shrike territories on the Bombing Range decreased from 35-40 territories per year before the fire to 17-21 afterwards, a change we attribute to the loss of suitable nesting habitat. Nest success, already low for the species at 39% before the fire, was only 19% in 2000-2001. Reductions in the extent of sagebrush habitat also resulted in fewer Sage Sparrow territories on the facility. Census data showed an overall 30% decrease in territory density on monitoring plots established in 1996. Abundance of two ground-nesting species, Western Meadowlark and Lark Sparrow, decreased on the Bombing Range as well. The decrease in Western Meadowlark abundance from pre-fire surveys was correlated with the extent of the burn within 40 ha study plots, but not at scale of individual sampling points.

This and earlier studies demonstrate the importance of the Bombing Range to a number of bird species. The declines we detected in some species due to the loss of sagebrush shrub cover resulting from the fire underscores the need to actively protect remaining sagebrush steppe habitat in the Columbia Basin.

# INTRODUCTION

In recent years concern has grown over the widespread declines of numerous songbird populations, particularly of Neotropical migrant species (Robbins et al. 1989). During the last 10 years this concern has fueled an unprecedented international effort coordinated through Partners in Flight (PIF) to protect non-game birds and their habitats. As a direct result of the PIF program, a cooperative project involving the Point Reyes Bird Observatory (PRBO), Oregon Department of Fish and Wildlife (ODFW), and the United States Navy began in 1995 on the Naval Weapons Systems Training Facility Boardman (locally known as the Boardman Bombing Range). This 19,000 ha facility represents one of the largest remaining blocks of shrubsteppe habitat within the Umatilla Plateau, Oregon's portion of the Columbia Basin Ecoregion.

The goals of the 1995-1997 project were to quantify songbird use in each of the facility's vegetation communities, identify conditions associated with the occurrence and abundance of as many species as possible, and to assess habitat requirements for successful nesting of as many species as possible. This three-year inventory and monitoring project documented the importance of the Bombing Range for many birds, including a number of species of concern. Results were summarized in a comprehensive report (Holmes and Geupel 1998) that has been used to guide management on the Bombing Range (Green and Livezey 1999), and have been included in the PIF bird conservation plan for the region (Altman and Holmes 2000).

Vegetation on the Bombing Range varies from a sandy shrubsteppe community dominated by antelope bitterbrush (*Purshia tridentata*) at the northern boundary to basin big sagebrush steppe on the loess soils present on the south half of the facility. Extensive perennial grasslands dominated by needle-and-thread (*Hesperostipa comata*) occur in the central part of the facility, although in much of the remaining area the native grasses have been replaced by cheatgrass (*Bromus tectorum*).

In August of 1998 a lightening strike started a wildfire that burned approximately 9,700 ha of the Bombing Range, including roughly half the existing sagebrush habitat (Appendix A, Map 1). Our pre-fire data sets provided a unique opportunity to study the effects of fire through comparisons of pre- and post-fire bird distribution, abundance, and nest success. Therefore, PRBO contracted with ODFW to repeat portions of the original monitoring program during the 2000 and 2001 breeding seasons. Our objectives were to:

1) evaluate changes in vegetation structure, songbird community composition, and relative abundance of key species on 8 sagebrush point count study plots;
2) evaluate changes in the breeding population size and nest success of Loggerhead Shrikes in sagebrush habitats of the Bombing Range;
3) survey and map locations of Sage Sparrow territories in order to make comparisons with pre-fire distributions and densities; and
4) provide management recommendations based on our results.

## STUDY AREA AND METHODS

Common names for birds species throughout this report are those of the American Ornithologists Union (AOU) *Checklist of North American Birds* (7th edition, 1998).

### Study Area

The Naval Weapons System Training Facility (NWSTF) Boardman is located in northern Morrow County, Oregon, an area characterized by hot, dry summers and cold, moist winters. Most of the precipitation occurs from November through May with November, December, and January being the wettest months. The average annual precipitation for Boardman is 22 cm. The elevation of the 19,020 ha training facility rises from 122 m at the northern boundary to 274 m at the southern. This study was carried out on the southern third of the facility, an area characterized by rounded hillsides and valleys with slopes of 5 to 20 percent. Soil associations vary from Sagehill-Taunton to Warden (McClelland and Bedell 1987).

Most vegetation has been drastically altered by decades of livestock grazing, and the 1998 fire resulted in significant loss of shrub cover. The southern part of the Bombing Range includes areas dominated by basin big sagebrush (*Artemesia tridentata* var. *tridentata*) or a mix of basin and wyoming (var. *wyomingensis*) big sagebrush. In areas sagebrush is mixed with rabbitbrush (*Chrysothamnus naseosus* or *viscidiflorus*). Understories vary from cheatgrass (*Bromus tectorum*) to mixed stands of cheatgrass and Sandberg's bluegrass (*Poa sandbergii*). Some bottlebrush squirreltail (*Sitanion hystrix*) is often present. Throughout the area there are relic stands of the native perennial grasses that once dominated the area – bluebunch wheatgrass (*Pseudoroegnaria spicata*) and to a lesser degree needle-and-thread grass (*Hesperostipa comata*). Important native forbs include several species of *Astragalus, Lomatium, and Castilleja.* Within the Research Natural Areas (RNAs) that are managed without livestock grazing, Carey's balsamroot (*Balsamorhiza carreyana*) is fairly abundant. Moving northward to the central part of the Bombing Range soils grade from loamy to sandy, and the habitat is increasingly dominated by rabbitbrush / needle-and thread grass and areas of rabbitbrush / cheatgrass. Further details of the study area are in Green and Livezey (1999).

### Point count surveys

Site selection: In the post-fire study, we restricted point counts to the 8 plots designated as sagebrush habitat prior to the 1998 fire (Appendix A, Map 1). These were selected in 1995 along with study plots in other vegetation communities (Holmes and Geupel 1998). In summary, we divided the entire facility into a 100m grid and created numbered coordinates. We then generated a list of numbers from a random number table, and using a Global Positioning System (GPS) we located the selected coordinates on the ground. If a plot met our pre-determined habitat condition (in the case of sagebrush they had to have > 5% shrub cover) the point was used as the SW corner of a study plot. If the habitat could not be classified (i.e. on habitat edge), the plot was rotated so that the selected coordinate would serve as the NE corner. If it still could not be classified we went on to the next coordinate on the list. This process continued until we had selected 3 plots within RNA C (ungrazed sagebrush) and 3 outside the RNA. In 1996, new plots were randomly selected within upland areas that contained greater proportional cover of the Wyoming subspecies of big sagebrush, a habitat that was not well sampled in 1995. Table 1 shows the habitat classification used in the pre-fire study, plot number, and fire status (burned or unburned) for plots surveyed 2000-2001.

**Table 1. Plot numbers, sagebrush habitat types as designated pre-fire, and degree of shrub loss related to 1998 wildfire for NWSTF point count plots monitored after the fire, 2000-2001.**

| Habitat | Plot Number | Number of Points | Burned in '98 | Severity of Shrub Loss From Fire[1] |
|---|---|---|---|---|
| Grazed sagebrush | 07 | 9 | No | N/A |
| | 08 | 9 | 3 of 9 points | Light to heavy |
| | 09 | 9 | Yes | Heavy to complete |
| Ungrazed sagebrush | 22 | 9 | Yes | Moderate to complete |
| | 23 | 9 | Yes | Moderate to complete |
| | 24 | 9 | Yes | Moderate to heavy |
| Upland sagebrush | 25 | 15 | Yes | Moderate to complete |
| | 26 | 15 | Yes | Moderate to complete |

[1] Each point was assessed individually.

Survey methods: Point counts were conducted at each of the 8 plots following standardized protocols (Ralph et al. 1993 and 1995). Points were spaced 200 m apart in lowland sagebrush and 250 m apart in upland sagebrush (Holmes and Geupel 1998). Each point was surveyed on 3 mornings at least 10 days apart between late April and June of each year. All individual birds detected within a 5-minute period, were classified according to type of detection (visual, song, or call in that hierarchical order) and location (within the fixed radii of 50 m, 50 to 100 m, or 100 to 200 m; or as flyovers above the point). Counts began about 15 minutes after local sunrise and continued for no more than three hours in order to restrict the count to peak singing hours. Counts were not conducted during poor weather conditions, such as rain or high winds, when probability of detection may be reduced.

Vegetation assessment: We collected habitat information at each of the 84 point count stations both before and after the fire. This information is used to characterize the vegetation on study plots and to establish correlates between vegetation conditions and bird abundance. At each point we measured intercept, shrub species, height, and vigor along 200m of transect (50m in each cardinal direction from the point). These measurements were taken both prior to the fire (1996-1997) and in 2000. In addition we sampled vegetation within 5m radius plots established at 3 locations: centered on the point, 35m away from the point at 120°, and 35m at 240°. To facilitate estimation, 2 ropes laid crosswise divided each plot into 4 quadrants. Cover estimates for all vegetation were made in each quadrant and then averaged. Additional information such as slope and plot aspect was collected. Pre-fire sampling effort was spread out among years – typically one of the 3 plots was done in each year for each point. Post fire sampling occurred at one plot per point in 2000 and the other 2 plots in 2001.

Coverage was estimated (0 - 100%) for small shrubs (less than 40 cm tall), grasses, forbs, cryptobiotic crust, litter, and bare ground. Percent cover of grass and forbs was then estimated by species. An overall "green cover" estimate was also made including shrubs less than 40cm, grass, and forbs. Litter depth was measured using a plastic ruler at 10 points along the ropes (2 in each direction and 2 within 20 cm of the center). The numbers of shrub stems less than 2.5 cm in diameter and greater than 2.5 cm (at 10 cm high) were recorded for each species occurring within the plot.

An index of burn intensity and vegetation damage within 100 m of the point was created and estimates were made at every point count station by a single observer in 2000. The index ranges from unburned (unburned = 0), lightly burned with large patches of sagebrush / unburned vegetation remaining (light = 1), mostly burned with small patches unburned shrub/vegetation (medium = 2), burn covers entire sampling area but contains scattered live shrubs (medium-heavy = 3), and high intensity burn which covers entire sampling area leaving no live shrubs (heavy = 4).

**Sage Sparrow census plots**

Point count survey data and casual observation in 1995 suggested that Sage Sparrow distribution on the NWSTF was limited primarily to the upland sagebrush areas that contained a habitat type not adequately sampled by BBIRD plots selected at random in 1995. Therefore in 1996, with input from the participants of the annual BBIRD meeting (March 1996, San Francisco, CA), we initiated a new "target species sampling" (TASP) protocol to concentrate on these 3 species in their preferred habitat of upland sagebrush. We attempted to sample all upland sagebrush tracts larger than 85 ha on the Bombing Range. Six such areas were located and established as plots (Appendix A, Map 3). TASP was conducted on all 6 plots at least once between April and the first week of May of 1996.

The TASP protocol is an adaptive sampling technique modified from the "strip adaptive cluster sampling" (Thompson 1992) that incorporates flush-mapping on multiple days to delimit territories. In summary, sampling was conducted with 1 or 2 observers, conducted with 4-5 hours of sunrise. Observers walked parallel transects at approximately 75-100 m apart, depending on terrain. When a target species was encountered no less than 20 minutes was spent attempting to track the individual. If territorial behavior (e.g. singing) was observed, the territory boundaries were delimited using a flush mapping protocol (Reed 1985). After mapping, flagging with a unique number identifying the territory was placed in the perceived center of the territory, with additional flagging around edges if needed. After a territory was marked, all adjacent areas (4 areas the size of the original territory) were searched for other conspecific territorial birds. The 20-minute flush-mapping and territory marking was repeated until no territorial birds were located in adjacent areas. At this time observers would return to the original encounter and resume walking the predetermined transect.

Sage Sparrow territories were confirmed if adults from the territory were observed for 15 minutes on each of two visits (separated by minimum of 10 days), or for a total of 20 minutes across 3 visits. If birds were not detected during the second census or were not detected for a full 15 minutes on the two separate visits, territories were revisited into June if necessary for territory confirmation. A few suspected territories were never confirmed and are not included in our results.

During the 2000 and 2001 seasons, the six Sage Sparrow Plots established in 1996 were covered twice between late March and mid-May with at least 10 days between visits in effort to locate active Sage Sparrow territories. Even areas no longer containing suitable habitat (but that had been designated upland sagebrush prior to the fire) were surveyed, as other studies have shown Sage Sparrows to have high site tenacity even after shrub loss has incurred (Martin and Carlson 1998). The timing of the surveys in 2000 and 2001 was generally earlier than the pre-fire surveys, which occurred between May and June. Sage Sparrows begin nesting in late March in Boardman, and we feel that earlier surveys were more efficient. Detectability likely decreases as the season progresses as once the young fledge, males sing less frequently (Best and Peterson 1982).

**Loggerhead Shrike**

Censuses: In 1995-1997, approximately 2550 ha of sagebrush habitat around Juniper Canyon and in Well Spring Canyon were censused for breeding shrikes. Upland sagebrush was surveyed for Loggerhead Shrikes during Sage Sparrow surveys (above). In 2000-2001, this effort was repeated in remaining sagebrush habitat. Areas of sagebrush surveyed prior to the fire that no longer contained suitable Loggerhead Shrike breeding habitat (i.e., lacked suitable nesting substrates) were not formerly censused. Typically, up to 200 ha was censused in a morning during the first 5-6 hours after sunrise. Smaller areas were often covered in a given morning in 2000-2001 due to the reduction in available habitat, but effort was comparable. Surveys consisted of one to two observers walking slowly through the area, stopping frequently to scan the surrounding vegetation for Loggerhead Shrikes, until the boundary of a pre-selected area was reached. The observer would then double back, walking at a parallel distance of 150-250 meters, depending on vegetation density, terrain and visibility. The entire survey area was censused twice between mid-April and late May. In addition to these surveys, we discovered some shrike territories while conducting other work.

Nest monitoring: Once shrike territories were identified, observers searched for and monitored nests using methods described in Martin and Geupel (1993). Nests were located at various stages using behavioral cues and systematic searches. Once located, nests were checked systematically (every 3-4 days) and carefully to minimize human induced mortality, until the outcome was determined. Nest-searching normally began within a half hour of sunrise and continued into the afternoon, weather permitting. Upon failure of a nest or early season fledging we intensively searched for subsequent nesting attempts on the territory.

Nest description and vegetation assessment: Numerous variables were recorded upon termination of each nesting attempt. These included measurements of the nest structure, measurements of the shrub or tree containing the nest structure, and assessments of the concealment of the nest. In addition, the same method for estimating shrub cover, shrub stem density, herbaceous vegetation cover, and ground cover described above for point counts (see *Point count surveys: vegetation assessment*) were taken at every nest in a 5 m radius plot centered on the nest. However, methodology differed from point counts in that we did not collect shrub intercept data; instead we recorded distance from nest, species, height, width and perpendicular width of the nearest shrub in each of the four quadrants.

Tracking fledgling fates: In 1997 and again in 2000-2001, we tracked fates of fledglings at 13-16 days out of the nest. We did not include nests that fledged prematurely (at day 12-15 of the nestling stage) in the analysis, because these nests are believed to have fledged early as a result of a partial or failed depredation attempt by a nest predator, and the number of young fledged was unknown. At approximately two weeks after fledgling (13 -15 days), we returned to the nest area where we located adults and fledglings and observed for a minimum of 30 minutes. After observing food carries to locate where fledglings were perched or actually observing fledglings, we approached and flushed the young at each location noted. If the entire brood was not accounted for, we repeated our observations and flushing of the fledglings, sometimes the following day, and the higher count was used.

**Juniper tree surveys**

Between 10 April and 23 April 2001, nearly all of the 188 mature western juniper (*Juniperus occidentalis*) trees in the southeastern part of the NWSTF were visited. Three trees (junipers 185-187) were never visited due to an active Ferruginous Hawk nest. Each tree was examined for active Black-billed Magpie, Common Raven, Long-eared Owl or hawk nests. This survey was conducted before Neotropical migrants Western Kingbirds and Bullock's Orioles had returned to the facility to breed and before Swainson's Hawks had selected nest sites, but timing was appropriate to assess nesting use by Long-eared Owls. Black-billed Magpie nests found with this method were subsequently monitored (see *Black-billed Magpie* below). In addition, this survey allowed us to assess the number of juniper trees killed in the 1998 wildfire.

**Birds of prey and corvids**

Black-billed Magpie: In 2000 and 2001 we monitored Black-billed Magpie nests following protocols outlined in Martin and Geupel (1993). Due to logistical constraints, we were not always able to monitor nests located far from activities related to our primary objectives. Most nests were found incidentally (during juniper nest censuses, shrike censuses or otherwise) or when adult behavior indicated a nest nearby. For all nests monitored, we collected nest and nest substrate measurements and descriptions, and for nests placed in sagebrush we conducted vegetation assessments of the nests as well (see *Loggerhead Shrike: nest description and vegetation assessment* above for details).

*Buteo* hawk nests: We kept track of all Ferruginous and Swainson's Hawks detected on the range and attempted to locate their nests. We checked on the status of these nests every few weeks in order to determine outcome.

Raven and crow observations: We kept daily records of the numbers and locations of Common Ravens and American Crows observed on the Bombing Range in 2000-2001. We also monitored nests of ravens breeding within our study area.

**Wildlife observations**

During 2000 and 2001, we maintained daily lists of all birds, mammals and reptiles observed on the Bombing Range, and documented locations for select species.

**Statistical analysis**

Point count vegetation data

Differences in vegetation were examined using 2-way ANOVA with a paired sample design, where for each point values before and after the fire were compared. We evaluated distributions of model residuals for approximation to normality (sktest; StataCorp 1999) and when necessary we applied either square-root or log transformations. In total we examined 17 habitat variables (Table 2).

Point count survey data:

All analyses were restricted to species of confirmed or suspected breeding status. In addition, we excluded species we felt were not well censused by this method, such as raptors, crows and ravens. We examined the abundance of birds by species at each point. This index of abundance is defined as the number of individuals detected per point across all 3 visits each year, which can then be averaged across study plots, treatments, or the entire study area.

We investigated differences in bird abundance indices both among years and between pre- and post-burn sampling periods at 2 scales: individual point count stations, and at the plot level (using mean values from all points). Because bird surveys were conducted at the same exact locations in all 5 years we focused our analyses on changes at each point or plot as opposed to overall changes. To do this, we first modeled variation in bird abundance among individual points and plots using 2-way ANOVA. Model residuals were then used as the dependent variable in 3-way ANCOVA to examine the influence of year and burn intensity (using vegetation burn index). Thus, final models account for the relative change in abundance that can be attributed year and burn intensity in a way that is analogous to paired tests (with 5 samples per point/plot for models that include year). We restricted models for Sage Sparrow and Grasshopper Sparrow abundance in relation to plots where at least one bird was detected either before or after the fire. Sage Sparrow detections primarily occurred in the upland sagebrush plots – which were not censused in 1995. Because of this and difficulties normalizing residuals associated with their limited distribution, the Sage Sparrow model was developed using the pre-fire and post-fire means (and does not account for annual variation).

Nest success: We used 3 indices of productivity: the Mayfield estimate of nest survivorship (Mayfield 1961, 1975); the proportion of nests that fledge; and the number of females that successfully produced young (the latter for Loggerhead Shrike only). Mayfield estimates of nest survivorship are considered better than simple proportional success in that they take into account the number of days nests were under observation, thus eliminating the potential underestimation of losses. This method yields a daily survival rate calculated by summing the number of days which nests were observed and at risk of failing and dividing by the number of nests known to have failed. Estimates can be generated for a particular stage of nesting (e.g., incubation period, nestling period), or for the entire nesting period. We defined the entire nesting period as beginning on the day of laying the first egg, and ending on the day of departure of the first nestling. We estimated variance as recommended by Johnson (1979). For Loggerhead Shrikes, we used period lengths of 5.5 days for laying, 16.5 days for incubation, and 16.5 days for nestling brooding. For Black-billed Magpies, these period lengths were 5.5 days, 17.5 days, and 25.5 days, respectively.

We used the program CONTRAST (Hines and Sauer 1989) for comparing daily nest survival rates for Loggerhead Shrikes and Black-billed Magpies.

For all statistical analyses, significance was assumed at $P < 0.05$. Alpha levels were adjusted when appropriate using the Bonferroni adjustment for multiple comparisons.

**Table 2. Habitat variables used in this report, unit of measurement, and sampling method used.**

| habitat variable | unit | description |
|---|---|---|
| sagebrush cover | % | cover determined from shrub intercept transects |
| sagebrush height | cm | mean height of live sagebrush shrubs from intercept transects |
| sagebrush stems <2.5 | # | number of stems <2.5cm from 3-5m sampling plots |
| sagebrush stems >2.5 | # | number of stems >2.5cm from 3-5m sampling plots |
| dead shrub | # | number of dead shrubs intercepted in 200m of transect |
| rabbitbrush cover | % | shrub cover derived from shrub intercept transects |
| rabbitbrush stems <2.5 | # | total number of stems <2.5cm from 3-5m sampling plots |
| rabbitbrush stems >2.5 | # | total number of stems >2.5cm from 3-5m sampling plots |
| snakeweed cover | % | cover of *Gutierrezia sarothrae* determined through shrub intercept |
| annual grass | % | mean cover estimate from 3-5m sampling plots |
| perennial grass | % | mean cover estimate from 3-5m sampling plots |
| sandberg's bluegrass | % | mean cover estimate from 3-5m sampling plots |
| forb cover | % | mean cover estimate from 3-5m sampling plots |
| total green | % | mean cover estimate from 3-5m sampling plots |
| cryptobiotic crust | % | mean cover estimate from 3-5m sampling plots |
| bare ground | % | mean cover estimate from 3-5m sampling plots |
| litter | % | mean cover estimate from 3-5m sampling plots |

**Personnel**

Field data collection was coordinated by PRBO biologist Diana Humple. Additional oversight was provided by Aaron Holmes and Geoff Geupel. Point count surveys were conducted by Diana Humple (2000-2001), biologist Verne Marr (2000-2001), and PRBO intern Jennifer Durbin (2001). All had experience conducting point count surveys, including at least one season in sagebrush habitat. Sage Sparrow censuses and territory mapping was primarily conducted by Diana Humple, with assistance from Aaron Holmes in 2000 and Jennifer Durbin in 2001. Student Conservation Association volunteers Bobbie Davis and Jon Philipsborn (2000), and PRBO intern Jennifer Durbin (2001), conducted shrike surveys, nest monitoring and vegetation sampling along with Diana Humple. All field technicians entered nest, vegetation and census data into database files, made initial proofs, and were responsible for daily data organization and writing up natural history accounts in the project journal. Point count and nest data was further checked for errors and corrected with the help of proofing programs. Aaron Holmes and Geoff Geupel coordinated all aspects of pre-fire field data collection.

# RESULTS

## Changes in vegetation

The 1998 wildfire altered vegetation on the range in a predictable fashion. The most notable changes were decreases in sagebrush and cryptogamic crust cover, and increases in the cover of annual grass, primarily cheatgrass (Table 3). Individual plots varied in the extent of sagebrush loss and other habitat change (Appendix 2). There were also shifts in the frequency distributions of cover values; sagebrush before the fire had a mean cover value of 19%, but during the latter part of the study 75% of the sampling plots contained less than 5% cover. Annual grass had a pre-fire mean cover of 8% with approximately 75% of the points containing less than 10% cover. After the fire, cover averaged 44% and the frequency distribution of cover values approximates normal (Figure 1).

**Table 3. Habitat characteristics from 8 plots measured before and after the 1998 wildfire. Statistical significance was determined with two-way ANOVA using paired comparisons (see methods).**

| | PRE-FIRE | | POST-FIRE | | |
|---|---|---|---|---|---|
| Variable | mean | SD | mean | SD | *P* |
| Sagebrush cover | 19.19 | 12.8 | 4.16 | 7.00 | *** |
| Sagebrush height | 77.73 | 25.5 | 54.12 | 52.92 | *** |
| Sagebrush stems (<2.5 cm) | 72.65 | 80.5 | 8.88 | 19.97 | *** |
| Sagebrush stems (>2.5 cm) | 72.75 | 54.5 | 10.87 | 23.86 | *** |
| # dead shrubs | 17.04 | 18.1 | 16.73 | 12.16 | ns |
| Rabbitbrush cover | 1.27 | 4.3 | 0.13 | 0.42 | ns |
| Snakeweed cover | 1.25 | 2.3 | 0.61 | 1.31 | ns |
| annual grass cover | 8.26 | 11.3 | 43.90 | 17.66 | *** |
| perennial grass cover | 3.87 | 7.9 | 5.20 | 7.98 | *** |
| Sandberg's bluegrass cover | 3.04 | 3.38 | 12.79 | 10.05 | *** |
| forb cover | 3.85 | 4.15 | 3.51 | 2.57 | ns |
| total green (<40 cm) | 19.23 | 12.87 | 66.43 | 15.67 | *** |
| cryptogam cover | 44.21 | 28.94 | 5.87 | 8.77 | *** |
| bare ground | 20.55 | 27.74 | 16.31 | 14.02 | ns |
| litter | 29.52 | 25.17 | 11.63 | 7.21 | *** |

In addition, 36 of 181 (19%) mature juniper trees located in juniper canyon and associated drainages were killed as a result of the fire. At least one is no longer standing. This proportion excludes the 7 dead juniper trees that we know were standing prior to the fire and includes one mature tree that was never given an identification number. At least 8 other trees have been partially killed (30-95% branch mortality).

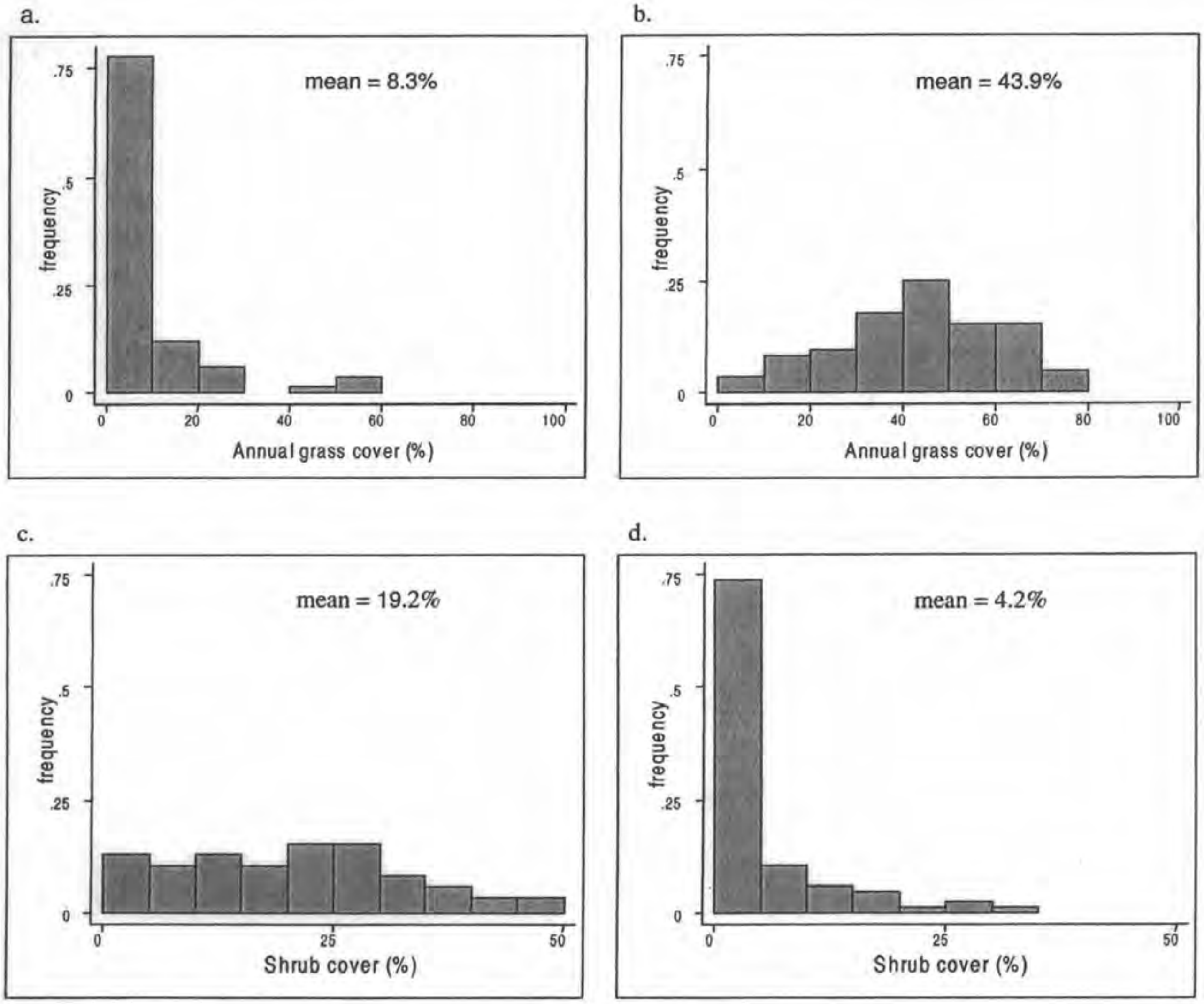


**Figure 1. Frequency distributions of cover values for annual grass before (a) and after (b), and shrub cover before(c) and after (d) the 1998 wildfire.**

**Point count surveys**

Mean abundance indices for each plot and year are presented for the most abundant species in appendix 3. Using data from all plots (therefore excluding 1995 when fewer plots were surveyed) there is little evidence for fire induced changes in abundance for Horned Lark and Grasshopper Sparrow (Figure 2). Abundance estimates for Western Meadowlark, Sage Sparrow, and Lark Sparrow, however, were all lower in the years following the fire. Models that considered annual variation both before and after the fire (and included all data gathered in 1995) were significant for several species at different scales. Western Meadowlark abundance was lower in the years after the fire, and was related to burn intensity as measured by our vegetation burn index when considered at

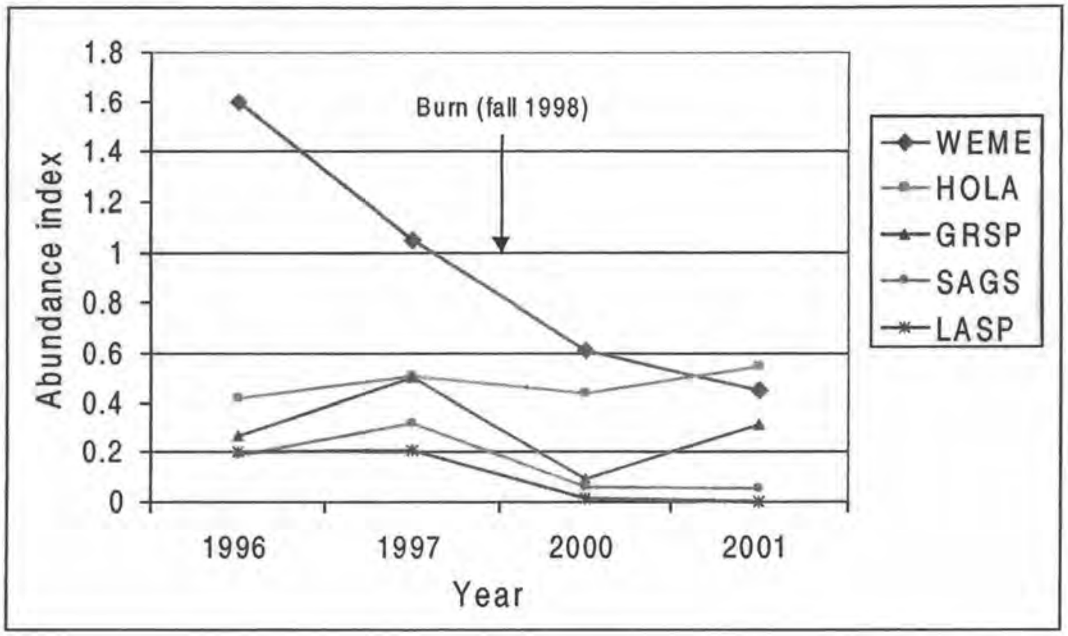


**Figure 2. Mean annual abundance indices (total detections per point across three 5-minute visits) for the 5 most common species from 8 sagebrush study plots on the Boardman bombing range. Data from 1995 is excluded due to differences in number of plots surveyed.**

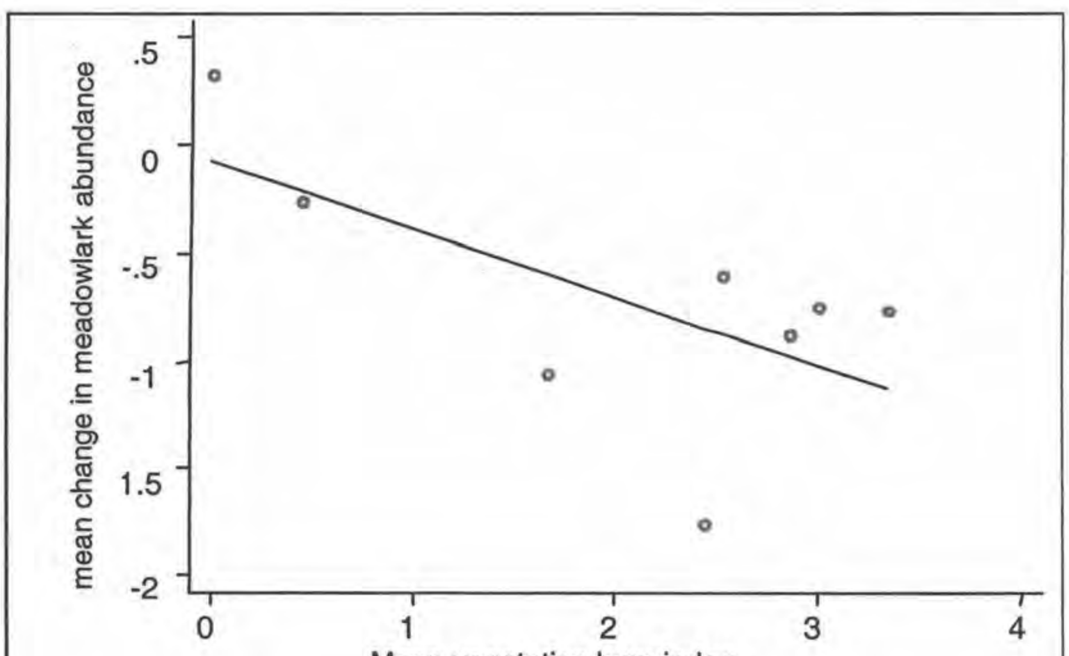


**Figure 3. Relationship between mean change in meadowlark abundance and mean vegetation burn index. Change was calculated as the post-fire annual mean minus pre-fire annual mean.**

the study plot scale (Table 4). This relationship is also shown using differences in pre- and post-fire plot means in relation to the vegetation burn index in figure 3. Grasshopper Sparrow abundance was related to burn intensity only at the scale of individual point count stations, and burn intensity explains only a very small amount of the observed variation in abundance – less so than is explained by year (Table 5). Sage Sparrow abundance was reduced following the fire, and was related to burn intensity at the local scale (Table 6). While Lark Sparrow abundance was lower in the years following the fire we did not examine this statistically due to the small number of detections.

**Table 4. Mean Western Meadowlark abundance (after controlling for variation among plots) in relation to year and average burn intensity. Six study plots were surveyed in 5 years, and an additional 2 were surveyed in 4 years. See methods for details on modeling procedure.**

| | | number of observations = 38 | Root MSE = 0.4226 | $R^2$=0.57<br>Adj. $R^2$=0.51 |
|---|---|---|---|---|
| Source | Partial SS | df | F | P > F |
| Model | 7.737 | 5 | 8.66 | <0.001 |
| Burn intensity (plot) | 0.684 | 1 | 3.83 | 0.0591 |
| Year | 2.796 | 4 | 3.91 | 0.0107 |
| Residual | 5.715 | 32 | | |
| Total | 13.452 | 37 | | |

**Table 5. Mean Grasshopper Sparrow abundance (square root transformed) in relation to year and average burn intensity at the scale of individual point count stations on the NWSTF, Boardman.** (Three plots within which Grasshopper Sparrows were not detected in any year of the study were excluded from model. 3 study plots with 9 sampling points each were surveyed in all 5 years of study, and 2 additional plots with 15 points each were surveyed in 4 years of study. See methods for details on modeling procedure. )

| | | number of observations = 255 | Root MSE = 0.4248 | $R^2$= 0.15<br>Adj. $R^2$= 0.14 |
|---|---|---|---|---|
| Source | Partial SS | df | F | P > F |
| Model | 8.27 | 5 | 9.16 | <0.001 |
| Burn intensity (point) | 0.647 | 1 | 3.58 | 0.0595 |
| Year | 4.236 | 4 | 5.87 | 0.0002 |
| Residual | 44.933 | 249 | | |
| Total | 53.202 | 254 | | |

**Table 6. Mean pre- and post-fire annual Sage Sparrow abundance in relation to local burn intensity at the scale of 50-m point count stations. Plots where Sage Sparrows were not detected either before or after the fire were excluded.**

| | number of observations = 78 | Root MSE = 0.4430 | | $R^2 = 0.12$<br>Adj. $R^2 = 0.11$ |
|---|---|---|---|---|
| Source | Partial SS | df | F | P > F |
| Model | 2.132 | 1 | 10.86 | 0.0015 |
| Burn intensity (point) | 2.132 | 1 | 10.86 | 0.0015 |
| Residual | 14.914 | 76 | | |
| Total | 17.046 | 77 | | |

**Sage Sparrow census data**

Sage Sparrow numbers on our sampling plots have declined since they were initially surveyed in 1996. Surveys documented 47 confirmed territories in 1996 (Holmes and Geupel 1998), 33 in 2000, and 34 in 2001. At 4 of 5 plots that were used by Sage Sparrows prior to the fire we observed decreases in density (Table 7). An additional remaining patch of appropriate habitat east of the Spurlock Road Plot was surveyed only in 2000 and 2001. The 4 territories confirmed in this area as well as additional off-plot territories from all years are included on Map 3 (Appendix A).

**Table 7. Summary of Sage Sparrow territories within each plot and percentage that had evidence of shrub cover loss due to the 1998 fire.**

| | # of territories | | | Number (%) of territories located in habitat that incurred shrub loss in the 1998 fire | |
|---|---|---|---|---|---|
| Plot | 1996 | 2000 | 2001 | 2000 | 2001 |
| Hey Road | 19 | 15 | 13 | 1 (6.7%) | 3 (23.1%) |
| Foot | 6 | 3 | 2 | 3 (100%) | 2 (100%) |
| Johnson | 1 | 3 | 4 | 3 (100%) | 4 (100%) |
| Southeast | 7 | 3 | 5 | 3 (100%) | 5 (100%) |
| Spurlock | 14 | 9 | 10 | 4 (44.4%) | 10 (100%) |
| Zalaco | 0 | 0 | 0 | n/a | n/a |
| **Plot Totals** | **47** | **33** | **34** | **14 (42%)** | **24 (71%)** |

During the first breeding season following the fire (1999), Sage Sparrows were observed singing and exhibiting territorial behavior in traditionally occupied areas that no longer contained live shrubs (Russ Morgan, pers. comm.). In 2000 and 2001 birds were often observed singing from snags in burnt areas but their territories always had at least small patches of live sagebrush. One exception was a pair on Southeast Plot in 2001 that nested successfully in Russian thistle that had become lodged against dead sagebrush. The nearest live shrubs were 19 m, 35 m, 41 m, and 55 m from the nest in the four respective quadrants; the nearest patch of live shrubs was 75 m from the nest.

**Loggerhead Shrike**

Population census: We documented 17 shrike territories within our census area in 2000 and 21 pairs in 2001. In contrast, prior to the 1998 fire, 35-40 pairs of shrikes were nesting each year in the same study area. In addition, we censused the patch of sagebrush and juniper trees along the west boundary of the facility (outside of study area) for shrikes and discovered one active territory. That territory extended west beyond the boundaries of the Bombing Range.

Nest monitoring: In 2000 we monitored 34 nests on 14 territories. Three were still active with nestlings when we left in mid-July. Of the 31 nests monitored to completion, only two fledged young (proportional nest success = 6.5). Our Mayfield estimate of total nest success was 11.9% (Table 8). There were 3 additional territories where we did not locate nests and 2 of these were known to produce young. Thus, depending on the outcome of the 3 nests that remained active, the proportion of territories producing young was somewhere between 23.5 and 41.2%. We estimate that 1.65 young per territory were produced making the assumption that only one of the three nests fledged young.

In 2001 we monitored 41 nests on 21 territories. Of these, 13 (32%) territories produced young. One of these fledged several days early, likely resulting from a partial depredation or depredation attempt. Mayfield estimate of total nest success this year was 26.1%. Shrikes on one of these territories produced young from a nest we did not monitor. Assuming 6 young were fledged in this brood, we estimate that 67% of territories bred successfully and an average of 3.48 young per territory were produced.

See maps 4 and 5 (Appendix A) for locations of shrike nests in all 5 years.

**Table 8. Estimates of daily and total nest survivorship (s) for Loggerhead Shrike on NWSTF, Boardman.**

| Year | Number of Nests | Days of Observation | Total s | Daily s (SE) |
|---|---|---|---|---|
| **Pre-fire** | | | | |
| 1995 | 39 | 687 | 29.7 | 0.9690 (0.007) |
| 1996 | 47 | 1116.5 | 45.6 | 0.9798 (0.004) |
| 1997 | 61 | 1362 | 39.7 | 0.9763 (0.004) |
| 1995-1997 | 147 | 3165 | 39.1 | 0.9759 (0.003) |
| **Post-fire** | | | | |
| 2000 | 34 | 510 | 11.9 | 0.9462 (0.010) |
| 2001 | 39 | 754.5 | 26.1 | 0.9655 (0.007) |
| 2000-2001 | 73 | 1264.5 | 19.0 | 0.9576 (0.006) |

There was a significant difference in daily survivorship pre- and post- fire ($x^2 = 7.96$, $P = 0.005$). Daily survivorship estimates for shrikes and Black-billed Magpies appear to track each other to some extent indicating they may face similar pressures of nest failure (Figure 4).

In the pre-fire study (n=156 nests), 91.6% of nests were placed in sagebrush, and in the years following the fire (n = 75) only 77.3% of nests were in sagebrush (Pearson $x^2 = 9.2$, $P = 0.002$). Most of the difference is explained by different rates of use for juniper trees during the same periods (from 2.6% to 13.3%). Other substrates used for nesting by shrikes on the Bombing Range include greasewood (*Sarcobatus vermiculatus*), dead Russian thistle (*Sasola Kali*), matrimony vine (*Lycium chinense*, an ornamental shrub in southern juniper canyon), and dead Jim Hill mustard (*Sysymbrium altissimum*).

Fledgling survival:

Of the 72 fledged young that we tracked, 43 (59.7%) were know to have survived 2 weeks. This proportion is identical to the survival rate at 2 weeks out of the nest determined in 1997 for 139 fledglings (Holmes and Geupel 1998).

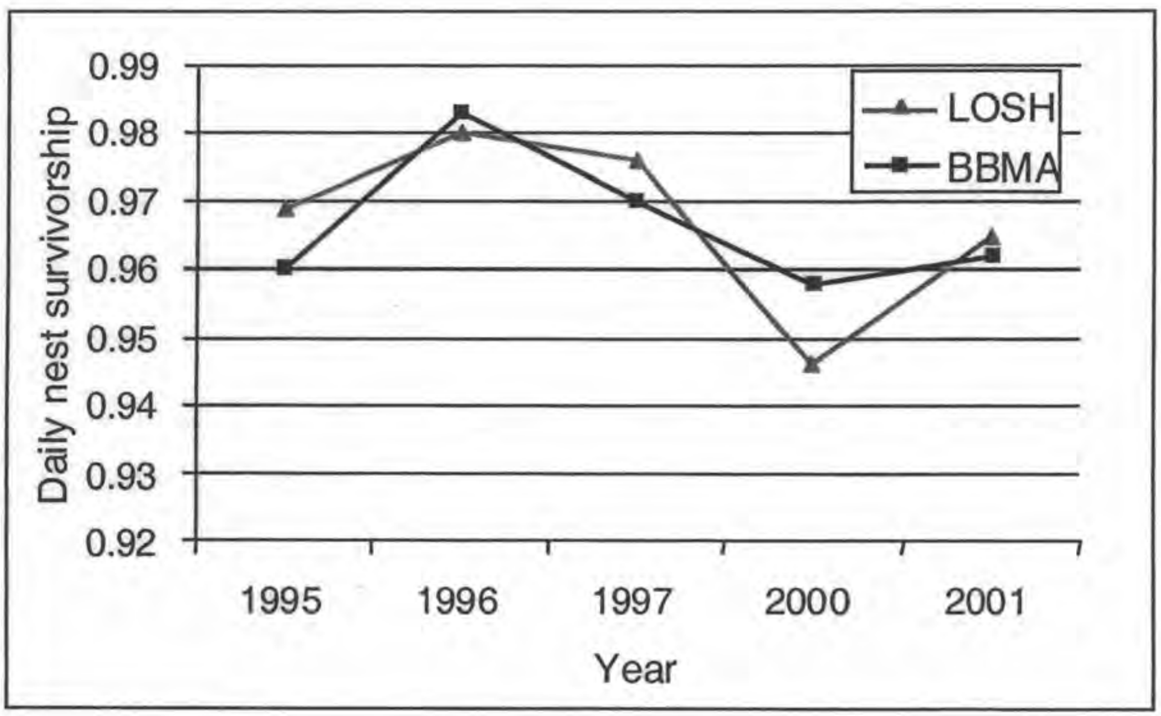


**Figure 4. Daily nest survivorship estimates for Loggerhead Shrike and Black-billed Magpie during five years of study on the Boardman Bombing Range.**

### Birds of prey and corvids

Long-eared Owls: In 2000, one Long-eared Owl nest was found (in juniper # 181) but as no extensive juniper survey was conducted we do not know if other pairs nested on the range that year. During the juniper tree nest survey in 2001, we found only one adult Long-eared Owl and no indication of nesting.

Black-billed Magpie: We observed a noticeable decline in the numbers of Black-billed Magpies breeding in the Juniper Canyon area. In 1996 and 1997 during juniper tree census work conducted between April 10 and April 23 we located 21 and 18 active magpie nests respectively. In contrast, only 10 nests were located in juniper trees during 2001. Two of 11 Black-billed Magpie nests monitored in 2000 fledged young and in 2001, 3 of 15 were successful. Eleven of 26 nests (42.3%) were preyed upon by ravens as indicated by at least partial removal of the top off the nest structure. Proportional nest success was 18% in 2000 and 20% in 2001. From 1995-1996 proportional nest success ranged from 25% to 52% (Holmes and Geupel 1998). Mayfield estimates of total survivorship were 12.4% in 2000 and 15.5% in 2001; from 1995-1997, total survivorship averaged 29% (Table 9). However, due to high variation in survivorship estimates (in particular low due to low nest success in 1995) there was not a significant effect of fire ($chi^2 = 1.19$, $P = 0.275$).

**Table 9. Mayfield estimates of nest survivorship (s) for Black-billed Magpies nesting on the NWSTF, Boardman during 5 years of study.**

| Year | Number of Nests | Days of Observation | Total s | Daily s |
|---|---|---|---|---|
| **Pre-fire** | | | | |
| 1995 | 16 | 299 | 0.137 | 0.9598 (0.011) |
| 1996 | 42 | 1094 | 0.427 | 0.9826 (0.004) |
| 1997 | 44 | 1008 | 0.231 | 0.9702 (0.005) |
| 1995-1997 | 102 | 2401 | 0.290 | 0.9748 (0.003) |
| **Post-fire** | | | | |
| 2000 | 11 | 205 | 0.124 | 0.9579 (0.014) |
| 2001 | 14 | 281 | 0.155 | 0.9623 (0.011) |
| 2000-2001 | 25 | 486 | 0.142 | 0.9605 (0.009) |

Ferruginous Hawks: In 2000 and 2001, three pairs of Ferruginous Hawks nested on the Bombing Range. The same nests were used during both years. One was in juniper # 185 (south of Hey Road), one on a nest platform located in the southeast corner of the range near the livestock pond on the Oregon Trail, and the third in a manmade rock outcrop near the southern boundary (Rattlesnake Canyon). In 2000, at least two nests fledged; we did not determine the outcome of the rock outcrop nest. In 2001 two of the nests fledged, while the pair using the rock outcrop abandoned their nest with two eggs. We do not know what prompted this abandonment.

Swainson's Hawks: Four pairs of Swainson's Hawks nested on the Bombing Range in 2000 and 2001. In both of these years, an additional pair may have nested just south of the Bombing Range in Juniper Canyon, as we sometimes observed adults behaving territorially in that area. In 2001, an apparently unmated bird built a nest in sagebrush during early May. This nest, which was located near the south boundary (on Hitchcock Rd) began losing structure almost immediately after being built.

Three of 4 nests used by Swainson's Hawks in 2000 were also used in 2001. One nest was in juniper # 17 (juniper forest), one in juniper # 138 (along Oregon trail), and one in juniper # 158 (the canyon just south of Tub Spring). A fourth pair in 2000 nested in the trees near the Hey Road / Quarisa Road intersection, but we did not find or monitor their nest. In 2001, a fourth pair nested in juniper # 150 (southwest of Tub Spring). We observed no nest loss, although both years we left while most nests still had nestlings. One nest (juniper #17) fledged 3 young in early July 2001.

Raven and crow observations: In 2000 and 2001, two pairs of Common Ravens bred in the southeast portion of the Bombing Range in juniper trees. One was located in the Juniper Forest and one at Tub Spring. In 2000, one pair fledged young; the first attempt of the other pair failed and we did not determine the outcome of their second nest. In 2001, both territories were re-occupied, and both fledged young on their first attempt. Additional pairs are known to nest in towers located further north of our study area on the bombing range. Numerous Common Ravens that were presumably not breeding were observed foraging on the Bombing Range during all years of this study. In June of 1995 through 1997 and again in 2000, groups of as many as 100 to 200 birds were observed regularly. Observed numbers of ravens were much reduced in 2001; no more than 63 birds were observed at one time, and only on 7 occasions were more than 20 birds observed together.

American Crows were observed regularly within our study area on the southern half of the range. Their distribution during this study appeared to be limited to the "lakebed area" (near plot 7). Numbers as well as frequency of detection were higher in 2000 (up to 51 individuals at a time) than in 2001 (no more than 8 individuals observed at once).

**Wildlife observations**

We detected 72 species of birds on the facility between April and July, 2000-2001 (Appendix D). Locations were recorded and are available upon request for certain species of interest that were not part of our breeding bird study, including Turkey Vulture, Golden Eagle, Red-tailed Hawk, Killdeer, Short-eared Owl, mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), Nuttall's cottontail (*Sylvilagus nutalli*) , and porcupine (*Erithizon dorsatum*). As far as we know pronghorn have not been observed on the bombing range in recent times (Livezey and Green 1999).

## DISCUSSION

### Changes in vegetation

The most dramatic effect of the 1998 wildfire on vegetation structure was reduction in the cover of sagebrush (Figure 5). We documented an overall 75% reduction in cover on our study plots – and in large areas shrubs were completely removed. Sagebrush can sometimes return to pre-burn densities within 15-30 years (Bunting 1994; Britton and Clark 1984). Recovery of shrubs has occurred fairly rapidly within a 1995 burn just north of the Oregon Trail. This was a smaller, lower intensity burn that impacted areas that contained little cheatgrass cover (ALH pers. obs). In addition, shrub loss in the 1995 fire occurred in a mosaic, which left numerous mature shrubs providing a well distributed seed source. This is important because sagebrush seeds generally fall within 1m of the shrub canopy – although wind allows some dispersal of seeds up to 30m (Meyer 1994). Nonetheless, even small patches that contained cheatgrass prior to the fire currently have fewer recruiting shrubs (Figure 6).

The 1998 fire burned a much larger area and in general resulted in more complete shrub loss and increases in the cover of cheatgrass, which does not bode well for recovery of big sagebrush. Competition for moisture with cheatgrass coupled with increased fire frequency may preclude reestablishment of sagebrush and perennial grasses (Young 1994). The Boardman area is similar in elevation and rainfall to the Snake River plains where significant conversion to annual grasslands has occurred. Cheatgrass there has been responsible for fires both more frequent and larger than those that occurred prior to settlement by Euro-americans (Whisenant 1990). Perennial grass cover on the range also increased moderately at some sites where shrub cover was reduced and sufficient perennial plants were present in the understory before the fire.

Cryptobiotic soil crusts, a component of the sagebrush steppe ecosystem whose role is not entirely understood, were much reduced where fire intensity was high and were apparently replaced with cheatgrass. In an extensive area just east of the juniper forest site crusts that was not killed directly by the fire were covered by shifting sands. These cyanobacterial-lichen and moss crusts may contribute in several ways to ecosystem function. They can enhance soil stability, reduce water runoff, and enhance establishment of some vascular plants (Belnap 1994). In addition to the substantial amount of sagebrush loss that was incurred by the 1998 fire, a significant number of the 188 mature juniper trees (19%) in the juniper canyon region were killed as well. This is a substantial reduction in the number of possible nest sites for breeding Swainson's and Ferruginous Hawks, Common Ravens, and Bullock's Orioles on the range.

### Songbird surveys

We found little evidence that fire induced habitat change affected the abundance of Grasshopper Sparrow or Horned Larks on our study plots. Grasshopper Sparrow detections were low in 2000, but returned to levels comparable to pre-fire data in 2001. We feel it is likely that low numbers in 2000 were related to regional factors (as opposed to habitat change on the bombing range) – although our study design does not allow us to make any conclusions. Interestingly, there was a tendency for greater reductions in Grasshopper Sparrow abundance at sites heavily burned in 1998 compared to sites that scored lower on the vegetation burn index (when comparing the 3-year pre-fire average with the 2-year post fire average). However this relationship was weak and not statistically significant. We had predicted that Horned Lark abundance would increase as a result of the decrease in shrub cover, a variable related negatively to their abundance in an earlier study (Holmes and Geupel 1998), but this prediction was inaccurate.

In contrast, Western Meadowlark numbers were generally lower on our plots in the years following the 1998 wildfire, and analysis suggests that this reduction resulted from fire induced habitat changes. Meadowlarks were the most abundant bird on the Bombing Range during an earlier study (Holmes and Geupel 1998), but we were never able to develop very strong predictive habitat use models. Because of this, and their similar abundance in sagebrush and annual grasslands we were hesitant to make predictions about any effect of fire-induced habitat change. Western Meadowlarks often sing from perches, preferring high shrubs that provide unobstructed views (Lanyon 1994) and abundance at Boardman before the fire was correlated with both shrub cover and shrub height (Holmes and Geupel 1998). Decreased abundance may be partly attributable to reductions in shrub cover, although this is by no means conclusively demonstrated by our data.

Sage Sparrow and Lark Sparrow were much reduced in abundance on our study areas following the 1998 wildfire. Reductions in Sage Sparrow abundance on plots where they occurred before the fire was related to the degree of shrub loss at individual sampling points. Lark Sparrows were very rare on our plots in the years following the fire; only one was detected among all 84 point count stations over both years. In a separate study during 2000 we recorded 7 Lark Sparrow detections within 50m during surveys of 22 point count stations approximately 30 km to the west at Horn Butte (PRBO unpublished data). This demonstrates they were present in the Umatilla Plateau that year and that the near absence we observed on the Bombing Range does not necessarily reflect regional patterns but may instead be related to habitat change. In further support of this conclusion, a fire burned portions of our Horn Butte study plots in the fall of 2000 and only one Lark Sparrow was detected there in 2001.

**Sage Sparrows census plots**

The number of Sage Sparrow territories on tracts of sagebrush monitored both before and after the fire declined by 27%. We believe the majority of breeding Sage Sparrows on the Bombing Range occurred within these plots and that this accurately reflects changes in the local population. In earlier work, a positive relationship between Sage Sparrow presence at point counts and sagebrush cover and stem density was demonstrated (Holmes and Geupel 1998). The 1998 wildfire resulted in severe reductions in both. In addition, Sage Sparrows were negatively associated with annual grass cover on the Bombing Range (Holmes and Geupel 1998), and cheatgrass cover increased at all our study sites in the years following the fire. We believe that the observed reduction in Sage Sparrow numbers, even in relatively unchanged areas such as the Hey Road plot, may be in part related to changes in landscape factors such as patch size and habitat homogeneity resulting from the fire. Sage Sparrows have been shown to be area sensitive (Vander Haegan et al. 2000) and more likely to occur in areas that are spatially similar to surrounding areas (Knick and Rotenberry 1995).

We observed an apparent increase in the number of Sage Sparrow territories on one survey area, Johnson Plot, despite high shrub loss. This may be due to territory "packing" of Sage Sparrows displaced from nearby areas no longer suitable for breeding. An alternative explanation is that these territories were occupied in 1996, but were not detected during our census. Sage Sparrows sing more frequently, and are therefore more likely to be detected earlier in the nesting cycle (Best and Peterson 1982), and surveys were conducted earlier in 2000-2001.

Although we did not individually mark birds, some of the territories we found in what we percieve to be marginal habitat following the 1998 fire may be testimony to the high site fidelity of Sage Sparrows (Wiens 1985, Peterson and Best 1987). Recent work suggests that in changing landscapes, historical habitat configuration can have a lasting influence on bird distribution and abundance (Knick and Rotenberry 2000). Given adult passerine mortality rates of 40-60% per year it could be expected that 12-25% of the Boardman population pre-burn would still be present during our study. Because of these factors we expect that additional reductions in Sage Sparrow density will occur over the next few years.

In the early 20$^{th}$ century, Morrow County was described as one of "the counties containing the great sagebrush areas of Oregon", and the Sage Sparrow brought "to mind the sage-covered sand areas of northern Morrow County" (Gabrielson and Jewett 1940). Today the current distributions of Sage Sparrows and of sagebrush are both much reduced in this region, and the Sage Sparrow is listed as a sensitive species in Oregon (ODFW 1997). The local breeding range for Sage Sparrows appears to be limited to remaining sagebrush on the Bombing Range and suitable habitat in the adjacent Boardman Conservation Area. Conservation efforts for Sage Sparrows should focus on preserving and restoring remaining large patches of appropriate sagebrush habitat for breeding birds, implementing fire suppression at patches with potential for future loss, maintaining or restoring native bunchgrass cover, and avoiding livestock management that results in habitat degradation (Altman and Holmes 2000).

**Loggerhead Shrike**

The reduction in breeding shrikes on the Bombing Range appears to be related to loss of suitable nesting habitat, primarily patches of mature sagebrush shrubs. Post-fire nest success was significantly lower than 1995-1997, and these were already below average for the species (Holmes and Geupel 1998). In 16 of 22 studies which summarize Loggerhead Shrike nest success (see Pruitt 2000 and Holmes and Geupel 1998), success was higher than 50%. The lowest Loggerhead Shrike nest success we have found reported for other studies was 25% (Collins 1996 *in* Pruitt 2000). Our post-fire nest success (19%) was even lower. We suspect that the reduction in sagebrush cover and patch size increased the ability of predators to find nests in the remaining sagebrush. At Boardman, ravens are the principal nest predator of magpie nests (Holmes and Geupel 1998), and the tracking of daily survivorship between shrikes and magpies suggests that ravens may be an important predator of shrike nests as well. Raven feathers were located below several failed nests allowing further support of this conclusion. Nest success was especially low in 2000 and we attribute some of this difference to differences we observed in raven use of the bombing range between 200 and 2001.

The increased use of nesting substrates other than sagebrush may reflect fire-related loss of suitable nest shrubs. The shift may also result from increased nest failure rates leading to multiple re-nesting attempts as later nests tend to be built higher off the ground (Gawlik and Bildstein 1990, Woods and Cade 1996, Holmes and Geupel 1998). After the fire 54% of all nests were renesting attempts whereas only 30% were built after initial failure in 1995-1997. The majority (86%) of nests placed in juniper trees during all years of this study were re-nesting attempts.

Our post-fledging survival rates are comparable to some other studies (Luukkonen 1987, Burton and Whitehead 1990, Poole 1992, Collister 1994) but all studies were carried out to a different time period after fledging, making comparisons difficult. However, there is some concern that post-fledging juvenile mortality rates may be a factor in population declines, and for this reason Pruitt (2000) suggests that estimating reproductive success of Loggerhead Shrike populations based only on nest success may be positively biased.

The Loggerhead Shrike is considered vulnerable in the Columbia Basin by the state of Oregon (ODFW 1997). It is also a USFWS region one species of concern, and was on the Audubon's Society Blue List of declining species every year of its publication, from 1972-1986 (Tate 1986). Populations of Loggerhead Shrike in the Columbia Plateau have been experiencing a significant long-term annual decline of 2.7% ($P < 0.01$) based on Breeding Bird Survey data from 1966-1998 (Sauer et al. 1999). During the same period they show significant annual declines across the state of Oregon of 3.4% ($P < 0.05$) and across the continent of 3.7% (Sauer et al. 1999). In fact, Loggerhead Shrikes are declining in most states, provinces, and physiographic regions in North America (Pruitt 2000, Sauer et al. 1999).

Most experts believe that the loss and degradation of appropriate breeding habitat for Loggerhead Shrikes are the major reasons for the population declines that have been observed (Cade and Woods 1997 *in* Pruitt 2000). In southeastern Oregon, where rates of conversion of shrub-steppe habitat to agriculture are relatively low, no decline has been observed in Loggerhead Shrike populations in the last two decades (Marshall et al. 1996 *in* Pruitt 2000). Specific conservation challenges for this species include: habitat conversion to agriculture; increased fire frequency and associated shrub loss related to cheatgrass invasion; poor historical and/or current grazing management resulting in changes to prey resources and degradation of vegetation; invasion of exotic grasses into previously open areas important for foraging; and sublethal effects of pesticide (Altman and Holmes 2000, Brooks and Temple 1990).

**Birds of prey and corvids**

Long-eared Owls: Perhaps the biggest change to the avifauna of the Bombing Range since the pre-fire study of 1995-1997 was the absence of breeding Long-eared Owls documented in 2001. One possibility for this change is a reduction in available nest sites. Long-eared Owls do not build their own nests but typically use nests built by other bird species in trees (Marks et al. 1994); prior to the fire, 93.3% of the 30 Long-eared Owl nests monitored were located in old magpie nests (Holmes and Geupel 1998). We noted many fewer old magpie nest structures in juniper trees during the 2001 survey than were present during surveys in 1996-1997. Another factor in this change may be the growth of hybrid poplar trees on the adjacent Potlatch tree farm. Long-eared Owls have been found nesting in corvid nests in these trees during the last several years (Russ Morgan, pers. comm.).

*Buteo* Hawks: Observations of nesting hawks in 2000-2001 suggest that similar numbers of breeding Ferruginous and slightly fewer pairs of Swainson's Hawk are breeding on the range compared to 1996-1997.

Black-billed Magpies: A reduction in the number of Black-billed Magpies breeding on the Bombing Range was observed following the wildfire. We believe it is likely that this results from a reduction in available nesting substrates (both juniper trees and sagebrush) since the 1998 wildfire. Another explanation could be the increase in available nest sites due to growth of poplar trees on the adjacent Potlach farm where Black-billed Magpies have been confirmed to breed (Brian Mosier, pers. comm.). While nest success tended to be lower after the fire the difference was not statistically significant.

Crows and Ravens: American Crows were not known to use the southern half of the facility during the 1995-97 PRBO study or during research conducted in the early 1980's (Greg Green, pers. comm.). The recent use of the southern half of the Bombing Range by American Crows may be due to the growth of trees on the adjacent Potlatch hybrid poplar farm to the appropriate size and structure to support nesting or roosting crows. In recent years, crow nests have been found at Potlatch (Russ Morgan and Brian Mosier, pers. comms.). Factors affecting raven use of the Bombing Range are not known, but reduced numbers in 2001 may be related to drought conditions.

Ravens, which depredate the nests of numerous bird species, remain the primary predator of Black-billed Magpie nests on the Bombing Range, and we believe they are a significant predator of Loggerhead Shrike nests as well. In 2000, when large numbers of American Crows and Common Ravens were observed almost daily in the lakebed area, we observed Long-billed Curlews staging in groups of up to 44 birds in late April. This may indicate high rates of nest predation from corvids, because Long-billed Curlews are thought not to re-clutch after failure of an initial attempt (Allen 1980) and April is typically the peak of the breeding season for the Boardman population (Holmes and Geupel 1998).

a)

b)

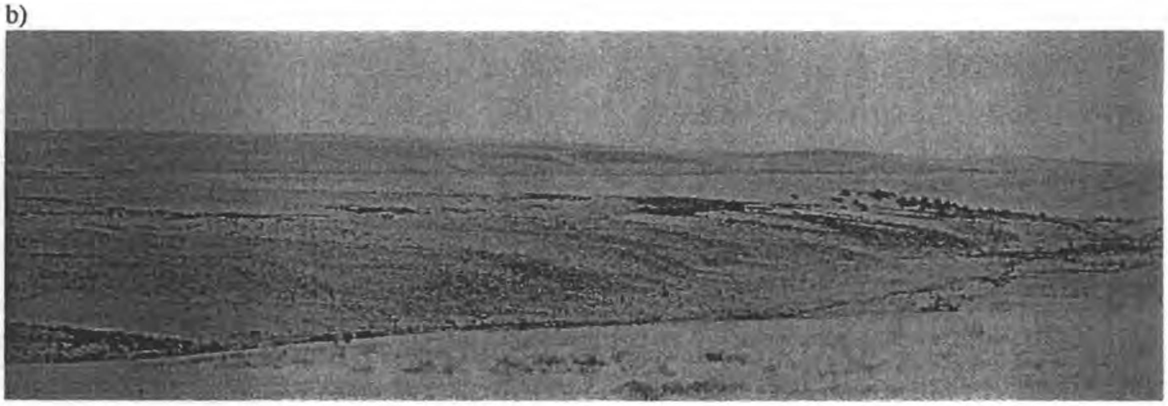

**Figure 5. Shot from north side of the Oregon trail looking West towards the juniper forest taken in 1996 (a) and in 1999 (b) showing shrub loss due to fire. This area includes part of point count plot #26 and part of the Sage Sparrow census area (SE plot).**


**Figure 6. Area burned in July 1995 showing differences in sagebrush recruitment in relation to cheatgrass density.**

## MANAGEMENT RECOMMENDATIONS

Reductions in breeding birds on the bombing range were related to the loss of sagebrush. We recommend that management steps be implemented to prevent the additional loss of sagebrush. In particular we recommend:

- Fire suppression. In particular we stress the need to protect the largest two patches of remaining sagebrush (see Appendix A). These are: the patch west and north of RNA B (encompassing point count plot 8 and Hey Road Sage Sparrow census plot); and the patch east of Tub Spring (encompassing Spurlock Road Sage Sparrow TASP Plot).

- The maintenance of certain existing roads on the facility as fire breaks. Maintenance of certain secondary roads in the Juniper Canyon area as fuel breaks may reduce the risk of future sagebrush loss. This is especially important if the Navy adopts a policy of no fire suppression unless human life or property is under threat. Roads served effectively as barriers to fire spread in the 1998 wildfire (See Appendix A Map 1).

- Livestock management practices that discourage the spread of cheatgrass and promote the growth of native perennial species. Areas currently not dominated by cheatgrass should be managed for minimal soil disturbance and maintenance of native grasses and forbs. Heavy spring grazing may prevent seed-set of native grasses and increase the likelihood of cheatgrass dominance.

- Expansion of RNA B (as proposed) to include much of the remaining sagebrush in the southeastern portion of the Bombing Range. This would protect from disturbance by livestock the 2 remaining large sagebrush patches and areas of exceptional cryptobiotic soils.

- In the proposed extension of RNA C westward to the NWSTF boundary, we recommend the inclusion of the sagebrush and juniper habitat located on the facilities west boundary. Incorporating this area would improve protection of this critical habitat while requiring little or no additional fencing.

- Experimentation with cheatgrass control and re-seeding sagebrush and native grasses. Such projects should include vegetation and wildlife monitoring.

In addition we recommend the implementation of activities that will protect bird populations on the Bombing Range, improve habitat quality, and increase our knowledge of sagebrush steppe, including:

- A buffer zone of no activity around nest sites of Ferruginous Hawks, a state sensitive species (ODFW 1997) known to sometimes desert their nests if disturbed. This may involve fencing around historic and current nest sites, particularly ones used in multiple years.

- Continue monitoring bird population and habitat changes related to the 1998 and future wildfires.

- Coordination with Potlatch to determine the extent that the hybrid poplar farm provides habitat for crows and ravens that may reduce the productivity of sensitive species using the Bombing Range through increased nest predation.

- Consider earlier removal of livestock. This would benefit numerous ground nesting species whose nests are vulnerable to trampling and who rely on grass cover for nest concealment.

- Limit livestock watering locations to sites already in poor condition.

- Develop contingency plans for livestock use in the years following fire to allow for recovery of native plants.

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This is PRBO contribution number 969.

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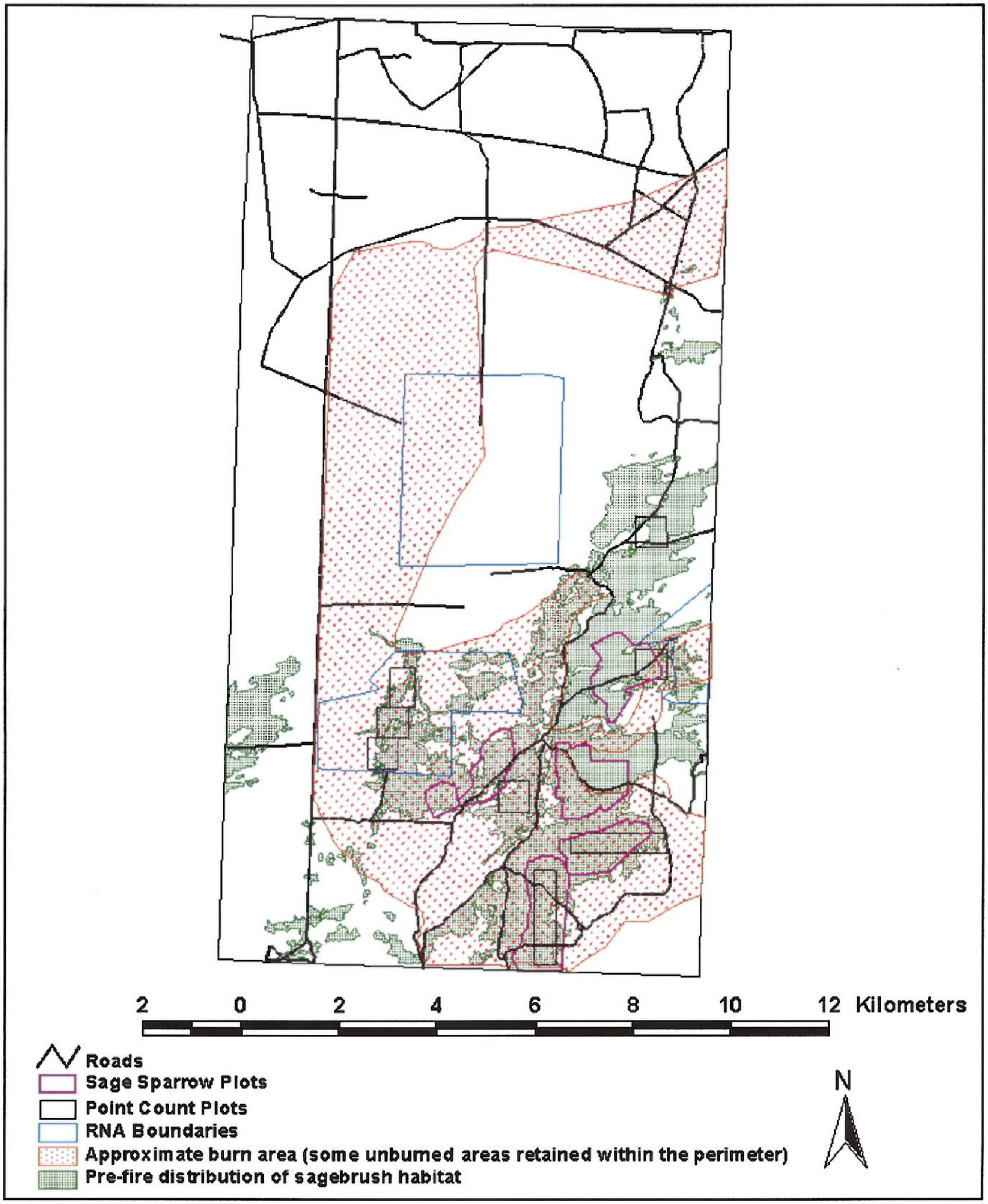
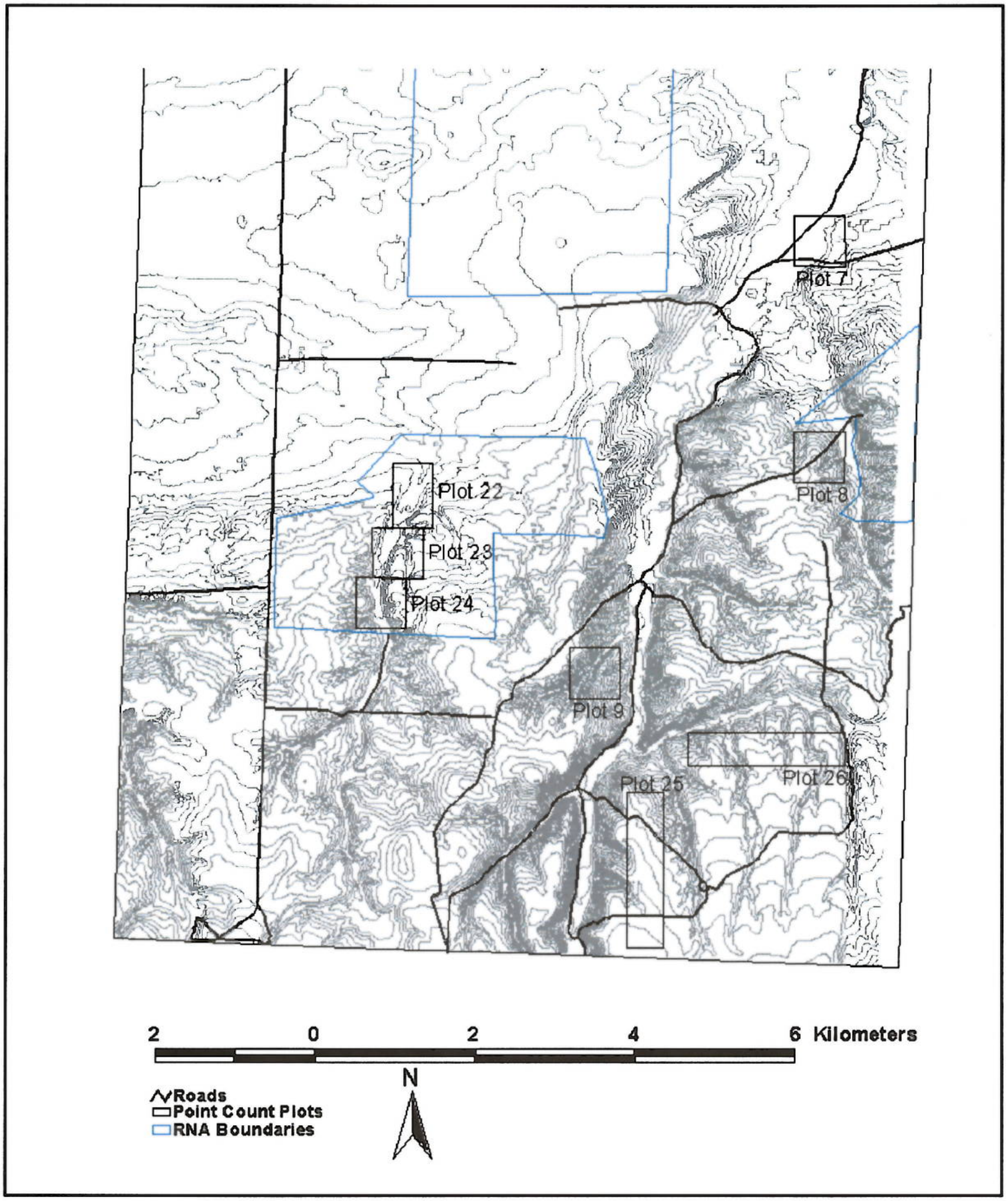
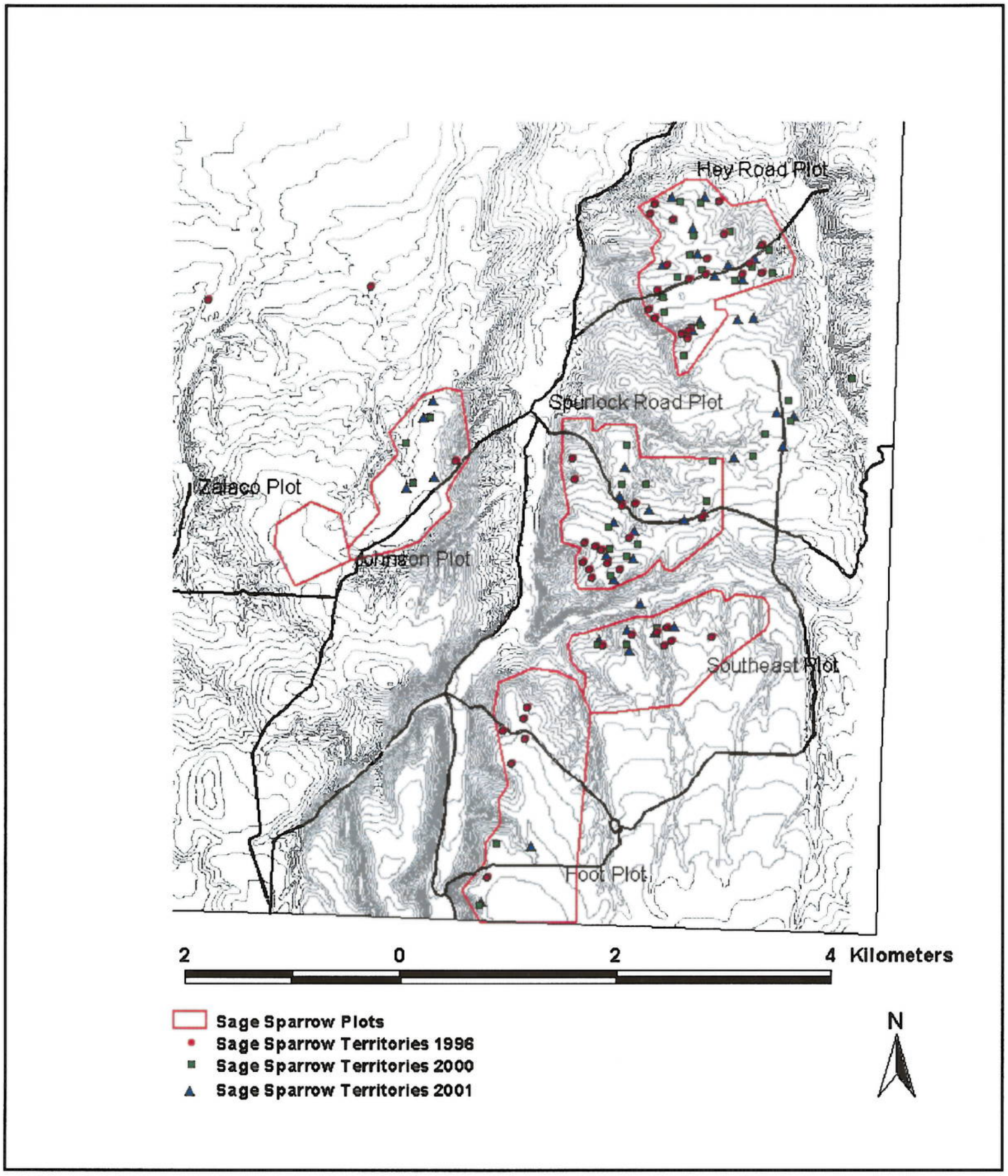


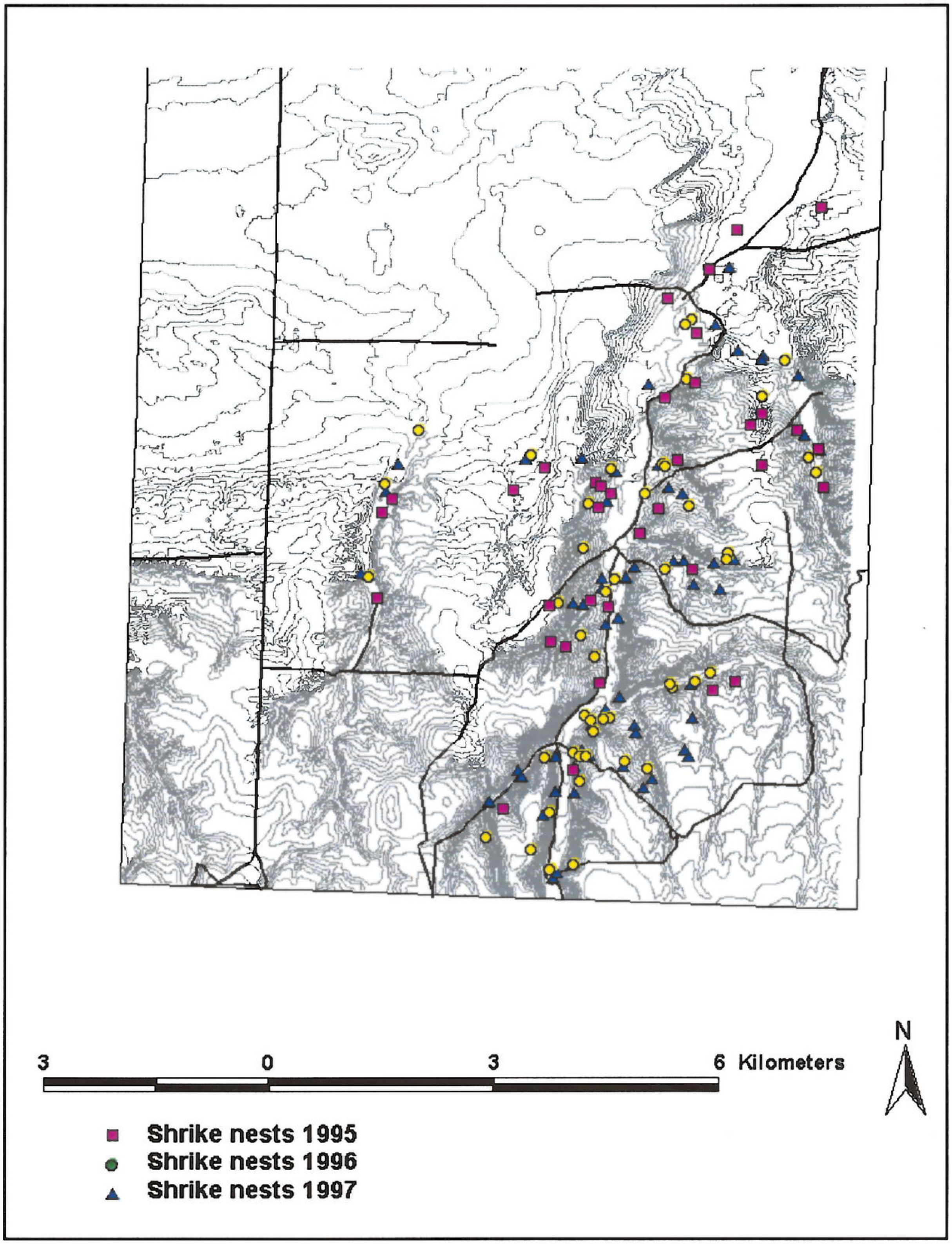

**Map 1. Extent of sagebrush prior to 1998 fire, approximate burn area, and locations of study plots, and research natural area boundaries (RNA).**



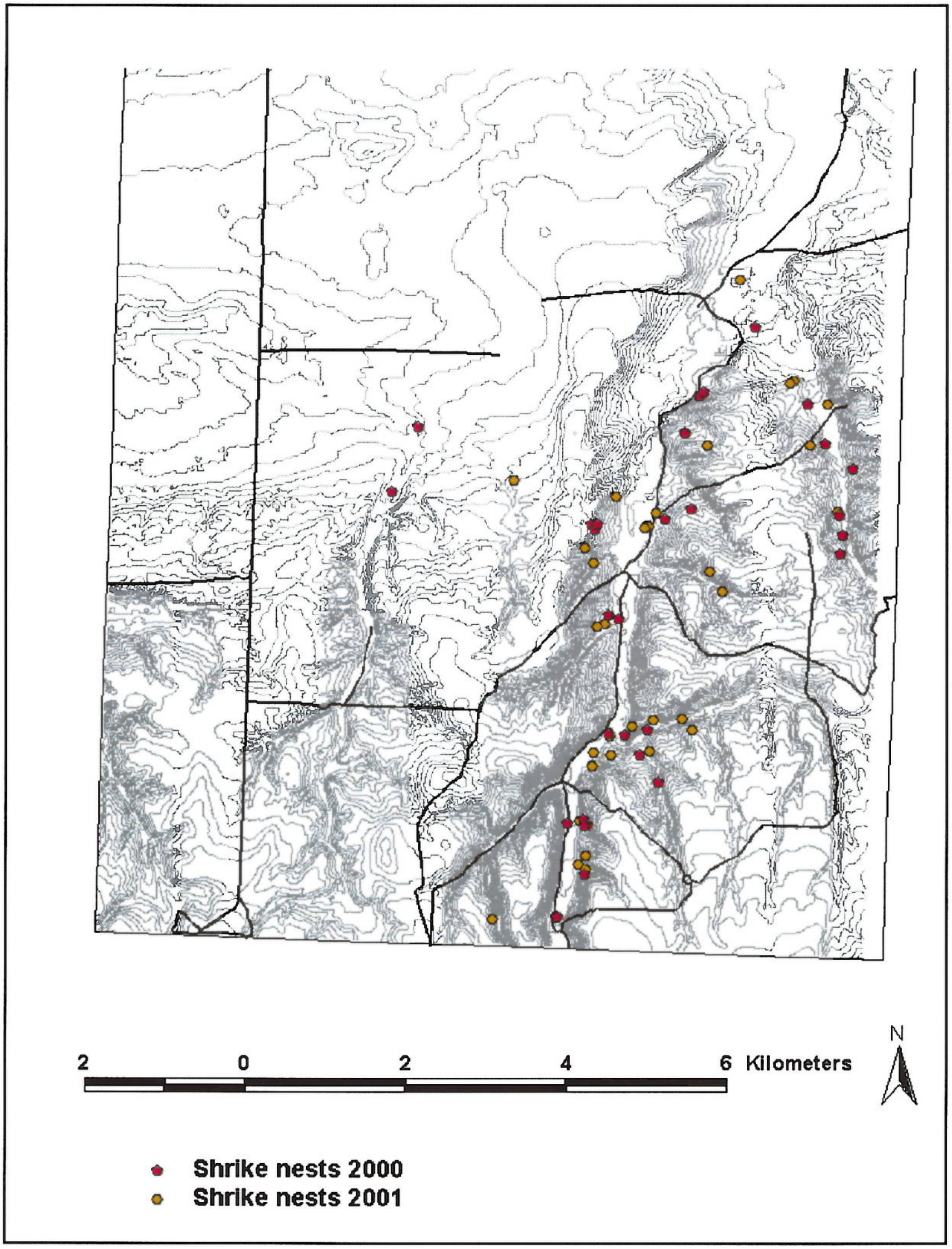

**Map 2. Locations of Point Count survey plots in sagebrush habitats of the NWSTF.**




**Map 3. Sage Sparrow census plots on the NWSTF showing confirmed territory locations in 1996, 2000, and 2001.**




**Map 4. Locations of Loggerhead Shrike nests on the NWSTF from 1995-1997 (pre- fire).**




**Map 5. Locations of Loggerhead Shrike nests on the NWSTF from 2000-2001 (post-fire)**

## Appendix B. Cover values and stem counts (mean, SD, range) taken before and after 1998 wildfire

Table B-1. Plot 7 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 17.13 (12.02) | 0 - 34.76 | 6.84 (4.77) | 0 - 15.50 |
| sagebrush height | 92.34 (42.87) | 0 - 135.61 | 94.53 (56.73) | 0 - 137.78 |
| sagebrush stems (small) | 16.56 (13.47) | 0 - 33 | 12.22 (15.30) | 0 - 45 |
| sagebrush stems (large) | 47.56 (40.39) | 0 - 110 | 11.11 (11.43) | 0 - 30 |
| shrub "snag" density | 19.33 (17.10) | 0 - 40 | 19.56 (14.60) | 0 - 44 |
| rabbitbrush cover | 0.02 (0.07) | 0 - 0.22 | 0 | 0 |
| rabbitbrush stems (small) | 0 | 0 | 0.56 (1.67) | 0 - 5 |
| rabbitbrush stems (large) | 0 | 0 | 0.56 (1.67) | 0 - 5 |
| snakeweed cover | 0 | 0 | 0 | 0 |
| annual grass cover | 12.81 (15.26) | 0.67 - 50.17 | 47.85 (17.17) | 12.33 - 67.12 |
| perennial grass cover | 0 | 0 | 0.02 (0.03) | 0 - 0.08 |
| Sandberg's bluegrass cover | 0 | 0 | 0.33 (0.73) | 0 - 2.27 |
| forb cover | 13.05 (4.77) | 5.25 - 21.58 | 5.69 (2.72) | 1.42 - 8.92 |
| total green | 24.21 (16.10) | 14.92 - 65.42 | 43.82 (15.77) | 22.25 (70.67) |
| cryptogamic crust cover | 14.06 (18.22) | 0 - 49.17 | 2.89 (3.60) | 0 - 9.83 |
| bare ground cover | 33.71 (32.63) | 2.92 - 93.17 | 22.08 (19.03) | 4.08 (63.58) |
| litter cover | 39.61 (31.70) | 1.5 - 83.33 | 21.07 (13.29) | 3.92 (42.92) |

Table B-2. Plot 8 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 34.15 (11.33) | 15.21 - 49.01 | 17.62 (9.49) | 0 - 30.6 |
| sagebrush height | 82.87 (10.42) | 67.50 - 99.16 | 80.66 (34.71) | 0 - 121.09 |
| sagebrush stems (small) | 91.67 (64.62) | 6 - 178 | 35.22 (37.73) | 0 - 96 |
| sagebrush stems (large) | 103.33 (31.70) | 55 - 145 | 48.67 (43.30) | 0 - 112 |
| shrub "snag" density | 21 (6.44) | 14 - 31 | 29.11 (13.90) | 15 - 53 |
| rabbitbrush cover | 0.06 (0.13) | 0 - 0.37 | 0.02 (0.07) | 0 - 0.22 |
| rabbitbrush stems (small) | 0 | 0 | 0 | 0 |
| rabbitbrush stems (large) | 0 | 0 | 0 | 0 |
| snakeweed cover | 1.82 (1.5) | 0 - 4.72 | 0 | 0 |
| annual grass cover | 8.14 (4.66) | 2.18 - 17.41 | 12.81 (15.26) | 0.67 - 50.17 |
| perennial grass cover | 0.05 (0.05) | 0 - 0.13 | 0 | 0 |
| Sandberg's bluegrass cover | 2.36 (1.64) | 0.41 - 5.11 | 0 | 0 |
| forb cover | 1.75 (1.16) | 0.75 - 4.17 | 13.05 (4.77) | 5.25 - 21.58 |
| total green | 12.94 (3.64) | 8.33 - 20.67 | 24.21 (16.10) | 14.92 - 65.42 |
| cryptogamic crust cover | 59.17 (26.25) | 13.92 - 86.08 | 14.06 (18.22) | 0 - 49.17 |
| bare ground cover | 15.26 (16.44) | 0.58 - 48.75 | 33.71 (32.63) | 2.92 - 93.17 |
| litter cover | 22.46 (13.81) | 7.67 - 53.67 | 39.61 (31.7) | 1.5 - 83.33 |

Table B-3. Plot 9 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 18.8 (13.37) | 0 - 39.52 | 0.57 (1.04) | 0 - 2.63 |
| sagebrush height | 74.36 (31.37) | 0 - 117.1 | 38.75 (63.25) | 0 - 173.5 |
| sagebrush stems (small) | 84.78 (81.73) | 0 - 217 | 0.11 (0.33) | 0 - 1 |
| sagebrush stems (large) | 56.56 (39.91) | 0 - 113 | 0.11 (0.33) | 0 - 1 |
| shrub "snag" density | 12.44 (16.31) | 0 - 50 | 10.67 (9.08) | 0 - 29 |
| rabbitbrush cover | 0.18 (0.05) | 0 - 0.16 | 0 | 0 |
| rabbitbrush stems (small) | 0 | 0 | 0 | 0 |
| rabbitbrush stems (large) | 0 | 0 | 0 | 0 |
| snakeweed cover | 2.45 (1.75) | 0 - 5.91 | 0.23 (0.25) | 0 - 0.62 |
| annual grass cover | 9.37 (9.57) | 1.01 - 29.08 | 54.49 (11.66) | 40.19 - 69.7 |
| perennial grass cover | 0.5 (0.46) | 0 - 1.43 | 1.22 (1.44) | 0 - 3.67 |
| Sandberg's bluegrass cover | 5.04 (5.52) | 0 - 17.2 | 14.58 (8.16) | 2.87 - 24.42 |
| forb cover | 3.3 (1.6) | 1.83 - 5.58 | 2.69 (0.86) | 1.5 - 3.75 |
| total green | 18.99 (11.28) | 9 - 36.58 | 72.78 (9.74) | 57.58 - 87.1 |
| cryptogamic crust cover | 40.93 (26.02) | 2.5 - 69.75 | 3.02 (3.96) | 0 - 10.92 |
| bare ground cover | 17.92 (19.07) | 0.08 - 53.05 | 2.65 (8.61) | 3.08 - 28.58 |
| litter cover | 38.60 (24.26) | 16.17 - 85.83 | 11.61 (4.23) | 5.5 - 18.58 |

Table B-4. Plot 22 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 15.08 (15.85) | 0 - 42.5 | 5.09 (7.05) | 0 - 18.63 |
| sagebrush height | 60.62 (47.40) | 0 - 109.92 | 60.35 (52.77) | 0 - 134.67 |
| sagebrush stems (small) | 32.44 (68.87) | 0 - 214 | 3.33 (5.85) | 0 - 17 |
| sagebrush stems (large) | 53.22 (68.13) | 0 - 202 | 4.11 (9.44) | 0 - 28 |
| shrub "snag" density | 28.67 (44.45) | 0 - 140 | 21.56 (15.91) | 1 - 57 |
| rabbitbrush cover | 9.54 (9.89) | 0 - 29.67 | 1 (0.85) | 0 - 2.18 |
| rabbitbrush stems (small) | 101.78 (111.9) | 0 - 350 | 39.11 (60.89) | 0 - 151 |
| rabbitbrush stems (large) | 10 (10) | 0 - 31 | 25.67 (36.18) | 0 - 91 |
| snakeweed cover | 2.15 (3.21) | 0 - 10.2 | 1.4 (1.91) | 0 - 4.65 |
| annual grass cover | 6.18 (3.81) | 1.09 - 13.9 | 35.66 (11.4) | 16.30 - 51.91 |
| perennial grass cover | 3.69 (7.68) | 0 - 23.20 | 6.17 (6.78) | 0.6 - 21.07 |
| Sandberg's bluegrass cover | 0.62 (1.19) | 0 - 2.97 | 4.06 (5.68) | 0 - 17.11 |
| forb cover | 5.36 (3.24) | 1.33 - 11.08 | 7.07 (3.19) | 3.92 (12.58) |
| total green | 18.36 (6.76) | 9.25 - 30.75 | 53.89 (8.85) | 38.58 - 64.75 |
| cryptogamic crust cover | 29.74 (22.53) | 8.67 - 80.17 | 4.11 (1.97) | 1.75 - 7.83 |
| bare ground cover | 44.87 (23.44) | 4.92 - 76.42 | 27.61 (8.14) | 15.25 - 42.33 |
| litter cover | 17.28 (9.70) | 7.67 - 31.83 | 13.95 (5.88) | 6.83 - 26.33 |

Table B-5. Plot 23 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 7.87 (6.76) | 1.63 - 23.03 | 0.80 (1.91) | 0 – 5.73 |
| sagebrush height | 70.18 (9.79) | 59.87 - 86.17 | 19.16 (38.03) | 0 - 88 |
| sagebrush stems (small) | 44.22 (50.49) | 4 - 145 | 0 | 0 |
| sagebrush stems (large) | 55.67 (45.37) | 6 - 135 | 0 | 0 |
| shrub "snag" density | 10.89 (8.58) | 1 - 25 | 8.67 (7.4) | 2 - 25 |
| rabbitbrush cover | 0.2 (0.34) | 0 - 0.92 | 0.01 (0.02) | 0 - 0.06 |
| rabbitbrush stems (small) | 0 | 0 | 0 | 0 |
| rabbitbrush stems (large) | 0 | 0 | 0 | 0 |
| snakeweed cover | 0.18 (0.33) | 0 - 0.95 | 0.12 (0.27) | 0 - 0.8 |
| annual grass cover | 20.57 (24.84) | 0.12 - 57.53 | 39.86 (29.05) | 8.42 (75.21) |
| perennial grass cover | 12.43 (10.05) | 0.09 - 25.18 | 16.5 (11.44) | 0.40 - 29.79 |
| Sandberg's bluegrass cover | 1.00 (0.53) | 0.27 - 1.86 | 11.85 (5.84) | 2.70 - 19.58 |
| forb cover | 3.44 (2.23) | 1.83 - 8.50 | 4.52 (1.54) | 2.42 - 7.5 |
| total green | 37.68 (17.58) | 16 - 65.25 | 74.59 (14.05) | 56.42 - 91.25 |
| cryptogamic crust cover | 48.06 (30.06) | 5 - 82.33 | 8.02 (8.24) | 0 - 19 |
| bare ground cover | 5.4 (5.73) | 0.92 - 19.83 | 9.97 (8.08) | 0.58 - 23.58 |
| litter cover | 29.37 (25.19) | 4.42 - 66.67 | 7.77 (3.73) | 2.08 - 13.08 |

Table B-6. Plot 24 vegetation variable means before and after 1998 wildfire.

| | Pre-fire | | Post-fire | |
|---|---|---|---|---|
| Variable | mean (SD) | range | mean (SD) | range |
| sagebrush cover | 15.70 (12.63) | 3.89 - 39.33 | 1.7 (1.36) | 0 - 3.74 |
| sagebrush height | 71.85 (11.23) | 57 - 86.80 | 86.4 (47.61) | 0 - 160 |
| sagebrush stems (small) | 37.56 (25.64) | 6 - 82 | 10.22 (21.17) | 0 - 65 |
| sagebrush stems (large) | 43.67 (45.39) | 3 -149 | 10.44 (17.41) | 0 - 54 |
| shrub "snag" density | 12.78 (9.01) | 2 – 27 | 13.89 (8.33) | 4 - 31 |
| rabbitbrush cover | 0.43 (0.83) | 0 - 2.54 | 0.11 (0.28) | 0 - 0.83 |
| rabbitbrush stems (small) | 10.11 (23.5) | 0 - 72 | 1 (3) | 0 - 9 |
| rabbitbrush stems (large) | 0 | 0 | 0 | 0 |
| snakeweed cover | 0.13 (0.22) | 0 - 0.62 | 0.07 (0.19) | 0 - 0.58 |
| annual grass cover | 4.95 (6.62) | 0.09 - 20 | 25.27 (13.05) | 5.04 - 45.06 |
| perennial grass cover | 17.73 (9.83) | 2.32 - 34.02 | 16.75 (7.55) | 7.13 - 31.46 |
| Sandberg's bluegrass cover | 3.54 (2.78) | 0.82 - 8.94 | 12.33 (5.38) | 7.37 - 25.39 |
| forb cover | 2.73 (1.32) | 1.25 - 4.83 | 2.99 (1.92) | 0.83 - 6.67 |
| total green | 29.93 (8.42) | 15.67 - 43.33 | 61.03 (14.45) | 46 - 85.42 |
| cryptogamic crust cover | 58.51 (19.84) | 13 - 78.33 | 20.08 (11.28) | 4.92 - 31.92 |
| bare ground cover | 14.08 (15.66) | 0.5 - 48.83 | 14.33 (8.84) | 3 - 30.58 |
| litter cover | 12.66 (11.27) | 2.5 - 35.58 | 7.14 (2.27) | 4.58 - 11.50 |

Table B-7. Plot 25 vegetation variable means before and after 1998 wildfire.

| Variable | Pre-fire mean (SD) | Pre-fire range | Post-fire mean (SD) | Post-fire range |
|---|---|---|---|---|
| sagebrush cover | 16.01 (8.6) | 2.57 - 30.01 | 0.79 (1.17) | 0 - 3.79 |
| sagebrush height | 89.67 (11.0) | 70.88 - 107.5 | 52.00 (52.31) | 0 - 147.33 |
| sagebrush stems (small) | 145.8 (121.24) | 14 - 394 | 4.13 (9.22) | 0 - 34 |
| sagebrush stems (large) | 90.13 (52.94) | 14 - 224 | 3.89 (9.20) | 0 - 35 |
| shrub "snag" density | 13.13 (12.25) | 3 - 42 | 15.07 (9.28) | 1 - 38 |
| rabbitbrush cover | 0.69 (1.35) | 0 - 4.55 | 0.07 (0.18) | 0 - 0.67 |
| rabbitbrush stems (small) | 9.33 (21.63) | 0 - 70 | 7.67 (16.36) | 0 - 49 |
| rabbitbrush stems (large) | 1.07 (2.28) | 0 - 7 | 7.67 (16.36) | 0 - 49 |
| snakeweed cover | 1.58 (3.30) | 0 - 12.89 | 0.47 (1.41) | 0 - 5.53 |
| annual grass cover | 4.46 (3.29) | 1.01 - 14.58 | 46.90 (16.93) | 7.11 - 69.46 |
| perennial grass cover | 0.34 (0.20) | 0 - 0.71 | 2.04 (2.23) | 0 - 7.76 |
| Sandberg's bluegrass cover | 4.94 (3.49) | 0.42 - 12.75 | 20.95 (11.34) | 2.63 - 45.17 |
| forb cover | 1.45 (0.61) | 0.83 - 2.67 | 2.38 (2.17) | 0.83 - 9.67 |
| total green | 10.63 (3.91) | 6.33 - 19 | 72.33 (19.2) | 24.5 - 94.42 |
| cryptogamic crust cover | 48.92 (27.09) | 7.67 - 92.33 | 1.38 (2.31) | 0 - 7.58 |
| bare ground cover | 2.86 (9.20) | 0 - 36.08 | 16.12 (20.77) | 1.25 - 71.83 |
| litter cover | 51.02 (26.37) | 10.75 - 91.67 | 10.14 (3.89) | 3.58 - 17.58 |

Table B-8. Plot 26 vegetation variable means before and after 1998 wildfire.

| Variable | Pre-fire mean (SD) | Pre-fire range | Post-fire mean (SD) | Post-fire range |
|---|---|---|---|---|
| sagebrush cover | 26.23 (8.54) | 15.84 - 42.6 | 2.94 (6.12) | 0 - 19.64 |
| sagebrush height | 74.28 (9.46) | 56.93 - 94.89 | 23.17 (34.26) | 0 - 80 |
| sagebrush stems (small) | 76.73 (49.60) | 5 - 190 | 8.93 (21.39) | 0 - 67 |
| sagebrush stems (large) | 101.27 (63.78) | 15 - 248 | 12.33 (27.73) | 0 - 88 |
| shrub "snag" density | 19.2 (8.44) | 4 – 34 | 16.53 (10.15) | 5 – 25 |
| rabbitbrush cover | 0.23 (0.49) | 0 - 1.71 | 0 | 0 |
| rabbitbrush stems (small) | 2.8 (9.79) | 0 - 38 | 0 | 0 |
| rabbitbrush stems (large) | 0.13 (0.52) | 0 - 2 | 0 | 0 |
| snakeweed cover | 1.38 (2.57) | 0 - 9.59 | 0.30 (0.69) | 0 - 2.66 |
| annual grass cover | 4.59 (3.94) | 0.45 - 12.75 | 49.75 (11.13) | 29.43 – 63.75 |
| perennial grass cover | 0.71 (1.08) | 0 - 4.17 | 2.46 (2.88) | 0 - 9.51 |
| Sandberg's bluegrass cover | 4.55 (3.12) | 0 - 8.58 | 18.32 (10.11) | 0 - 30.62 |
| forb cover | 2.36 (2.90) | 0.75 - 12.08 | 1.78 (1.32) | 0.08 - 4.25 |
| total green | 11.82 (4.81) | 3.33 - 23.42 | 72.76 (12.42) | 40.83 - 85.42 |
| cryptogamic crust cover | 48.38 (34.32) | 3.58 - 93.17 | 0.51 (1.35) | 0 - 5.33 |
| bare ground cover | 33.52 (29.96) | 1 - 90.83 | 18.83 (12.44) | 6.67 - 54.58 |
| litter cover | 18.31 (22.16) | 3.42 - 85 | 7.97 (3.51) | 4.25 - 14.08 |

TABLE C-1. Mean number of Long-billed Curlews detected per point within 50 meters, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| **Plot (# pts)** | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 0.44 (0.34) | 0.22 (0.15) | 0.22 (0.15) | 0.33 (0.24) | 0.22 (0.22) |
| 08 (9) | 0 | 0 | 0.22 (0.22) | 0 | 0 |
| 09 (9) | 0.22 (0.15) | 0.11(0.11) | 0 | 0 | 0.11 (0.11) |
| 22 (9) | 0.22 (0.22) | 0 | 0.22 (0.15) | 0 | 0 |
| 23 (9) | 0.04 (0.03) | 0.11 (0.11) | 0 | 0 | 0 |
| 24 (9) | 0.22 (0.15) | 0 | 0.11 (0.11) | 0 | 0 |
| 25 (15) | not counted | 0.20 (0.14) | 0 | 0.13 (0.13) | 0 |
| 26 (15) | not counted | 0 | 0.73 (0.56) | 0.67 (0.25) | 0.20 (0.14) |

TABLE C-2. Mean number of Horned Larks detected per point within 50 meters, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| **Plot (# pts)** | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 0 | 0.78 (0.52) | 0 | 0 | 0 |
| 08 (9) | 0 | 0 | 0 | 0 | 0 |
| 09 (9) | 0 | 0 | 0 | 0 | 0 |
| 22 (9) | 0 | 0.7 (0.29) | 0.44 (0.18) | 0.33 (0.24) | 2.11 (0.56) |
| 23 (9) | 0.22 (0.15) | 1.0 (0.37) | 1.78 (0.49) | 1.0 (0.47) | 0.56 (0.24) |
| 24 (9) | 0.56 (0.34) | 0.78 (0.36) | 2.56 (1.03) | 1.11 (0.65) | 1.22 (0.49) |
| 25 (15) | not counted | 0.40 (0.24) | 0 | 0.20 (0.14) | 0 |
| 26 (15) | not counted | 0 | 0 | 0.80 (0.24) | 0.73 (0.27) |

TABLE C-3. Mean number of Grasshopper Sparrows detected per point within 50 meters, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| **Plot (# pts)** | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 0 | 0 | 0 | 0 | 0 |
| 08 (9) | 0 | 0 | 0 | 0 | 0 |
| 09 (9) | 0 | 0 | 0 | 0 | 0 |
| 22 (9) | 0.67 (0.24) | 0.78 (0.36) | 0.56 (0.29) | 0 | 0.67 (0.33) |
| 23 (9) | 2.0 (0.41) | 0.22 (0.15) | 2.56 (0.47) | 0.11 (0.11) | 0.56 (0.24) |
| 24 (9) | 2.44 (1.21) | 1.22 (0.52) | 1.0 (0.37) | 0.78 (0.28) | 1.67 (0.62) |
| 25 (15) | not counted | 0 | 0.07 (0.07) | 0 | 0 |
| 26 (15) | not counted | 0.20 (0.14) | 0.27 (0.12) | 0 | 0 |

TABLE C-4. Mean number of Lark Sparrows detected per point within 50 meters, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| Plot (# pts) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 0.89 (0.31) | 0.22 (0.15) | 0 | 0 | 0 |
| 08 (9) | 0.44 (0.29) | 0.44 (0.29) | 0.22 (0.22) | 0.11 (0.11) | 0 |
| 09 (9) | 1.0 (0.44) | 0.56 (0.29) | 0.67 (0.37) | 0 | 0 |
| 22 (9) | 0 | 0 | 0.11 (0.11) | 0 | 0 |
| 23 (9) | 0 | 0.22 (0.22) | 0 | 0 | 0 |
| 24 (9) | 0.11 (0.11) | 0 | 0 | 0 | 0 |
| 25 (15) | not counted | 0.07 (0.07) | 0.47 (0.22) | 0 | 0 |
| 26 (15) | not counted | 0.20 (0.11) | 0.13 (0.09) | 0 | 0 |

TABLE C-5. Mean number of Sage Sparrows detected per point within 50 meters, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| **Plot (# pts)** | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 0 | 0 | 0 | 0 | 0 |
| 08 (9) | 0.22 (0.14) | 0.33 (0.24) | 0.67 (0.44) | 0.11 (0.11) | 0 |
| 09 (9) | 0 | 0 | 0 | 0 | 0 |
| 22 (9) | 0 | 0 | 0 | 0 | 0 |
| 23 (9) | 0 | 0 | 0 | 0 | 0 |
| 24 (9) | 0 | 0 | 0 | 0 | 0 |
| 25 (15) | not counted | 0 | 1.33 (0.50) | 0 | 0 |
| 26 (15) | not counted | 0.87 (0.34) | 0.07 (0.07) | 0.27 (0.18) | 0.27 (0.21) |

TABLE C-6. Mean number of Western Meadowlarks detected within 50 meters of each point, by plot, for three years prior to the fire and two years post-fire.

| | 1995 | 1996 | 1997 | 2000 | 2001 |
|---|---|---|---|---|---|
| **Plot (# pts)** | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| 07 (9) | 1.22 (0.32) | 1.33 (0.65) | 0.44 (0.24) | 1.56 (0.56) | 1.11 (0.42) |
| 08 (9) | 1.11 (0.35) | 0.56 (0.24) | 0.44 (0.24) | 0.56 (0.18) | 0.33 (0.33) |
| 09 (9) | 0.67 (0.24) | 2.0 (0.55) | 0.89 (0.42) | 0.44 (0.18) | 0.44 (0.18) |
| 22 (9) | 1.11 (0.59) | 2.78 (1.01) | 1.44 (0.63) | 1.0 (0.44) | 0.44 (0.34) |
| 23 (9) | 1.22 (0.68) | 2.0 (0.33) | 1.22 (0.76) | 0.67 (0.29) | 0.78 (0.36) |
| 24 (9) | 1.33 (0.41) | 2.89 (0.59) | 1.89 (0.61) | 0.33 (0.17) | 0.22 (0.15) |
| 25 (15) | not counted | 1.47 (0.26) | 0.80 (0.22) | 0.67 (0.35) | 0.40 (0.19) |
| 26 (15) | not counted | 0.60 (0.24) | 1.27 (0.33) | 0 | 0.13 (0.09) |

State sensitive species are listed in bold (ODFW 1997 list) and confirmed or suspected breeders on NWSTF are marked by an asterisk.

Black-crowned Night-heron
Great Blue Heron
Mallard
*Killdeer
***Long-billed Curlew**
Ring-billed Gull
Turkey Vulture
Golden Eagle
*Northern Harrier
Sharp-shinned Hawk
Red-tailed Hawk
***Swainson's Hawk**
Rough-legged Hawk
***Ferruginous Hawk**
*American Kestrel
Prairie Falcon
*Gray Partridge
*Ring-necked Pheasant
*Morning Dove
*Rock Dove
*Barn Owl
*Short-eared Owl
*Long-eared Owl
***Burrowing Owl**
*Common Nighthawk
Red-shafted Flicker
*Western Kingbird
*Say's Phoebe
Dusky Flycatcher
*Horned Lark
*Northern Rough-winged Swallow
Bank Swallow
Violet-green Swallow
Tree Swallow
Cliff Swallow
Barn Swallow
*Black-billed Magpie
American Crow
*Common Raven
Mountain Chickadee
*Rock Wren
American Robin
Mountain Bluebird
Western Bluebird
Hermit Thrush
Ruby-crowned Kinglet
Golden-crowned Kinglet
***Loggerhead Shrike**
*Sage Thrasher
*European Starling
Townsend's Warbler
Yellow-rumped Warbler
Black-headed Grosbeak
*Lark Sparrow
***Sage Sparrow**
***Grasshopper Sparrow**
Savannah Sparrow
*Brewer's Sparrow
Vesper Sparrow
Chipping Sparrow
White-crowned Sparrow
Golden-crowned Sparrow
Spotted Towhee
Oregon Junco
*Western Meadowlark
*Brewer's Blackbird
Red-winged Blackbird
*Bullock's Oriole
*Brown-headed Cowbird
*House Sparrow
American Goldfinch
House Finch

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# JUNIPER TREE SURVEY DATA

| TREE# | LAT_NAD83 | LONG_NAD83 | UTM_EAST27 | UTM_N27 | UTM_EAST83 | UTM_N83 | HEIGHT_m | STEMS | CIRC_cm | ASP | COND_1995 | OLD_NESTS | NESTS_1995 | NOTES_1995 | COND_2008 | YR_KILLED | NOTES_2008 | NEST_2008 | TYPE_2008 | NEST_2014 | TYPE_2014 | FLEDG_2014 | NEST_2015 | TYPE_2015 | FLEDG_2015 | NEST_2016 | TYPE_2016 | FLEDG_2016 | NEST_2017 | TYPE_2017 | FLEDG_2017 | NEST_2018 | TYPE_2018 | FLEDG_2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45.64178 | -119.67232 | 291826 | 5057523 | 291744 | 5057728 | | 1 | 100 | W | L | FEHA,BBMA | | FURTHEST SOUTH TREE IN JUNIPER CYN | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 2 | 45.64717 | -119.67163 | 292042 | 5057871 | 291960 | 5058076 | 10.3 | 3 | 46 | SW | L | FEHA | | | ALIVE | | | YES | UNKNOWN | | | | | | | | | | | | | | | |
| 3 | 45.64694 | -119.67062 | 291983 | 5058094 | 291901 | 5058299 | | 0 | 89 | W | L | FEHA | | OLD NEST BLOWN OUT | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 4 | 45.64689 | -119.67069 | 291970 | 5058087 | 291888 | 5058292 | 2.8 | 2 | 32 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 5 | 45.64694 | -119.67157 | 291904 | 5058098 | 291822 | 5058303 | 2.8 | 3 | 67 | W | L | | | CIRC IS AT .5 M ABOVE GROUND | ALIVE | | | | | | | | | | | | | | | | | | | |
| 6 | 45.64707 | -119.67202 | 291873 | 5058110 | 291791 | 5058315 | 4.6 | 1 | 86 | W | L | SWHA | | | ALIVE | | | | | | | | | | | YES | SWAINSON'S HAWK | UNKNOWN | | | | | | |
| 7 | 45.64705 | -119.67204 | 291870 | 5058106 | 291788 | 5058311 | 4.4 | 1 | 66 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 8 | 45.64763 | -119.67073 | 291980 | 5058161 | 291898 | 5058366 | 3.9 | 2 | 49 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 9 | 45.65028 | -119.67643 | 291543 | 5058475 | 291461 | 5058680 | 4.5 | 7 | 85 | na | PD | FEHA,LEOW | | ONLY 3 STEMS HAVE LIFE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 10 | 45.64975 | -119.66906 | 292114 | 5058397 | 292032 | 5058602 | 4.3 | 1 | 70 | W | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 11 | 45.64971 | -119.66960 | 292071 | 5058398 | 291989 | 5058603 | 3.1 | 5 | 36 | W | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 12 | 45.64978 | -119.67009 | 292041 | 5058400 | 291959 | 5058605 | 4.4 | 1 | 68 | W | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 13 | 45.65033 | -119.67024 | 292023 | 5058462 | 291941 | 5058667 | 5.8 | 3 | 92 | W | L | CORA | | OLD RAVEN NEST BLOWN OUT | DEAD | 2008 | | YES | FERRUGINOUS HAWK | | | | | | | | | | | | | | | |
| 14 | 45.65037 | -119.67134 | 291938 | 5058467 | 291856 | 5058672 | 3.6 | 5 | 83 | W | L | FEHA | | A VERY CONTORTED TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 15 | 45.65053 | -119.67217 | 291871 | 5058488 | 291789 | 5058693 | 4.8 | 1 | 111 | SW | PD | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 16 | 45.65133 | -119.67126 | 291975 | 5058566 | 291893 | 5058771 | 4.2 | 1 | 85 | W | L | | | LG JUNIPER S. END OF JUNIPER SLOPE | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 17 | 45.65184 | -119.67244 | 291858 | 5058636 | 291776 | 5058841 | 5.6 | 2 | 92 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 18 | 45.65226 | -119.67232 | 291866 | 5058687 | 291784 | 5058892 | 6 | 1 | 102 | na | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 19 | 45.65287 | -119.67246 | 291855 | 5058747 | 291773 | 5058952 | 5 | 1 | 66 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 20 | 45.65289 | -119.67248 | 291854 | 5058757 | 291772 | 5058962 | 4.4 | 1 | 77 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 21 | 45.65289 | -119.67253 | 291854 | 5058756 | 291772 | 5058961 | 4.6 | 1 | 56 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 22 | 45.65285 | -119.67252 | 291853 | 5058751 | 291771 | 5058956 | 4.7 | 1 | 56 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 23 | 45.65286 | -119.67250 | 291855 | 5058750 | 291773 | 5058955 | 4 | 2 | 0 | W | L | | | MOSTLY DEAD, SMALL AMT OF GREEN | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 24 | 45.65287 | -119.67265 | 291842 | 5058752 | 291760 | 5058957 | 2.5 | 1 | 47 | W | L | | | SM TREE, LEANING, ROOTS EXPOSED | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 25 | 45.65295 | -119.67228 | 291871 | 5058763 | 291789 | 5058968 | 3 | 1 | 71 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 26 | 45.65316 | -119.67221 | 291880 | 5058385 | 291798 | 5058590 | 4.1 | 1 | 88 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 27 | 45.65317 | -119.67220 | 291880 | 5058385 | 291798 | 5058590 | 5.3 | 1 | 82 | W | L | | | ONLY 40 cm FROM #26 | ALIVE | | | | | | | | | | | | | | | | | | | |
| 28 | 45.65268 | -119.67185 | 291905 | 5058732 | 291823 | 5058937 | 4.2 | 1 | 86 | W | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 29 | 45.65357 | -119.67223 | 291880 | 5058827 | 291798 | 5059032 | 4.1 | 3 | 52 | W | L | | | #29, 30 ARE VERY CLOSE TO EACH OTHER | ALIVE | | | | | | | | | | | | | | | | | | | |
| 30 | 45.65358 | -119.67222 | 291881 | 5058832 | 291799 | 5059037 | 5.2 | 1 | 97 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 31 | 45.65388 | -119.67195 | 291901 | 5058867 | 291819 | 5059072 | 3.1 | 2 | 58 | na | D | | | SMALL DEAD JUNIPER ON THE FLAT | DEAD | <1998 | | | | | | | | | | | | | | | | | | |
| 32 | 45.65390 | -119.67171 | 291920 | 5058870 | 291838 | 5059075 | 5.1 | 2 | 75 | | L | | | 25 m NORTH OF DEAD JUNIPER | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 33 | 45.65380 | -119.67172 | 291923 | 5058859 | 291841 | 5059064 | 4.9 | 1 | 80 | | L | | | 25 m NE OF DEAD JUNIPER | ALIVE | | | | | | | | | | | | | | | | | | | |
| 34 | 45.65372 | -119.67159 | 291927 | 5058851 | 291845 | 5059056 | 5.9 | 1 | 81 | na | L | CORA | | NEST WAS ACTIVE IN 1994 | ALIVE | | | | | | | | | | | | | | | | | | | |
| 35 | 45.65518 | -119.67092 | 291991 | 5059014 | 291909 | 5059219 | 4.5 | 1 | 77 | na | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 36 | 45.65166 | -119.67093 | 291970 | 5058613 | 291888 | 5058818 | 4.8 | 7 | 70 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 37 | 45.65189 | -119.67098 | 291971 | 5058638 | 291889 | 5058843 | 5.1 | 3 | 67 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 38 | 45.65212 | -119.67076 | 291995 | 5058665 | 291913 | 5058870 | 4.9 | 9 | 87 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 39 | 45.65210 | -119.67064 | 292003 | 5058659 | 291921 | 5058864 | 3.4 | 3 | 40 | W | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 40 | 45.65188 | -119.67024 | 292027 | 5058640 | 291945 | 5058845 | 4.2 | 2 | 71 | W | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 41 | 45.65161 | -119.67000 | 292048 | 5058611 | 291966 | 5058816 | 3.5 | 4 | 49 | W | L | | | UPPER MOST TREE S. SIDE OF JUNIPER FOREST | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 42 | 45.65223 | -119.67022 | 292033 | 5058677 | 291951 | 5058882 | 2.7 | 3 | 50 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 43 | 45.65255 | -119.67038 | 292016 | 5058717 | 291934 | 5058922 | 4.9 | 3 | 95 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 44 | 45.65295 | -119.67068 | 292004 | 5058757 | 291922 | 5058962 | 4.7 | 3 | 65 | na | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 45 | 45.65332 | -119.67088 | 291988 | 5058802 | 291906 | 5059007 | 7 | 2 | 130 | W | L | | LEOW | 250 m EAST OF DEAD JUNIPER | ALIVE | | | | | | | | | | | | | | | | | | | |
| 46 | 45.65308 | -119.67031 | 292033 | 5058770 | 291951 | 5058975 | 4.6 | 4 | 68 | | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 47 | 45.65273 | -119.66975 | 292067 | 5058731 | 291985 | 5058936 | 7.1 | 3 | 75 | W | L | | | VERY LARGE BUSHY TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 48 | 45.65200 | -119.66933 | 292095 | 5058653 | 292013 | 5058858 | 3.3 | 3 | 69 | | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 49 | 45.65362 | -119.67037 | 292021 | 5058816 | 291939 | 5059021 | 6.5 | 2 | 78 | W | L | | | LARGE TREE WITH 1 STEM BROKEN OUT | ALIVE | | | | | | | | | | | | | | | | | | | |
| 50 | 45.65371 | -119.67029 | 292028 | 5058828 | 291946 | 5059033 | 5.9 | 1 | 71 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 51 | 45.65380 | -119.67004 | 292049 | 5058852 | 291967 | 5059057 | 4.5 | 6 | 77 | W | L | | | #50,51 AT BOTTOM EDGE OF SLOPE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 52 | 45.65347 | -119.67001 | 292049 | 5058813 | 291967 | 5059018 | 3.8 | 2 | 41 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 53 | 45.65338 | -119.66966 | 292074 | 5058803 | 291992 | 5059008 | 4.2 | 1 | 81 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 54 | 45.65320 | -119.66920 | 292105 | 5058781 | 292023 | 5058986 | 4.8 | 2 | 89 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 55 | 45.65322 | -119.66905 | 292121 | 5058783 | 292039 | 5058988 | 6.6 | 1 | 120 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 56 | 45.65312 | -119.66906 | 292120 | 5058768 | 292038 | 5058973 | 6.7 | 1 | 111 | NW | L | FEHA | | OLD NEST ON GROUND AT BASE OF TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 57 | 45.65296 | -119.66914 | 292113 | 5058754 | 292031 | 5058959 | 6.2 | 1 | 144 | NW | L | | | BRANCHES W/TREE SUGGESTS A ROOST, LEOW? | ALIVE | | | | | | | | | | | | | | | | | | | |
| 58 | 45.65261 | -119.66894 | 292128 | 5058714 | 292046 | 5058919 | 3.3 | 3 | 69 | NW | L | BBMA | | OLD NEST COULD BE LEOW | ALIVE | | | | | | | | | | | | | | | | | | | |
| 59 | 45.65285 | -119.66867 | 292149 | 5058737 | 292067 | 5058942 | 2.5 | 1 | 60 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 60 | 45.65290 | -119.66850 | 292166 | 5058745 | 292084 | 5058950 | 3.4 | 1 | 90 | NW | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 61 | 45.65316 | -119.66838 | 292190 | 5058785 | 292108 | 5058990 | 4.7 | 1 | 84 | NW | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 62 | 45.65394 | -119.66957 | 292080 | 5058853 | 291998 | 5059058 | 4.7 | 1 | 58 | NW | L | | LEOW | NEST IS A CONVERTED MAGPIE NEST | ALIVE | | | | | | | | | | | | | | | | | | | |
| 63 | 45.65381 | -119.66879 | 292144 | 5058854 | 292062 | 5059059 | 4.7 | 2 | 132 | | L | | | LEOW ROOST TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 64 | 45.65368 | -119.66856 | 292161 | 5058833 | 292079 | 5059038 | 3.9 | 4 | 53 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 65 | 45.65365 | -119.66861 | 292159 | 5058827 | 292077 | 5059032 | 5.2 | 5 | 62 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 66 | 45.65361 | -119.66856 | 292165 | 5058820 | 292083 | 5059025 | 3.9 | 2 | 64 | W | L | LEOW | | PROBABLY LEOW | ALIVE | | | | | | | | | | | | | | | | | | | |
| 67 | 45.65356 | -119.66843 | 292177 | 5058819 | 292095 | 5059024 | 3.6 | 3 | 60 | W | L | LEOW | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 68 | 45.65346 | -119.66824 | 292193 | 5058810 | 292111 | 5059015 | 4.2 | 4 | 76 | W | L | | | LEOW ROOST TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 69 | 45.65365 | -119.66821 | 292195 | 5058828 | 292113 | 5059033 | 5.7 | 1 | 97 | W | L | | CORA | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 70 | 45.65342 | -119.66801 | 292206 | 5058797 | 292124 | 5059002 | 3.2 | 7 | 58 | W | L | | | SHORT MULTI-STEMMED SHRUBBY TREE | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 71 | 45.65335 | -119.66802 | 292209 | 5058794 | 292127 | 5058999 | 4.2 | 1 | 76 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 72 | 45.65337 | -119.66795 | 292212 | 5058796 | 292130 | 5059001 | 3.1 | 1 | 63 | | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 73 | 45.65302 | -119.66802 | 292203 | 5058573 | 292121 | 5058778 | 5.9 | 6 | 76 | | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 74 | 45.65287 | -119.66755 | 292231 | 5058731 | 292149 | 5058936 | | 2 | 142 | | L | | | VERY LARGE VOLUME TREE AT TOP OF SLOPE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 75 | 45.65300 | -119.66766 | 292225 | 5058740 | 292143 | 5058945 | 4.4 | 1 | 75 | NW | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 76 | 45.65306 | -119.66776 | 292210 | 5058753 | 292128 | 5058958 | 2.4 | 3 | 33 | NW | D | | | HAS BEEN DEAD FOR SEVERAL YEARS, WOBBLY | DEAD | <1998 | | | | | | | | | | | | | | | | | | |
| 77 | 45.65305 | -119.66792 | 292223 | 5058752 | 292141 | 5058957 | 5.1 | 1 | 104 | | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 78 | 45.65325 | -119.66788 | 292213 | 5058777 | 292131 | 5058982 | 5.3 | 1 | 87 | | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 79 | 45.65319 | -119.66755 | 292245 | 5058773 | 292163 | 5058978 | 4.9 | 4 | 98 | | L | | | APPARENT LEOW ROOST TREE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 80 | 45.65323 | -119.66754 | 292245 | 5058775 | 292163 | 5058980 | 5.3 | 0 | 65 | | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 81 | 45.65332 | -119.66754 | 292240 | 5058788 | 292158 | 5058993 | 5.2 | 4 | 45 | | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 82 | 45.65333 | -119.66756 | 292240 | 5058794 | 292158 | 5058999 | 6.1 | 2 | 103 | | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 83 | 45.65337 | -119.66778 | 292226 | 5058798 | 292144 | 5059003 | 4.6 | 3 | 67 | NW | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 84 | 45.65337 | -119.66748 | 292249 | 5058800 | 292167 | 5059005 | 5.8 | 1 | 103 | NW | L | UNK | | PROBABLY FEHA OR SWHA | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 85 | 45.65353 | -119.66729 | 292266 | 5058808 | 292184 | 5059013 | 6.1 | 6 | 128 | NW | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 86 | 45.65365 | -119.66752 | 292249 | 5058829 | 292167 | 5059034 | 3.7 | 2 | 69 | NW | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 87 | 45.65376 | -119.66730 | 292266 | 5058836 | 292184 | 5059041 | 3.1 | 1 | 49 | | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 88 | 45.65399 | -119.66740 | 292262 | 5058862 | 292180 | 5059067 | 5.2 | 2 | 150 | NW | L | FEHA, BBMA | | ACTIVE FEHA NEST 1994, BBMA COULD BE ACTIVE NOW | ALIVE | | | | | | | | | | | | | | | | | | | |
| 89 | 45.65399 | -119.66773 | 292233 | 5058868 | 292151 | 5059073 | 3.7 | 6 | 50 | | L | | LEOW | 3 CHICKS ON 4/23/95 | ALIVE | | | | | | | | | | | | | | | | | | | |
| 90 | 45.65405 | -119.66767 | 292239 | 5058874 | 292157 | 5059079 | 6.7 | 1 | 91 | | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 91 | 45.65409 | -119.66764 | 292240 | 5058876 | 292158 | 5059081 | 4.1 | 1 | 81 | | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 92 | 45.65423 | -119.66744 | 292258 | 5058888 | 292176 | 5059093 | 6.1 | 1 | 94 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 93 | 45.65425 | -119.66754 | 292250 | 5058890 | 292168 | 5059095 | 3.6 | 3 | 67 | NW | L | LEOW | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 94 | 45.65426 | -119.66775 | 292230 | 5058896 | 292148 | 5059101 | 3.1 | 4 | 51 | NW | L | LEOW | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 95 | 45.65417 | -119.66804 | 292204 | 5058888 | 292122 | 5059093 | 4.2 | 4 | 76 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 96 | 45.65423 | -119.66808 | 292206 | 5058890 | 292124 | 5059095 | 2.9 | 5 | 57 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 97 | 45.65421 | -119.66822 | 292186 | 5058885 | 292104 | 5059090 | 3.5 | 2 | 65 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 98 | 45.65438 | -119.66810 | 292200 | 5058904 | 292118 | 5059109 | 4.1 | 1 | 97 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 99 | 45.65438 | -119.66812 | 292200 | 5058907 | 292118 | 5059112 | 3.5 | 2 | 71 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 100 | 45.65535 | -119.66857 | 292172 | 5059022 | 292090 | 5059227 | 3.6 | 1 | 71 | na | W | | | LOOKS UNHEALTHY, SOME MISTLETOE CLUMPS | ALIVE | | | | | | | | | | | | | | | | | | | |
| 101 | 45.65611 | -119.66809 | 292207 | 5059098 | 292125 | 5059303 | 4.5 | 1 | 65 | na | PD | LEOW | | LIVE 1/2 LOOKS VERY UNHEALTHY | ALIVE | | | | | | | | | | | | | | | | | | | |
| 102 | 45.65505 | -119.66773 | 292235 | 5058991 | 292153 | 5059196 | 3.3 | 4 | 55 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 103 | 45.65459 | -119.66711 | 292280 | 5058934 | 292198 | 5059139 | 5 | 1 | 97 | NW | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 104 | 45.65356 | -119.66702 | 292282 | 5058815 | 292200 | 5059020 | 3.1 | 2 | 40 | | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 105 | 45.65355 | -119.66697 | 292288 | 5058818 | 292206 | 5059023 | 3.4 | 2 | 51 | | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 106 | 45.65304 | -119.66687 | 292292 | 5058758 | 292210 | 5058963 | 3.7 | 2 | 100 | | L | BBMA | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 107 | 45.65313 | -119.66679 | 292293 | 5058779 | 292211 | 5058984 | 4.9 | 1 | 80 | N | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 108 | 45.65279 | -119.66656 | 292320 | 5058736 | 292238 | 5058941 | 4.4 | 5 | 53 | N | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 109 | 45.65285 | -119.66510 | 292427 | 5058731 | 292345 | 5058936 | 7.6 | 2 | 119 | N | L | CORA | | RAVEN NEST COULD BE ACTIVE | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 110 | 45.65310 | -119.66457 | 292472 | 5058758 | 292390 | 5058963 | 6.4 | 5 | 75 | W | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 111 | 45.65321 | -119.66583 | 292379 | 5058779 | 292297 | 5058984 | 4.5 | 4 | 73 | | L | | | FOUND OLD COYOTE TRAP, I PLACED IT IN TREE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 112 | 45.65327 | -119.66596 | 292367 | 5058776 | 292285 | 5058981 | 4.7 | 6 | 75 | N | L | | | LEOW ROOST TREE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 113 | 45.65334 | -119.66661 | 292318 | 5058785 | 292236 | 5058990 | 5.9 | 5 | 110 | N | L | | | LEOW ROOST TREE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 114 | 45.65342 | -119.66650 | 292317 | 5058796 | 292235 | 5059001 | 4.9 | 3 | 84 | N | L | | | LEOW ROOST TREE | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 115 | 45.65345 | -119.66562 | 292397 | 5058795 | 292315 | 5059000 | 4.7 | 1 | 95 | N | L | | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 116 | 45.65348 | -119.66586 | 292374 | 5058803 | 292292 | 5059008 | 5.1 | 1 | 112 | | L | LEOW | | ACTIVE LEOW ROOST TREE | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 117 | 45.65344 | -119.66598 | 292368 | 5058808 | 292286 | 5059013 | 4.2 | 0 | 61 | | L | | LEOW | 4 CHICKS ON 4/23/95 | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 118 | 45.65361 | -119.66598 | 292367 | 5058814 | 292285 | 5059019 | 5.9 | 1 | 82 | | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 119 | 45.65387 | -119.66662 | 292316 | 5058842 | 292234 | 5059047 | 4.1 | 1 | 69 | N | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 120 | 45.65413 | -119.66630 | 292345 | 5058885 | 292263 | 5059090 | 4.8 | 3 | 70 | N | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 121 | 45.65423 | -119.66604 | 292365 | 5058893 | 292283 | 5059098 | 6.3 | 1 | 121 | N | L | FEHA | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 122 | 45.65446 | -119.66609 | 292360 | 5058910 | 292278 | 5059115 | 4.1 | 6 | 48 | N | L | BBMA | | NEST COULD BE ACTIVE, TREE FALLEN OVER BUT ALIVE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 123 | 45.65423 | -119.66541 | 292414 | 5058886 | 292332 | 5059091 | 6.7 | 1 | 115 | W | L | BBMA | | TOP HAS BLOWN OUT OF TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 124 | 45.65388 | -119.66502 | 292444 | 5058842 | 292362 | 5059047 | 6.4 | 1 | 103 | | L | BBMA | | NEST ON GROUND BELOW TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 125 | 45.65348 | -119.66402 | 292511 | 5058792 | 292429 | 5058997 | 4.9 | 3 | 99 | N | L | BBMA | | EAST PART OF TREE IS BLOWN DOWN | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 126 | 45.65374 | -119.66414 | 292508 | 5058828 | 292426 | 5059033 | 4.9 | 2 | 104 | N | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 127 | 45.65408 | -119.66440 | 292491 | 5058865 | 292409 | 5059070 | 4.2 | 3 | 71 | N | L | | | AN OLD LEOW ROOST TREE | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 128 | 45.65410 | -119.66443 | 292487 | 5058869 | 292405 | 5059074 | 4.9 | 1 | 104 | N | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 129 | 45.65442 | -119.66499 | 292444 | 5058909 | 292362 | 5059114 | 3 | 1 | 51 | N | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 130 | 45.65439 | -119.66449 | 292481 | 5058905 | 292399 | 5059110 | 4.1 | 1 | 76 | NW | L | | BBMA | FAIRLY CERTAIN IT IS ACTIVE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 131 | 45.65467 | -119.66423 | 292502 | 5058928 | 292420 | 5059133 | 3.9 | 1 | 85 | N | L | FEHA | | NEST STRUCTURE ON GROUND BELOW TREE | ALIVE | | | | | | | | | | | | | | | | | | | |
| 132 | 45.65471 | -119.66357 | 292555 | 5058932 | 292473 | 5059137 | 3.7 | 2 | 38 | | PD | | | ONE STEM IS DEAD, REST OF TREE IS HEALTHLY | ALIVE | | | | | | | | | | | | | | | | | | | |
| 133 | 45.65442 | -119.66276 | 292616 | 5058904 | 292534 | 5059109 | 3.9 | 2 | 99 | | L | | | | ALIVE | | | | | | | | | | | | | | YES | FERRUGINOUS HAWK | UNKNOWN | YES | FERRUGINOUS HAWK | UNKNOWN |
| 134 | 45.65495 | -119.66282 | 292615 | 5058957 | 292533 | 5059162 | 5.1 | 3 | 84 | na | L | LEOW,BBMA | | BBMA NEST POSSIBLY ACTIVE, 4 OLD LEOW NESTS | ALIVE | | | | | | | | | | | | | | | | | | | |
| 135 | 45.65472 | -119.66207 | 292673 | 5058930 | 292591 | 5059135 | 4.5 | 0 | 82 | na | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | | | | |
| 136 | 45.65724 | -119.66204 | 292686 | 5059214 | 292604 | 5059419 | 3.7 | 1 | 96 | na | L | FEHA,SWHA | | NUMEROUS OLD RAPTOR NESTS | ALIVE | | | | | | | | | | | | | | | | | | | |
| 137 | 45.65704 | -119.66332 | 292589 | 5059193 | 292507 | 5059398 | 3.3 | 4 | 45 | S | L | | | MAIN LIMB HAS BROKEN RECENTLY | ALIVE | | | | | | | | | | | | | | | | | | | |
| 138 | 45.65661 | -119.66367 | 292558 | 5059141 | 292476 | 5059346 | 3 | 2 | 51 | S | L | | | | ALIVE | | | YES | UNKNOWN | | | | | | | | | | | | | | | |
| 139 | 45.65721 | -119.66396 | 292536 | 5059211 | 292454 | 5059416 | 3.9 | 1 | 62 | S | L | | | | ALIVE | | | YES | UNKNOWN | | | | | | | | | | | | | | | |
| 140 | 45.65720 | -119.66453 | 292492 | 5059206 | 292410 | 5059411 | 3 | 2 | 37 | W | L | | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 141 | 45.65752 | -119.66449 | 292498 | 5059237 | 292416 | 5059442 | 3 | 4 | 37 | W | L | BBMA,LEOW | | NORTHERN MOST TREE OF THE JUNIPER FOREST | ALIVE | | | | | | | | | | | | | | | | | | | |
| 142 | 45.65657 | -119.66569 | 292401 | 5059121 | 292319 | 5059326 | 3.4 | 3 | 53 | W | L | BBMA | | | ALIVE | | | | | | | | | | | | | | | | | | | |
| 143 | 45.65714 | -119.66517 | 292442 | 5059204 | 292360 | 5059409 | 3.7 | 2 | 49 | W | L | FEHA | | | DEAD | 1998 | | | | | | | | | | | | | | | | | | |
| 144 | 45.65458 | -119.67524 | 291647 | 5058949 | 291565 | 5059154 | 5.6 | 2 | 76 | E | L | SWHA | | W. SIDE OF CANYON ACROSS FROM JUNIPER FOREST | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 145 | 45.65548 | -119.67584 | 291605 | 5059056 | 291523 | 5059261 | 3.8 | 1 | 64 | E | PD | | | DEAD TOP | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |
| 146 | 45.65738 | -119.67263 | 291868 | 5059259 | 291786 | 5059464 | 4.9 | 1 | 97 | E | L | FEHA | BBMA | FEHA NEST ON GROUND, BBMA NEST W/6 EGGS | PARTIALLY DEAD | | | | | | | | | | | | | | | | | | | |

## JUNIPER TREE SURVEY DATA

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 147 | 45.64735 | -119.68887 | 290560 | 5058179 | 290477 | 5058383 | | 0 | 0 | na | | | FEHA,WEKI | Lone DEAD juniper in ann grass draw,3/4 mi W. of J | DEAD | <1998 | COMPLETELY BURNED IN 1998 | | | | | | | | | | | | | | |
| 148 | 45.66068 | -119.66851 | 292196 | 5059607 | 292113 | 5059811 | | 0 | 0 | | D | | FEHA | DEAD JUNIPER 100 m W. OF JUNIPER CANYON ROAD | DEAD | <1998 | COMPLETELY BURNED IN 1998 | | | | | | | | | | | | | | |
| 149 | 45.66929 | -119.66761 | 292295 | 5060561 | 292212 | 5060765 | 5.9 | 1 | 134 | | L | | SWHA | TREE CLOSE TO JUNIPER CANYON ROAD | ALIVE | | | | | | | | | | | | | | | | |
| 150 | 45.66862 | -119.67032 | 292089 | 5060498 | 292006 | 5060702 | 6.9 | 3 | 138 | | L | FEHA | WEKI | | ALIVE | | | | | | | | | | | | | | | | |
| 151 | 45.66879 | -119.67070 | 292057 | 5060522 | 291974 | 5060726 | | 0 | 0 | | L | | FEHA | | ALIVE | | | | | | | | | | | | | | | | |
| 152 | 45.67206 | -119.66402 | 292582 | 5060864 | 292499 | 5061068 | 5.5 | 1 | 124 | W | L | FEHA,SWHA | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 153 | 45.67436 | -119.66421 | 292572 | 5061117 | 292489 | 5061321 | 7.1 | 1 | 131 | na | L | | WEKI | | ALIVE | | | YES | UNKNOWN | YES | SWAINSON'S HAWK | 1 | | | | | | | | | |
| 154 | 45.67315 | -119.66005 | 292902 | 5060972 | 292819 | 5061176 | 4.3 | 1 | 102 | W | L | BBMA | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 155 | 45.67351 | -119.65841 | 293026 | 5061010 | 292943 | 5061214 | 3.6 | 1 | 90 | SW | L | FEHA | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 156 | 45.67347 | -119.65821 | 293046 | 5061002 | 292963 | 5061206 | 2 | 3 | 32 | W | PD | | | ONE STEM IS DEAD | DEAD | 1998 | COMPLETELY BURNED IN 1998 | | | | | | | | | | | | | | |
| 157 | 45.67550 | -119.65869 | 293016 | 5061233 | 292933 | 5061437 | 6.1 | 2 | 92 | S | L | FEHA | SWHA,WEKI | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 158 | 45.67578 | -119.65839 | 293038 | 5061262 | 292955 | 5061466 | 5.6 | 1 | 97 | S | L | | NOOR | | ALIVE | | | | | | | | | | | | | | | | |
| 159 | 45.67535 | -119.65805 | 293064 | 5061218 | 292981 | 5061422 | 6 | 1 | 109 | S | L | BBMA | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 160 | 45.67381 | -119.65162 | 293559 | 5061024 | 293476 | 5061228 | 5.6 | 3 | 91 | S | L | FEHA | WEKI,BBMA | | ALIVE | | | | | | | | | | | | | | | | |
| 161 | 45.67242 | -119.64759 | 293869 | 5060860 | 293786 | 5061064 | 5.2 | 1 | 76 | S | L | FEHA | WEKI | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 162 | 45.67227 | -119.64699 | 293912 | 5060843 | 293829 | 5061047 | 5.7 | 1 | 115 | S | L | FEHA | | | DEAD | 2008 | | | | | | | | | | | | | YES | FERRUGINOUS HAWK | UNKNOWN |
| 163 | 45.67262 | -119.64681 | 293905 | 5060873 | 293822 | 5061077 | 2.9 | 2 | 51 | S | PD | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 164 | 45.67293 | -119.64748 | 293878 | 5060918 | 293795 | 5061122 | 5.3 | 2 | 86 | S | L | FEHA | LEOW | | ALIVE | | | | | | | | | | | | | | | | |
| 165 | 45.67331 | -119.64790 | 293848 | 5060959 | 293765 | 5061163 | 2.7 | 3 | 52 | S | L | LEOW | | 2 OLD LEOW NESTS | ALIVE | | | | | | | | | | | | | | | | |
| 166 | 45.67333 | -119.64727 | 293896 | 5060959 | 293813 | 5061163 | 4.5 | 1 | 66 | S | L | | | | ALIVE | | | | | | | | | | | | | | | | |
| 167 | 45.67466 | -119.64820 | 293834 | 5061104 | 293751 | 5061308 | 5.4 | 1 | 138 | SE | L | | | | ALIVE | | | | | | | | | | | | | | | | |
| 168 | 45.67364 | -119.64623 | 294374 | 5061176 | 294291 | 5061380 | 5.2 | 2 | 75 | | D | | | HAS BEEN DEAD FROM 4-5 YEARS, IN DRAW BOTTOM | DEAD | 1998 | COMPLETELY BURNED IN 2008 | | | | | | | | | | | | | | |
| 169 | 45.66966 | -119.64927 | 293729 | 5060559 | 293646 | 5060763 | 4.7 | 1 | 85 | W | L | | | #169-171 IN DRAW TO SOUTH OF THE #157-168 CANYON | DEAD | 2008 | | | | | | | | | | | | | | | |
| 170 | 45.66942 | -119.64955 | 293706 | 5060536 | 293623 | 5060740 | 3 | 3 | 37 | W | L | | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 171 | 45.66985 | -119.64983 | 293682 | 5060581 | 293599 | 5060785 | 5.5 | 3 | 87 | W | L | LEOW,FEHA | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 172 | 45.67763 | -119.65993 | 292923 | 5061472 | 292840 | 5061676 | | 0 | 0 | W | L | BBMA | LEOW | 4 LEOW NESTLINGS ON 5/27/95 | ALIVE | | | | | | | | | | | | | | | | |
| 173 | 45.68073 | -119.65812 | 293075 | 5061812 | 292992 | 5062017 | 4.2 | 3 | 85 | W | PD | BBMA | | COULD BE ACTIVE IN 1995 | ALIVE | | | | | | | | | | | | | | | | |
| 174 | 45.68089 | -119.65812 | 293078 | 5061827 | 292995 | 5062031 | 3.1 | 2 | 53 | W | PD | BBMA | | | ALIVE | | | | | | | | | | | | | | | | |
| 175 | 45.68098 | -119.65812 | 293079 | 5061837 | 292996 | 5062041 | 3.1 | 4 | 35 | W | L | SWHA | | STRUCTURE WAS STARTED BUT NEVER COMPLETED | ALIVE | | | | | | | | | | | | | | | | |
| 176 | 45.68072 | -119.65899 | 293009 | 5061818 | 292926 | 5062022 | 2.6 | 1 | 112 | S | W | | | TREE BLOWN OVER AND DEFORMED | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 177 | 45.68074 | -119.65900 | 293014 | 5061813 | 292931 | 5062017 | 3.5 | 1 | 60 | | L | BBMA | | SAME ORIGIN AS #176, NOW APPEARS SEPARATE TREE | ALIVE | | | | | | | | | | | | | | | | |
| 178 | 45.68009 | -119.66063 | 292883 | 5061750 | 292800 | 5061954 | 5.1 | 1 | 81 | | L | | FEHA,WEKI | FEHA NEST ABANDONED BY 5/27/95 | ALIVE | | | | | | | | | | | | | | | | |
| 179 | 45.68048 | -119.66109 | 292848 | 5061796 | 292765 | 5062000 | 5.7 | 1 | 91 | W | L | | | | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 180 | 45.68037 | -119.66115 | 292844 | 5061782 | 292761 | 5061986 | 4.4 | 1 | 69 | S | L | | BBMA | | ALIVE | | | | | | | | | | | | | | | | |
| 181 | 45.67990 | -119.66286 | 292709 | 5061729 | 292626 | 5061933 | 4.1 | 1 | 112 | na | L | LEOW,BBMA | | ACTIVE LEOW ROOST TREE | ALIVE | | | | | | | | | | | | | | | | |
| 182 | 45.67998 | -119.66352 | 292656 | 5061744 | 292573 | 5061948 | 5.1 | 1 | 165 | | L | SWHA | | LEOW ROOST TREE | DEAD | 2008 | | | | | | | | | | | | | | | |
| 183 | 45.67929 | -119.66397 | 292616 | 5061669 | 292533 | 5061873 | | 0 | 0 | | L | BBMA | SWHA | NO MEASUREMENTS | DEAD | 2008 | | | | | | | | | | | | | | | |
| 184 | 45.68150 | -119.66996 | 292158 | 5061925 | 292075 | 5062129 | 4.5 | 2 | 73 | | L | FEHA,BBMA | | PART OF TOP IS BLOWN OVER | DEAD | 2008 | | | | | | | | | | | | | | | |
| 185 | 45.67812 | -119.64993 | 293706 | 5061499 | 293623 | 5061703 | | 0 | 0 | na | L | | SWHA,WEKI | SWHA W/2 EGSS, WEKI W/3 EGGS ON 5/27/95 | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 186 | 45.67799 | -119.64952 | 293737 | 5061486 | 293654 | 5061690 | 5.8 | 1 | 119 | na | L | | CORA | 5 JUVENILE FLEDGED RAVENS ON 5/27/95 | DEAD | 2008 | | YES | SWAINSON'S HAWK | | | | | | | | | | | | |
| 187 | 45.67773 | -119.64912 | 293766 | 5061453 | 293683 | 5061657 | 5.1 | 2 | 98 | na | L | SWHA | | #185-187 IN CANYON SOUTH OF HEY ROAD | PARTIALLY DEAD | | | | | | | | | | | | | | | | |
| 188 | 45.66984 | -119.74882 | 285974 | 5060834 | 285892 | 5061039 | 7.2 | 1 | 100 | na | L | | | #188-206 ARE ALL ON THE WEST EDGE OF NWSTF | ALIVE | | | | | | | | | | | | | | | | |
| 189 | 45.66988 | -119.74896 | 285966 | 5060841 | 285884 | 5061046 | 2.9 | 1 | 29 | N | L | | | VERY SMALL TREE | ALIVE | | | | | | | | | | | | | | | | |
| 190 | 45.66996 | -119.74883 | 285975 | 5060853 | 285893 | 5061058 | 5.2 | 1 | 127 | N | L | | | COUNTED 48 SM TREES (<1 m TALL) AROUND #188-190 | ALIVE | | | | | | | | | | | | | | | | |
| 191 | 45.67034 | -119.74880 | 285976 | 5060894 | 285894 | 5061099 | 8 | 1 | 135 | N | L | | | | ALIVE | | | | | | | | | | | | | | | | |
| 192 | 45.67041 | -119.74830 | 286017 | 5060894 | 285935 | 5061099 | 8.1 | 1 | 175 | na | L | SWHA | | | ALIVE | | | | | | | | | | | | | | | | |
| 193 | 45.67023 | -119.74778 | 286056 | 5060876 | 285974 | 5061081 | 8.5 | 2 | 122 | na | L | FEHA | | | ALIVE | | | | | | | | | | | YES | SWAINSON'S HAWK | 1 | | | |
| 194 | 45.67024 | -119.74751 | 286077 | 5060878 | 285995 | 5061083 | 5.2 | 1 | 112 | na | L | BBMA | | | ALIVE | | | | | | | | | | | | | | | | |
| 195 | 45.67024 | -119.74481 | 286287 | 5060874 | 286205 | 5061079 | 2.5 | 1 | 78 | na | W | | | A SMALL TREE BLOWN DOWN AND TRYING TO SURVIVE | ALIVE | | | | | | | | | | | | | | | | |
| 196 | 45.67124 | -119.74488 | 286288 | 5060988 | 286206 | 5061193 | 5.3 | 2 | 97 | na | L | FEHA,BBMA | | FEHA NEST HAS BEEN BLOWN OUT | PARTIALLY DEAD | 2008 | | | | | | | | | | | | | | | |
| 197 | 45.67223 | -119.74086 | 286602 | 5061079 | 286520 | 5061284 | 4.3 | 7 | 97 | na | L | BBMA | | | ALIVE | | | | | | | | | | | | | | | | |
| 198 | 45.67611 | -119.74486 | 286310 | 5061529 | 286228 | 5061734 | 5.1 | 1 | 153 | na | L | FEHA | WEKI | FEHA NEST STRUCTURE BLOWN OUT | DEAD | 2008 | | | | | | | | | | | | | | | |
| 199 | 45.67733 | -119.74412 | 286369 | 5061656 | 286287 | 5061861 | 5.9 | 4 | 104 | W | L | BBMA | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 200 | 45.67934 | -119.74413 | 286379 | 5061884 | 286297 | 5062089 | 4.8 | 1 | 103 | na | L | FEHA | | | DEAD | 2008 | | | | | | | YES | SWAINSON'S HAWK | UNKNOWN | | | | YES | FERRUGINOUS HAWK | UNKNOWN |
| 201 | 45.68309 | -119.74656 | 286202 | 5062309 | 286120 | 5062514 | | 1 | 0 | | L | FEHA | | | DEAD | 2008 | | | | | | | | | | | | | | | |
| 202 | 45.68345 | -119.74788 | 286103 | 5062348 | 286021 | 5062553 | | 13 | 0 | | L | BBMA | | NEST COULD BE ACTIVE, VERY UNIQUE TREE | DEAD | 2008 | | | | | | | | | | | | | | | |
| 203 | 45.68155 | -119.74748 | 286126 | 5062136 | 286044 | 5062341 | | 0 | 0 | | L | FEHA | | WOODRAT TREE WITH 2 MIDDENS | DEAD | 2008 | | | | | | | | | | | | | | | |
| 204 | 45.67980 | -119.74722 | 286134 | 5061932 | 286052 | 5062137 | | 0 | 0 | | L | FEHA | | OLD WOODRAT MIDDEN | DEAD | 2008 | | | | | | | | | | | | | | | |
| 205 | 45.67829 | -119.74888 | 285998 | 5061780 | 285916 | 5061985 | | 0 | 0 | | L | | | | ALIVE | | | YES | FERRUGINOUS HAWK | | | | | | | | | | | | |
| 206 | 45.67834 | -119.74892 | 285999 | 5061778 | 285917 | 5061983 | | 0 | 0 | | | | SWHA,WEKI | WEKI NEST W/4 EGGS | ALIVE | | | | | | | | | | | | | | | | |

# INTEGRATED WILDLAND FIRE MANAGEMENT PLAN

# NAVAL WEAPONS SYSTEMS TRAINING FACILITY BOARDMAN

Enclosure (2)

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# CHAPTER 1
# INTRODUCTION AND GENERAL OVERVIEW

1. Integrated Wildland Fire Management Plan

a. The purpose of the Integrated Wildland Fire Management Plan (IWFMP) is to present a comprehensive approach to help reduce the frequency of wildland fires and the associated costs and damages. The plan lays out specific guidance, procedures, and protocols in the prevention and suppression of wildland fires. The goal is to convey the methods and protocols necessary to minimize wild fire frequency, severity, and size.

b. Navy Region Northwest Regional Fire Chief is assigned responsibility for implementing and maintaining the IWFMP. The IWFMP will implement improvements to its land and firefighting resources that will enhance the response and capabilities of firefighters.

c. Naval Weapons Systems Training Facility (NWSTF) Boardman hosts a significant tenant/user in the Oregon National Guard, also referred to as the Oregon Military Department.

d. This plan will be revised as needed based on the results of ongoing environmental analysis and proposed project execution.

2. Location. NWSTF Boardman occupies 47,432 acres in Morrow County, located in north-central Oregon. The NWSTF Boardman is located approximately 2 miles (mi) (3.2 kilometers [km]) south of the city of Boardman, Oregon and the Columbia River, 6 mi (9.7 km) southwest of the United States (US) Army's Umatilla Chemical Depot, and 16 mi (25.7 km) southwest of Hermiston, Oregon. Figure 1 shows the location of NWSTF Boardman. The installation is federally withdrawn land with title held by the United States. Management responsibilities for the installation are held by the Commander Navy Region North West (CNRNW) and have been delegated to Commanding Officer Naval Air Station (NAS) Whidbey Island.

3. Environmental Impact Statement. The potential environmental effects of activities described in this IWFMP were analyzed in the Naval Weapons Systems Training Facility Boardman Final Environmental Impact Statement (Navy 2013).

4. Goals and Objectives

a. The following goals and objectives from the broader CNRNW Wildland Fire Management Plan help to lay out the methods and protocols necessary to control wildland fire frequency, intensity, and size on CNRNW lands in order to comply with federal and state laws and meet CNRNW land stewardship responsibilities; while providing for personnel and public safety and supporting continuation of military training and operations necessary to maintain a high level of combat readiness.

(1) Provide, first, for public and personnel safety. All other objectives are secondary.

(2) Protect all natural and cultural resources, to the extent feasible, through a program of prevention, pre-suppression, and suppression. Support the goals and objectives of existing CNRNW land management plans.

(3) Base all fire management activities on the best available science.

(4) Incorporate public health and environmental quality considerations into fire management planning and execution.

(5) Coordinate and cooperate where possible and beneficial with other federal, state, and local agencies.

(6) Examine and identify resource requirements and availability at each organizational level, to provide needed suppression and support. Establish suppression measures and determine the confine, contain, and control strategies.

(7) Base fire management activities on the evaluation of economic factors that consider resource and social values.

(8) Continually evaluate and improve upon fire management policies and procedures with the goal of constantly improving the level of fire protection on CNRNW lands.

(b) Objectives

(1) Maintain or improve the quality of lands represented within the installations of CNRNW.

(2) Allow military operations and training to occur at the tempo required to maintain a high level of combat readiness.

(3) Prioritize installations and locations for funding and implementation of fire management improvements.

(4) Establish a series of firebreaks and/or fuel breaks at high fire risk installations/areas to reduce the probability of a fire moving into high value areas or off installation.

(5) Establish monitoring protocols and minimum specifications for these breaks.

(6) Control the timing of ignitions such that fires that occur do so when conditions are such that there is a high probability of controlling the fire and protecting all valued resources.

(7) Establish guidelines and implement a prescribed burn program that includes the use of wildland fires for resource benefit in predetermined areas and under predetermined conditions.

(8) Communicate within the fire management hierarchy to improve practices and policies.

(9) Communicate and educate other departments to facilitate a reduction in fire starts.

(10) Update interagency agreements as necessary to ensure prompt and complete cooperation during wildland fire incidents both on and off CNRNW lands in coordination with the agreeing agencies.

(11) Establish fire management qualifications for all personnel tasked with providing initial fire response and ensure all personnel assigned to those positions are trained to a level appropriate for their expected duties.

(12) Fires will be suppressed at minimum cost while still considering public and firefighter safety and resources to be protected.

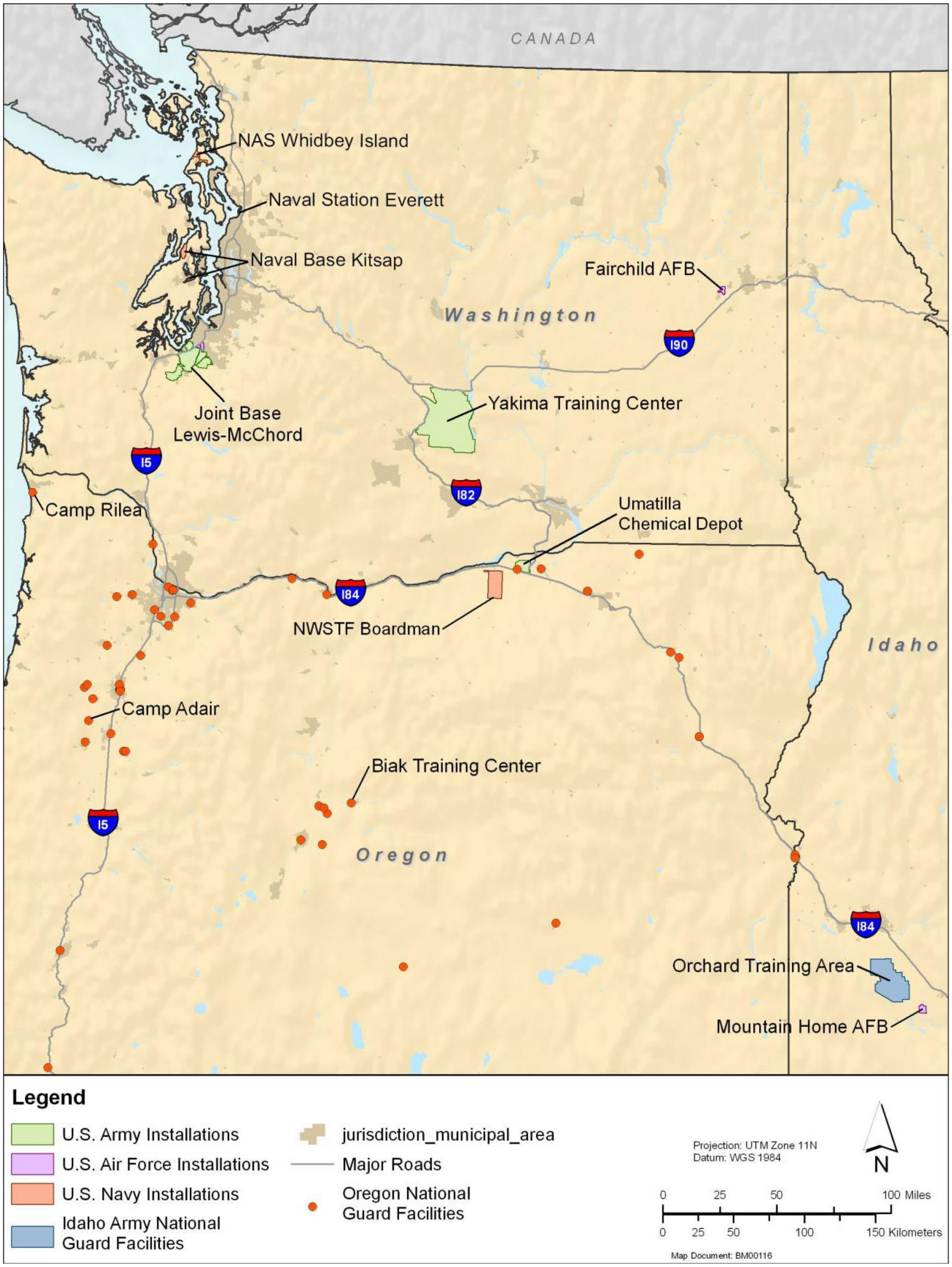


FIGURE 1. NWSTF Boardman Location

5. <u>NWSTF Boardman goals and objectives</u>. The following goals and objectives are specific to NWSTF Boardman and are taken from the NWSTF Boardman 2012 Integrated Natural Resources Management Plan (INRMP).

a. <u>Goal 1</u>. Ecosystem restoration: Use soil parameters and historical vegetation data to protect soil stability, restore wildlife habitat, and restore training lands. Objective: Utilize native seed for restoration seeding.

b. <u>Goal 2</u>. General wildlife management. Inventory natural resources and monitor species and/or communities that are components of prey habitat and/or indicators of ecosystem integrity, status of sensitive species, and maintaining the capability of NWSTF Boardman to support military missions. Objective: Protect shrub habitats from fire and damage.

c. <u>Goal 3</u>

a. Rare and listed species management. Continue to mitigate potential negative effects to Urocitellus Washington (Washington ground squirrel) from military training and other military-related activities.

b. Providing an adequate and safe level of rapid response fire protection for military-related and other wildland fires.

(1) <u>Objective 1</u>. Suppress fires.

(a) Suppress wildland fires, regardless of origin, on NWSTF Boardman and surrounding areas if requested.

(b) Maintain fire crews on alert during training exercises and at the ready year round.

(c) Develop and maintain mutual aid support agreements with other federal, state, and local entities for the suppression of wildland fires at NWSTF Boardman.

(2) <u>Objective 2</u>. Restore areas damaged by fires.

(a) Restore fire-damaged areas using native species and broadcast seeding.

(b) Collect and plant small amounts of native seed not commercially available.

(c) Monitor the success of the seeding.

d. Goal 4. Fire management. Prevent and suppress wildland fires to maintain ecosystem biodiversity and functionality.

(1) Objective 1. Maintain trained and equipped wildland fire crews year round and staff appropriately during the fire season while training activities are occurring.

(2) Objective 2. Continue mutual aid agreements for wildland fire suppression on NWSTF Boardman.

(3) Objective 3. Provide natural/cultural resources management-related recommendations relative to suppression activities to NWSTF Boardman Range personnel.

(4) Objective 4. Respond to wildland fires as soon as possible and begin immediate suppression, consistent with safety and staffing requirements.

(5) Objective 5. Manage range and training activities to prevent wildland fires.

(6) Objective 6. Provide environmental awareness materials to stress the importance of fire prevention to all users of NWSTF Boardman.

6. Wildland fire history. NWSTF Boardman has an extensive history with wildland fires. Historically, the area was comprised of fire adapted habitats with fire return intervals from around 20-50 years. With the widespread introduction of invasive plant species and non-native annual grasses, the fuel loading of understory vegetation has greatly changed and fires now tend to be more frequent, more severe and can be long-term or permanent habitat altering events. Therefore, wildland fire can have a major effect on natural resources. Studies conducted after a large fire in 1998 showed that avian species and Washington ground squirrel occurrence and densities can be affected by the habitat-altering effects of a large hot burning wildland fire (Humple and Holmes 2001, March 2001). Wildland fires can be from a natural ignition source (e.g. lightning) and from a manmade ignition source (e.g. military training and/or ordnance use). Most major fires since 1998 have been from lightning strikes with the exception of a 2009 fire for which the ignition source is unknown and the 2018 fire which was started during an Oregon National Guard operation to destroy unexploded ordinance. Since 1998, more than 85 percent of NWSTF Boardman has been burned by wildland fires which have caused short and long-term habitat alterations. The fires ranged in size from 17,514 acres; 1,639 acres; 11,664 acres; 30,612 acres; 618 acres and 16,350 acres in 1998; 2002; 2007; 2008; and 2009, and 2015 respectively. Figure 2 shows the locations of the wildland fires which have occurred since 1998.

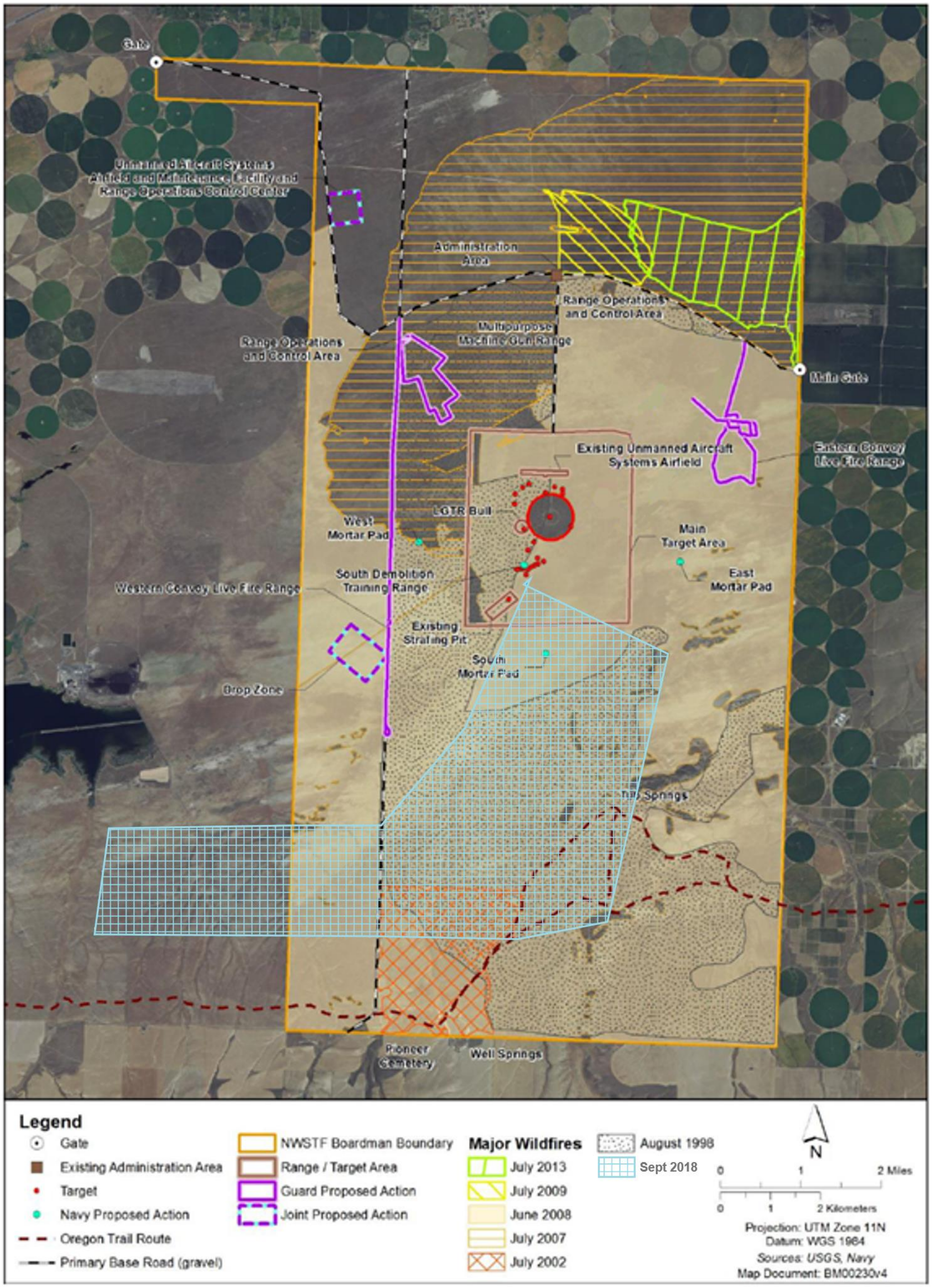


FIGURE 2. Locations of the wildland fires on NWSTF Boardman since 1998

Enclosure (2)

# CHAPTER 2
# FIRE MANAGEMENT AREA CHARACTERISTICS

1. Wildland fuels

a. At a coarse scale, the area of the NWSTF Boardman is classified as dry shrub land. This dry shrub land is a remnant of the dry shrub sagebrush steppe of the interior Columbia River basin. The grass, forbs and shrub communities in the interior Columbia Basin, particularly the sagebrush and shrub steppe cover types, have been altered over time (ICBEMP Strategy, 2003), principally through historic grazing and fire suppression practices. The Interior Columbia Basin Ecosystem Management Project (ICBEMP) identified twenty-nine potential vegetation types representing rangeland ecosystems within the interior Columbia Basin. The ICBEMP combined these vegetation types into six groups; two of which are found at NWSTF Boardman: dry grass and dry shrub (ICBEMP, 1997). However, on stages in the development and life cycle of the big sagebrush steppe ecosystem and are considered here NWSTF Boardman, these two vegetation groups, dry grass and dry shrub, actually represent separate serials as meeting the reference conditions for the "Sagebrush – Warm (Basin Big Sagebrush) Without Trees" potential natural vegetation group (PNVG) or biophysical setting (BPS) according to the Interagency Fire Regime Condition Class (FRCC) Guidebook and website (Hann, 2003). Figure 3 illustrates the various potential vegetation pathways within the sagebrush steppe cycle (ICBEMP, 1997).
Wildland fire, particularly the return frequency of wildland fire, is a key component in splitting the natural cycle into the three pathways illustrated in Figure 3. In resetting the vegetation seral stage of burned areas against the backdrop of unburned areas, wildland fire creates of mosaic pattern of juxtaposed several stages from early, through development, to late seral stages across the landscape. Table 3 provides a synopsis of the fire regime condition class data.

b. Historically, the early settlers of the Columbia Plateau region started livestock grazing soon after the Civil War, mid to late 1860's (Quigley, et al, 1996). By present day standards, the region was overgrazed by the late 1800's resulting in significant changes to the native vegetation communities and several collapses in range land grazing starting in the 1890's into the 1920's due to the general decline in rangeland vegetation conditions.
However, grazing activities continued on NWSTF Boardman until the late 1990's. Consequently, the current sagebrush steppe plant community is not entirely representative of pre-settlement sagebrush steppe conditions.

c. The INRMP (US Navy, 2012) identifies the numerous plant species found on NWSTF Boardman. The INRMP groups the plant species into six major plant associations. These plant associations are: Big Sagebrush with Bluebunch Wheatgrass; Big Sagebrush with western Needle-and-Thread Grass; Bluebunch Wheatgrass and Sandberg's Bluegrass; Antelope Bitterbrush with Western Needle-and Thread Grass; Western Needle-and Thread Grass with Sandberg's Bluegrass; and Snowy Buckwheat with Sandberg's Bluegrass.
These six plant associations represent seral stages in the sagebrush steppe cycle and collectively make up the surface fire fuels that carry wildland fires on the Range. Due to the semi- arid

climate conditions and sandy soils, there is not an accumulation of ground fuels to carry a fire nor is there a canopy of aerial fuels that will carry a crown fire. Consequently, surface wildland fire in the fine grass-shrub fuels is the dominant fire spread condition on NWSTF Boardman.

d. The major wildland fires of 1998, 2002, 2007, 2015 and 2018 on NWSTF Boardman significantly affected the current distribution of seral sagebrush steppe vegetation; hence class distribution of wildland fire fuels. These fires were stand replacing for much of the Big Sagebrush that once covered portions of the central area of the NWSTF Boardman project area. Whether these burned areas were formerly in mid or late seral stages can no longer be determined, however, the fires did reset conditions in much of the north and central fire management zones back to an early seral stage dominated by native bunch grasses and herbs coupled with invasive non- native grasses. Carson (2005) discusses the fire adaptability of Big Sagebrush and other major plant species on NWSTF Boardman, noting that Big Sagebrush is "readily killed when the above ground plant parts are charred by fire". During field investigations in 2005, observations were made of dead charred limbs and trunks of sagebrush in areas where no living big sagebrush currently grow, sites now dominated by annual or perennial grasses with only a minor small shrub component. Figure 4 documents some of these field observations of the charred remnants of Big Sagebrush in an area now dominated by bunchgrass. Figure 5 illustrates the now uniform early seral stage grass steppe which covers much of the central area of NWSTF Boardman, replacing the former sagebrush steppe. This photo also illustrates the very low relief of NWSTF Boardman's central plain. Figures 6 through 9 document several of the sagebrush steppe seral stages and illustrate current fuel types on NWSTF Boardman. Carson (2005) provides a further discussion of the wildland fire fuels and the fire regime at NWSTF Boardman.

e. Interior Columbia Basin Ecosystem Management Project (ICBEMP) illustrates three common pathways of plant succession for the Columbia Basin dry shrub sagebrush steppe. Pathway A represents a succession from native perennial grassland to a mixed

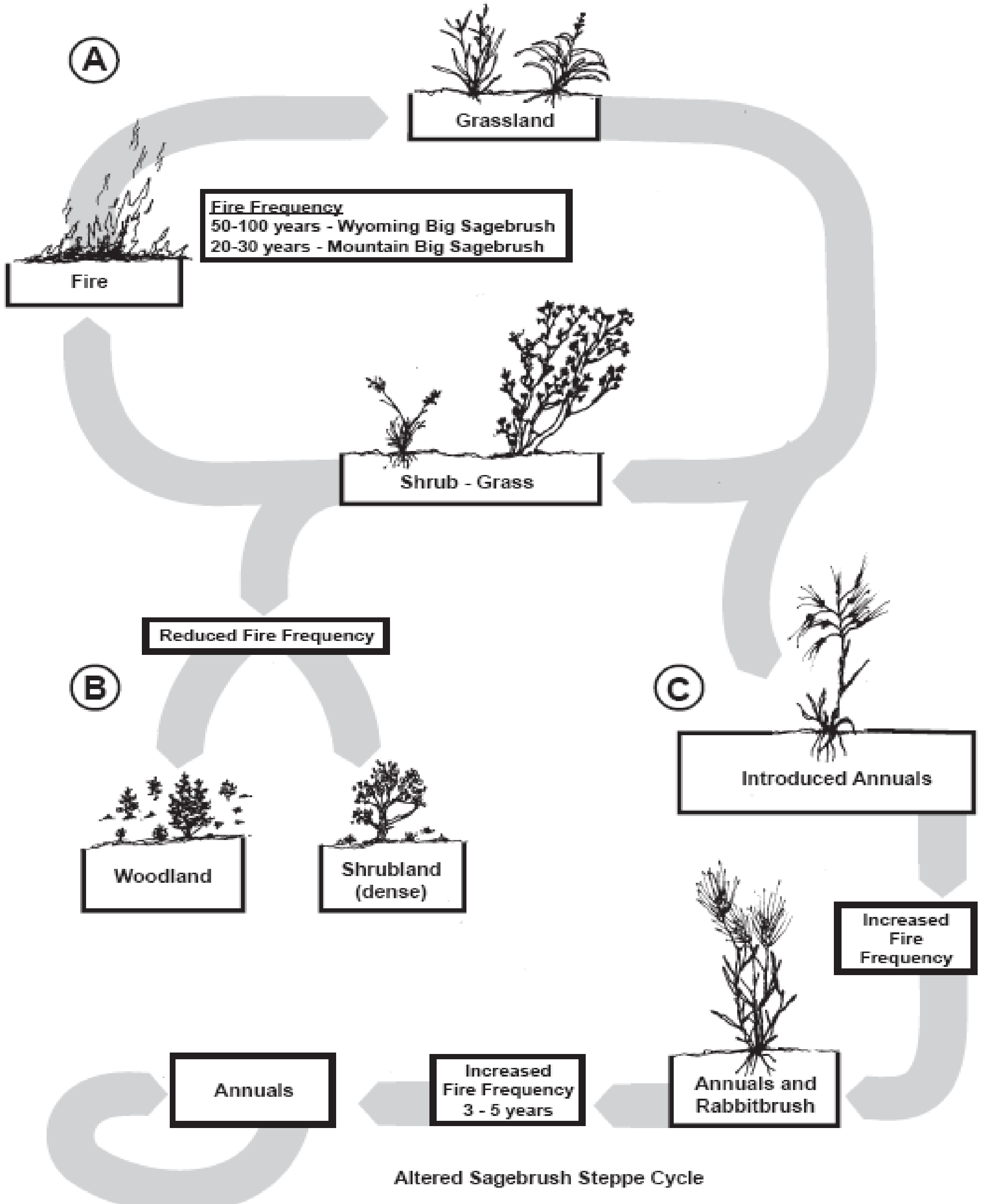


Figure 3. Sagebrush Steppe Plant Successions: The Interior Columbia Basin Ecosystem shrub-grass community with fire acting to return the community back to the native perennial grassland. Pathway B represents a succession diverting from shrub-grass dominate community towards a dominate shrub land or juniper woodland by a reduction of the fire frequency. Pathway C represents a succession diverting from a shrub-grass dominant community towards a community dominated by introduced annual grasses characterized by an increase in the fire frequency. (Illustration from: ICBEMP, 1997)

FIGURE 4. Photograph of charred Big Sagebrush remnants in an area currently dominated by bunch grasses in December, 2005. Location of this site is west of the proposed east side range development area within the Central Fire Management Zone. The large number of charred remains indicates that this area once sustained a large stand of Big Sagebrush which suffered a stand replacing wildland fire.

FIGURE 5. This aerial view of NWSTF Boardman looking southeast across the area of the proposed MPMG range, within the Central Fire Management Zone, shows the uniform grass steppe which covers much of the Boardman Range. This uniform grass steppe is the result of the major wildland fires of 1998, 2002 and 2007 which replaced stands of Big Sagebrush and other shrubs with a dominance of grasses (Fuel Models L or GR4).


FIGURE 6. Early seral stage, post fire, dominant short perennial bunch grass fuels of heights less than 2 feet (Fuel Models L or GR-4) in the vicinity of the proposed MPTR range project within the Central Fire Management Zone.

FIGURE 7. Early seral, post fire, mixed grass and small shrub fuels of heights less than 3 feet (Fuel Models L or GS-2) downrange of the proposed MPTR range project within the Central Fire Management Zone. A mosaic pattern of scattered Big Sagebrush can be seen in the background.


FIGURE 8. Mid seral stage, open (<15%), mixed Big Sagebrush, shrub and bunchgrass fuels near the Oregon Trail, east of Juniper Canyon within the South Fire Management Zone (Fuel Models L or GS2).

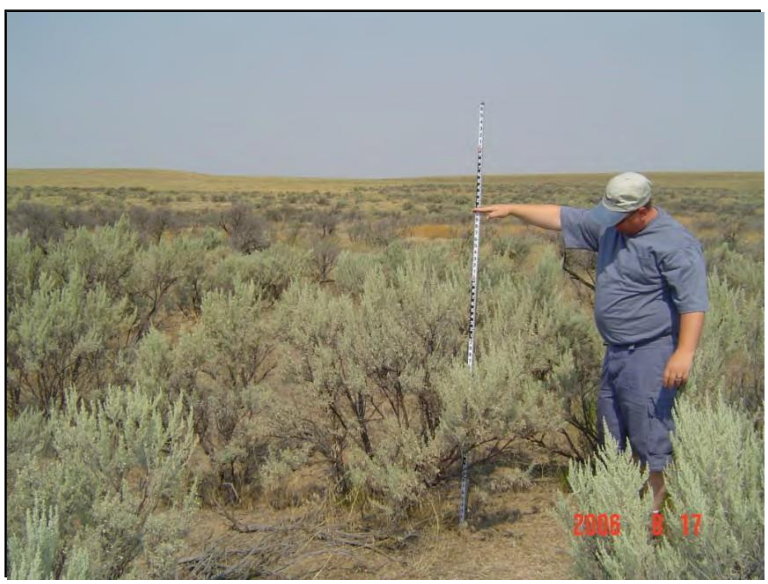


FIGURE 9. Late seral development, closed (>15%), Sagebrush steppe fuels with brush heights ranging from 4 to 5 feet with non-native annual grass understory (Fuel Models T or SH-5). This Big Sagebrush stand is near the outflow of Juniper Canyon onto the central plain within the Central Fire Management Zone. The central plain is seen in the background and represents the mosaic of early seral stage sagebrush steppe against the late seral development stage.

| Potential Natural Life Form | Biophysical Life Form | PNVG/BPS | Class | Seral Stage | Percent of natural landscape (%) | Mean Fire Interval (MFI) | Dominant Fire Regime | Percent Stand Replace Potential (%) | Fire Regime Condition Class (FRCC) |
|---|---|---|---|---|---|---|---|---|---|
| Shrub land | Shrub dominated uplands - sagebrush, bitterbrush | Sagebrush – Warm (Basin Big Sagebrush) without trees (PNVG Code: BSAG1) | A: Post-fire replacement | Post fire community of forbs and perennial grasses (e.g.: Figure X8(a&b)) | 25% | 24 | II, primarily short-interval (e.g. <25 yr) stand replacement and mixed severity fires | 61% | 1 |
| | | | B: Mid-development closed | Mid-seral, dense (>15%) canopy cover sagebrush stands with understory of forbs and grasses | 20% | | | | 1 |
| | | | C: Mid-development open | Mid-seral, open (<15%) sagebrush community with perennial asses and forbs in interspaces. (e.g.: Figure X8(c)) | 25% | | | | 1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | D: Late-development open | Late-seral, open (<15%) sagebrush community with limited shrub/herbaceous community | 15% | | | | 2 |
| | | | E: Late-development closed | Late-seral, closed (>15%) sagebrush community, noticeable dead component with limited shrub/herbaceous community (e.g.: Figure X8(d)) | 15% | | | | 2 |

TABLE 1. Vegetation data table showing potential natural vegetation group or biophysical setting, mean fire interval (MFI), dominant fire regime, stand replacement probability due to wildland fire for NWSTF Boardman. Data table follows standard fire regime condition class terminology and definitions (Hann, Wendel; Havlina, Doug; Shlisky, Ayn, et al, 2003, Interagency and The Nature Conservancy Fire Regime Condition Class Website: USDA Forest Service, US Department of the Interior, The Nature Conservancy, and Systems for Environmental Management http://www.frcc.gov]).

| Wildland Fire Fuel Models Identified at NWSTF Boardman | | | | |
|---|---|---|---|---|
| Fuel Descriptions | Photograph | NFDRS Fuel Models | FBPS Fuel Models | |
| | | | (Anderson, 1982) | (Scott & Burgan, 2005) |
| Annual Grasses | | A | 1 | GR-2 |
| Western Perennial Grasses | Figures 5 & 6 | L | 1 | GR-4 |
| Mixed Grass and Shrub | Figures 7 & 8 | L | 2 | GS-2 |
| Sagebrush | Figure 9 | T | 2 and 6 | GS-2 and SH-5 |

TABLE 2. Table of fuels classification within the NWSTF Boardman project area. Fuels within the project area are classified by either the National Fire Danger Rating System (NFDRS) or by the Fire Behavior Prediction System (FBPS). The FBPS has been recently revised (Scott and Burgan, 2005) and consequently this table provides a cross walk between the NFDRS classifications, the older FBPS fuel model classification (Anderson, 1982) and the revised FBPS fuel model classification (Scott and Burgan, 2005).

2. Wildland fire behavior fuel models

a. A number of wildland fire fuel models have been developed over the past four decades to bring uniformity to fuel descriptions and compute fire danger and fire behavior. Table 4 presents a compilation of the most common fuel model descriptions and relates these to wildland fire fuel conditions on NWSTF Boardman and the photographic illustrations presented above. The common fuel model descriptions are: the National Fire Danger Rating System (NWCG, 2002), the fire behavior models of Anderson (1982) and the most recent by Scott and Burgan (2005). These fuel classifications are based upon the fire behavior of these fuels under active burning conditions and do not directly correlate to plant community associations, potential natural vegetation group seral stages, or biophysical setting.

b. Carson (2005) modeled potential wildland fires for the NWSTF Boardman fuels. By varying the parameters and assumptions used, Carson modeled six potential wildland fires on Boardman. Known parameters are terrain and fuels. The fire weather assumptions input by Carson are based on mean parameter values and do not represent the most extreme potential fire weather conditions found on the Range. Output data from the models include probable fire rate of spread and flame length for the given terrain and fuel parameters, and fire weather assumptions. Of the six models, only two produced flame lengths of approximately 4.7 feet or less that would allow for direct wildland fire attack by hand crews. Modeled flame lengths varied from 4.7 feet up to 11.2 feet. The potential rates of spread for the modeled wildland fires were 112 chains per hour up to 270 chains per hour. These fire spread rates exceeded the fire line production rate for hand crews with the upper values exceeding production rates for tractors (NWCG, 2004). Consequently, based on Carson's modeled wildland fires and if not caught early enough while still small, indirect attack procedures are the most probable fire suppression tactics for the Boardman Range. Output data from Carson's modeling appears to agree with fuel type data for flame length and rate of spread as graphed in Scott and Burgan (2005). Note that in the models, assumptions for fire weather conditions approximated mean fire weather conditions and not the potential extreme fire weather conditions.

3. Natural and cultural resource considerations

a. Wildland fire management on NWSTF Boardman implements the natural and cultural resource conservation direction given in the INRMP and in the Integrated Cultural Resources Management Plan (ICRMP).

b. The primary natural resource considerations are to protect juniper trees, native sagebrush stands, and native perennial grasses from wildland fire as much as possible.

c. Natural resource implications for fire management include:

(1) Aggressively, but safely, suppress all wildland fires in or threatening juniper trees, native shrub stands, and native perennial grasslands.

(2) Do not use tracked vehicles in fire suppression.

d. Cultural resources on NWSTF Boardman are primarily susceptible to fire management activities, not to fire damage.

e. Cultural resource implications for fire management include:

(1) Notify Cultural Resources Manager if any cultural resources are found during fire management activities. For further guidance, refer to the NWSTF Boardman Integrated Cultural Resources.

(2) Management Plan, Standard Operating Procedure 3: Accidental Discovery of Archaeological Sites or Burials. Also attached to this IWFMP as Appendix H.

(3). Do not use tracked vehicles or ground disturbing firefighting methods on or across remnants of the Oregon Trail or known archaeological sites for either fire management or fire suppression.

4. Organization and responsibilities

a. CNRNW F&ES has overall responsibility for wildland firefighting activities on NWSTF Boardman. The Oregon Military Department (OMD) is responsible for providing organic wildland firefighting resources during Oregon Army National Guard (ORARNG) training located on NWSTF Boardman. All OMD wildland firefighting actions are coordinated with CNRNW F&ES and NWSTF Boardman staff in accordance with the National Wildfire Coordination Group (NWCG) standards.

b. For the OMD, the fire budget will be the responsibility of the OMD Fire Management Officer or his/her designated representative (FMO). The OMD Fire Captain reports to the OMD FMO and ensures full time and seasonal firefighters are trained at the appropriate levels in accordance with the NWCG standards and is responsible for their scheduling and pay. Based on the annual ORARNG training range schedules and forecasted fire potential, seasonal firefighters will be hired and trained to provide wildland fire suppression accordingly.

5. <u>Personnel training and certification standards and records</u>

a. All NWSTF Boardman firefighters must meet the Firefighter Type 2 (FFT2) requirements established in the Wildland Fire Qualification System Guide, PMS 310-1 (National Wildfire Coordinating Group, National Interagency Incident Management System, October 2016) as a minimum to be able to engage in any fire operations. This standard requires completion of basic firefighter training and an annual refresher. The annual refresher must be completed proceeding each fire season. The Basic fire training and annual refresher will be coordinated by NRNW Fire & Emergency Services Programs using qualified instructors and may be provided by OMD. It is ultimately the responsibility of NRNW Fire and Emergency Services Training Division to ensure annual compliance of the initial and annual training.

b. All personnel engaging in fire activities must meet the arduous physical fitness level established in the PMS 310-1. This standard requires passing the pack test: completing a 3-mile hike with a 45-pound pack in 45 minutes. NWSTF Boardman fire personnel will take the pack test annually, prior to beginning their firefighting duties. NWSTF Boardman fire personnel certification records are kept on file at NWSTF Boardman and with NRNW Fire Emergency Services Training Division

c. All CNRNW F&ES personnel that respond to fires at NWSTF Boardman must be at a minimum Wildland FF2 and Red Card certified. All Senior Fire Officers who perform as Incident Commander from NRNW F&ES will be Strike Team Leaders or working towards their Strike Team Leader.

6. <u>Interagency cooperation and mutual aid agreements</u>. NWSTF Boardman has a mutual aid agreement with the Oregon Military Department's Camp Umatilla Oregon located within the confines of the Army's Umatilla Chemical Depot approximately 15 miles east of Boardman. A copy of the Memorandum of Agreement (MOA) is found in Appendix A. The MOA establishes a fire protection responsibility area for the NWSTF Boardman firefighters; identifies incident command, organization, and communications; and outlines the cooperators' capabilities and limitations. Under the MOA, Oregon Military Department resources may assist Navy and resources on wildland fires on Boardman and vice versa. Additional mutual aid agreements will

be established with adjacent Rural Fire Departments and federal and state agencies in the region where appropriate and where mutually acceptable arrangements can be negotiated. NWSTF Boardman south boundary is covered by the Ione Rural Fire Department and on all other boundaries by the Boardman Rural Fire Department.

7. Mission considerations**.** To maximize safety for training units, wildland fire suppression activities will be conducted as quickly as possible in a safe manner based on the conditions presented during the event. No suppression actions will be taken on wildland fires occurring within the “exclusion areas” which are areas known or suspected to have Unexploded Ordnance (UXO) or white phosphorous and are depicted on Figure 10.

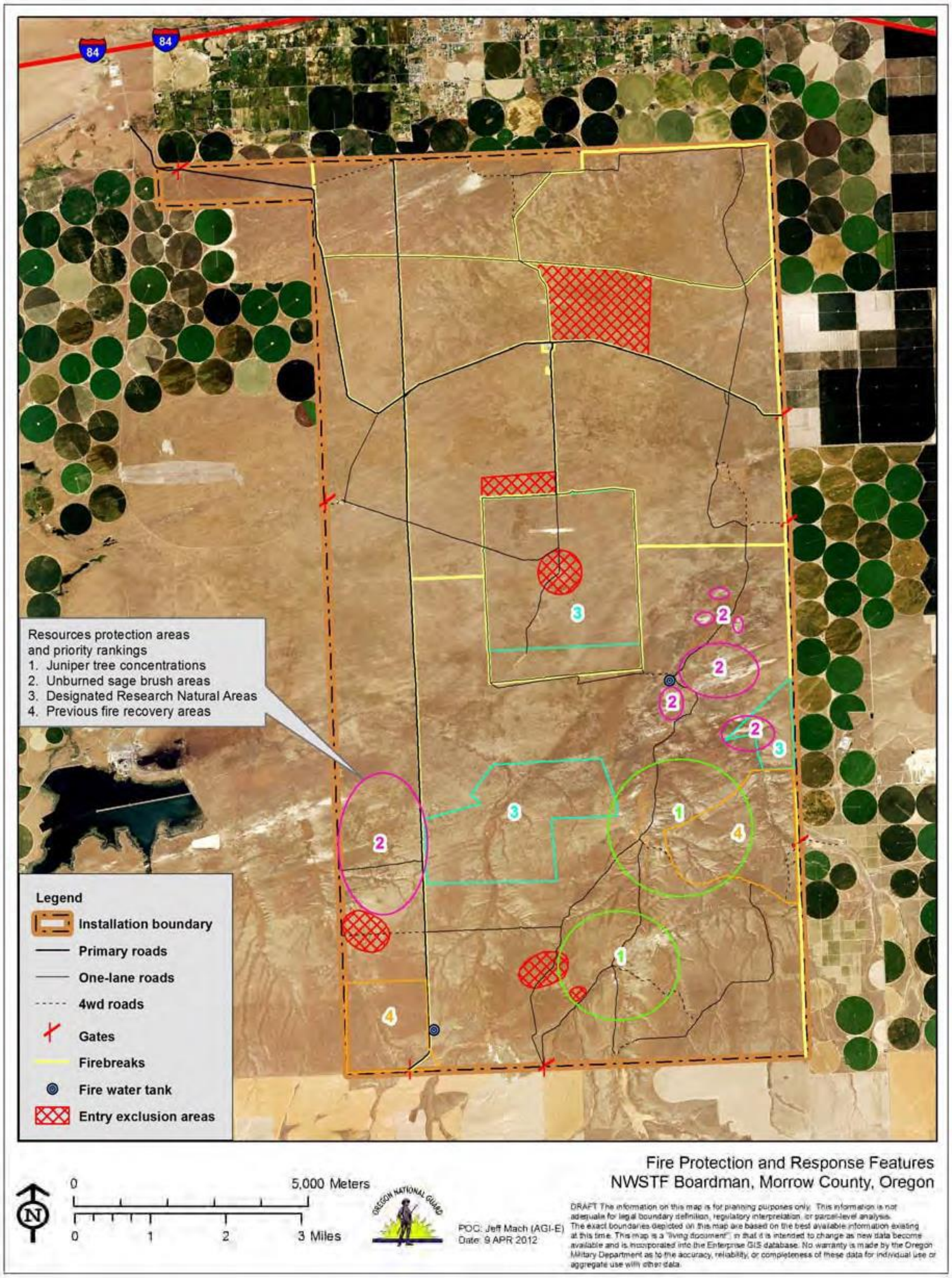


FIGURE 10. Fire suppression at NWSTF Boardman

Enclosure (2)

8. Military training restrictions. On high fire danger days during ORARNG live-fire training, the OMD FMO will recommend modifying the use of pyrotechnics (e.g. IED simulators, artillery simulators, flares, smoke grenades, etc.) Pyrotechnic devices may be fired in open-topped 55-gallon metal drums with fire extinguishers present. These drums mitigate the risk of fire and allow training to continue with minimal disruption. The range Officer in Charge (OIC) retains the authority to accept extreme fire danger days (Red Flag Warning, Fire Weather Watch); the Range Officer will accept, disallow or reject recommendations made by the OMD FMO to limit or modify the use of certain ammunitions based on fire hazard, except in cases of extreme fire danger. Overall authority to permit training during extreme fire danger lies with NAS Whidbey Island Commanding Officer, who has delegated this responsibility to the Operations Office located at NAS Whidbey Island. Such an authorization would be coordinated through the NAS Whidbey Island Range Program Manager. Determination of fire danger is made based on the criteria established in Section 3.9, Fire Danger Indices.

9. Wildland and community/urban interface

a. NWSTF Boardman Firefighters and Structure Firefighting: NWSTF Boardman personnel are not trained and therefore not permitted to suppress structural fires. The NWSTF Boardman personnel involvement in structure firefighting will be limited to suppressing the fire while still in wildland fuels only. NWSTF Boardman personnel do not have the PPE or training to engage in defensive or offensive structural firefighting. Personnel can provide structure protection IAW their training and under the direction of a trained crew boss or their designee.

b. Wildland and community/urban interface.

(1) There are no communities or urban areas within NWSTF Boardman boundary. However, the Navy does have multiple structures within NWSTF Boardman. These are located primarily on the main Range Road near the center of the property. There are high-voltage wooden transmission lines located within the east boundary of the property running north/south. In addition, the ORARNG has proposed construction of several live-fire ranges and an Unmanned Aerial Systems building within the NWSTF Boardman range.

(2) Structures outside of, but adjacent to the NWSTF Boardman include the McCarty Power Plant on the southwest boundary, the Boeing Test Facility just north of that, and rural agricultural residential areas along the north boundary. High value non-structural areas exist in the form of The Nature Conservancy's Conservation area adjacent to the southwest corner of the property, a tree farm along Bombing Range Road on the east boundary, pivot irrigation agricultural farming on the east, north, and west boundaries, and dry land farming activities on the southern boundary.

10. Fire danger indices/risk assessment

a. Fire danger indices correlate weather and fuel moisture data to potential fire activity and intensity. These indices are used to determine the need to modify or limit the use of pyrotechnics and certain munitions. Table 5 relates the fire danger rating (NWCG 2002) to the Burning Index (BI). The correlation of fire danger rating to BI is based on historical BI data and past fire activity. The Bureau of Land Management (BLM) Vale District Office in Vale, Oregon calculates the BI daily and broadcasts the index as part of the fire weather forecast.

b. BI is derived from a combination of how fast the fire will spread and how much energy it will produce. The BI value for a particular fuel type is roughly equivalent to ten times the potential flame length in that fuel. For example, a BI of 40 indicates a potential flame length of four feet.

c. Information displayed on these pocket cards can indicate how a particular day's index rates relative to historical ones. Pocket cards are distributed annually to NWSTF Boardman personnel and a poster of the pocket card is posted at Range Control. The current Vale North pocket card covering the NWSTF Boardman area is found in Appendix E. BLM pocket cards are updated annually and can be found at the following web site: http://fam.nwcg.gov/fam-web/pocketcards/pocketcards.htm#.

d. Table 4 displays additional local weather conditions that have historically led to extreme fire behavior and large fire growth. All weather parameters are reported in the National Oceanic and Atmospheric Administration (NOAA), National Weather Service Fire Weather daily forecast found at the following web site. Breakpoint values are identified on the current Vale District BLM pocket cards: http://radar.srh.noaa.gov/fire/.

| Fire Danger Rating and Color Code | Burning Index (BI) | Description | Recommended Military Considerations |
|---|---|---|---|
| Low (Green) | 0-20 | Fuels do not ignite readily from small firebrands. Most prescribed burns are conducted in this range. | None. |
| Moderate (Blue) | 21-40 | Fires are not likely to become serious and control is relatively easy. Fires burning in these conditions generally represent the limit of control for direct attack methods. | None. |
| High (Yellow) | 41-60 | Fires may become serious and their control difficult unless they are attacked successfully while small. Machine methods are usually necessary or indirect attack should be used. | OMD Fire Captain will recommend firing pyrotechnics into open drums or altering firing times to hours with lower fire danger. |

| | | | |
|---|---|---|---|
| Very High (Orange) | 61-79 | Fires start easily from all causes and, immediately after ignitions, spread rapidly and increase quickly in intensity. The prospects for direct control by any means are poor at this intensity. | No pyrotechnics allowed, except with written authorization from NWSTF Boardman OIC/ NCOIC (authorized by NAS Whidbey Island Operations Office). |
| Extreme (Red) | 80+ | Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. The heat load on people within 30 feet of the fire is dangerous. | No pyrotechnics allowed. |

TABLE 3. Fire Danger Indices. Fire danger rating pocket cards (pocket cards) illustrate daily historic average BI and maximum BI for a given area and fuel model.

| Fuel model | Weather parameter | Value |
|---|---|---|
| Sagebrush – grass | Wind (20’) | >12 mph |
| | Relative humidity | < 19 % |
| | Temperature | > 82 deg F |
| | BI | > 55 |
| | Haines | > 5 |
| Western annual grasses | Wind (20’) | > 12 mph |
| | Relative humidity | < 14 % |
| | Temperature | > 91 deg F |
| | BI | > 44 |
| | Haines | > 5 |

TABLE 4. (Note: Fuel models group vegetation based on potential fire behavior, not actual vegetation composition) Weather conditions indicative of extreme fire behavior potential

11. Safety and emergency operations. During an actively burning fire, the Incident Commander on the ground will have overall authority and all safety and emergency operations are coordinated through the Incident Commander. Any need to evacuate the NWSTF Boardman due to wildland fire will be communicated to personnel by the IC. Medical emergencies requiring evacuations are also coordinated through the IC.

12. Public relations. The NAS Whidbey Island Public Affairs Officer will provide public information for any fires on NWSTF Boardman. If a fire is related to ORARNG training, then the ORARNG Public Affairs Office will coordinate with the NAS Whidbey Island Public Affairs Officer.

# CHAPTER 3
# WILDLAND FIRE OPERATIONS

NWSTF Boardman firefighters respond to all wildland fires on the training area and those offsite that are covered by mutual aid agreements.

1. Fire Protection Resources (Availability/Requirements)

a. There is no organized career fire department located at NWSTF Boardman. The Navy has an authorization for six full time personnel at the range; however, the number actually on site varies at any given time. The NAS Whidbey Island Air Operations is responsible to maintain appropriate Naval personnel and needed support equipment for initial wildland firefighting capability and to maintain fire breaks. This equipment includes a tractor that can be used during the peak fire season by assigned personnel to maintain existing fire/fuel breaks as discussed in Section 4.2 of this plan. All personnel assigned wildland firefighting duties must maintain Red Card certification and be properly equipped and protected.

b. In addition, the OMD provides additional firefighting personnel and equipment when live-fire ranges are active during the fire season.

c. These Navy personnel are not stationed at the bombing range on a 24/7 basis. There are times during non-training hours when there are no personnel on duty, and the main gate is secured during these periods, NWSTF Boardman personnel will monitor the NOAA weather website for fire watches and warning and a Lighting Tracker program.

d. These Navy personnel provide an initial wildland fire response force capable of containing a small fire or, when augmented by outside agency assistance, during an extended wildland fire operation. This initial response force is a critical first line of defense to contain a small fire and in providing initial efforts to prevent a wildland fire from spreading beyond the installation boundaries.

2. Personal Protective Equipment. All firefighting personnel will be issued and will carry personal protective equipment (PPE) that meets the minimum standards identified by the National Fire Protection Association (NFPA) and the NWCG:

a. Flame-resistant Nomex pants and shirts

b. Eight-inch (minimum) leather boots with Vibram sole

c. Hard hats

d. Gloves

e. Eye and ear protection

f. Fire shelter with carrying case and harness

3. Current Assets

a. NWSTF Boardman personnel have five firefighting vehicles assigned to them; two (2) Type VI Brush trucks, two (2) GSA trucks that have a 250-gallon firefighting skid unit mounted making them additional Type VI Brush trucks and an Osh Kosh P-19 1000 gallon converted ARFF truck used as a tender. The type VI Brush Trucks are Navy-owned assets assigned to NRNW F&ES and assigned to NWSTF Boardman based on an agreement with the CNRNW and the installation. All equipment is maintained and supported by N4. Additional assets include a leased tractor and disc for use during the fire season to maintain fire/fuel breaks. In extreme situations, the tractor can also be u s e d for incipient wildland fire suppression efforts when the applications of water and foam lines are unavailable, exhausted, or ineffective.

b. At minimum, the OMD supplies an additional modern Type VI engine when conducting live fire training on NWSTF Boardman. In extreme situations, the OMD can provide two Type IV and three Type VI engines, as well as aviation assets.

4. Aerial resources. A helicopter will be available for water or foam drops during ORARNG live-fire training events when the OMD FMO has determined that conditions warrant this resource. The helicopter must be requested through Range Control and the ORARNG G-3 office to the ORARNG State Army Aviation Officer for final approval and coordination. Planned training events that may require aviation support will be coordinated at least two weeks in advance. Emergency requests for aviation support will be coordinated through the ORARNG Joint Operations Center (JOC). All aviation support will be dependent on resource availability. Through a Mutual Aid Agreement between the Navy and the OMD, aviation resources may also be able to support non-ORARNG training related firefighting on NWSTF Boardman at Navy request.

5. Water sites

a. Water supply on the range is very limited. There are two 10,000-gallon poly water storage tanks and two 5,000-gallon storage tanks supported by portable transfer pumps which feed a fill connector hose for the fire vehicles. A deep well is located near the main facility building, during periods when the deep well is out of service there are mitigation in place with the neighboring farmers and power plant for water supply resources

b. The ORARNG has an agreement with the Carty Power Plant to use their Cooling Pond as a dip source for helicopter firefighting activities.

6. Prevention

a. In the course of developing this IWFMP, the Navy and OMD wildland fire personnel reviewed the existing fire/fuels break system at NWSTF Boardman to determine what modifications should be implemented to improve their effectiveness. This review included analyzing historical fire data, typical weather conditions, and better understanding the function of fire/fuel breaks, and tradeoffs between prevention/suppression of wildland fires and management of natural resources. Clear from this analysis is the understanding that on-site firefighting capability (trained personnel, equipment, and effective SOPs) will be more effective in extinguishing wildland fires early, than any number of fire/fuel breaks, regardless of size or composition. Fire/fuel breaks are one tool of several available to support firefighters' ability to contain and extinguish wildland fires quickly.

b. Permanent firebreaks, typically of a width 4 times the height of adjacent downwind fuels, are designed to help prevent fires from advancing and slow down the rate of spread during low wind speeds, providing firefighters an anchor point for direct or flank attack, and a means of escape should the fire suddenly flare. Given the fuel regime and typical fire season weather patterns at NWSTF Boardman, permanent fire/fuel breaks are effective roughly 50 percent of the time and more so when the potential ignition location is well defined such as live-fire training ranges, as opposed to random lightning strikes. Application of temporary foam breaks in closer proximity to emerging wildland fires can be a more effective method to contain these lightning strike fires early, effectively reducing their spread and damage. During periods of moderate or extreme wind speeds, permanent fire breaks can provide a means of egress and a point at which firefighters can set back burns. These uses were evident during the fires of 1998, 2007 and 2008, where most firebreaks were breached in places and the fires were finally stopped with substantial back burns. The downside to permanent fire breaks from a natural resources management perspective is that they contribute to a loss of native habitat, blowing sand events, wind erosion, and promote invasive cheatgrass establishment (which, in turn, can create additional fuel loading issues).

c. Given that the prevailing winds during fire season are from the west and south, the Navy has determined that permanent fire breaks need to be east and north of major ignition source areas, and west and south of resource protection areas to be most effective. Lightning strike ignition sources occur evenly across the range from east to west, but seem to increase from north to south, possibly due to elevation rise. The primary training ignition source areas would be within the existing main target area and the proposed Multi-Purpose Machine Gun Range, Convoy Live-Fire Ranges, and Multi-Purpose Training Range. Based on this analysis, the following recommendations, also depicted in Figure 11, will be addressed in a phased approach.

(1) Existing disked firebreaks will be maintained along Bombing Range Road to help prevent escape of a wildland fire off of NWSTF Boardman, and the existing firebreak along the northern property boundary will be maintained and extended further to the west to help provide additional protection against escape.

(2) The existing road and disked firebreak that brackets all sides of the main target area will be maintained to help prevent escape of wildland fires from known ignition sources within the target area.

(3) Primary roads such as the "Seabee Road" running north-south, the main entry road to the compound running east-west, and a number of other roads on the northern end of the installation will be maintained; however, the disked firebreaks adjacent to these roads will be converted to fuel breaks with the establishment of low growing native species. This re-vegetation effort would likely include both herbicide applications and a mowing regime to reduce the likelihood of cheatgrass.

(4) The existing firebreak and road running north from the main target area past the compound and along the west side of the white phosphorous exclusion area will be maintained.

(5) The two disked firebreaks without associated roads that run east-west from Bombing Range Road to the east edge of the main target area, and from the west edge of the main target area to the "Interstate" will be eliminated as the priority protection areas are located south of these two breaks.

(6) A new fire break will be disked along an existing two-track road along the east side of the white phosphorous exclusion area in order to fully bracket all sides of this potential ignition source area (the Navy would conduct appropriate consultations under Section 106 of the National Historic Preservation Act prior to disking new fire breaks).

(7) Old grazing-related fences will be removed beginning with those adjacent to existing roads and firebreaks. The fences are no longer needed and compromise the the firebreak system by collecting significant fuel loading in the form of tumbleweeds.

(8) Though not under control of either the Navy or the OMD, there are several north-south trending roads outside the west boundary of NWSTF Boardman that may help to protect the installation from slow moving fires originating on the 20,000-acre Conservation Area.

(9) Most of the proposed range improvement infrastructure projects will likely include firebreak features around them to help protect capital investments and to prevent potential wildland fires from training operations from escaping the immediate range areas.

(10) All units training at NWSTF Boardman are required to be briefed on wildland fire hazards. Briefings include instructions on reporting fires to Range Control, and procedures for fires occurring down range.

(11) On high, very high and extreme fire danger days, the OMD Fire Captain will recommend modifying, limiting, or prohibiting the use of pyrotechnics during any ORANG operations.

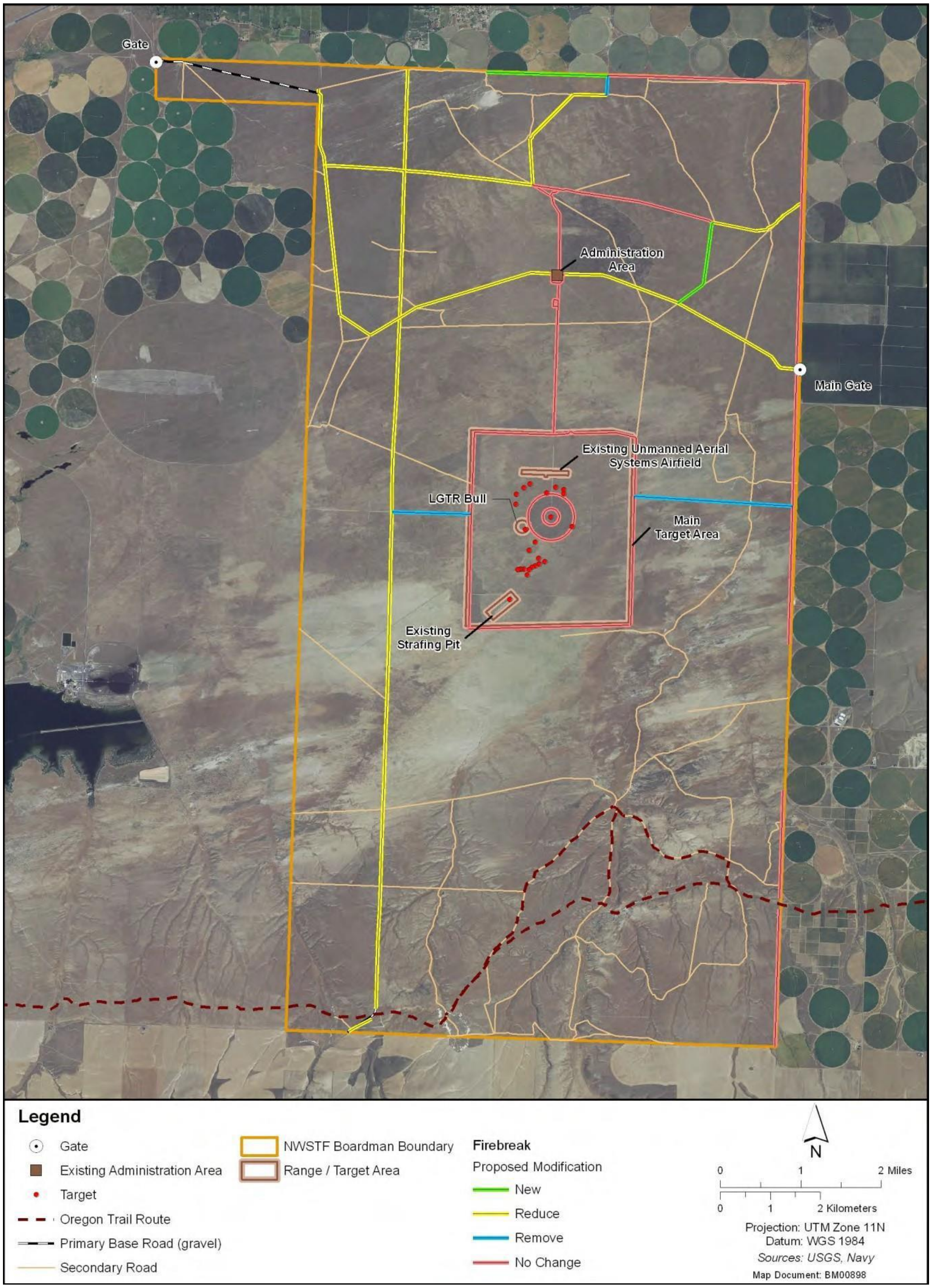


FIGURE 11. Firebreak analysis recommendations

7. Dispatch procedures. Fires on Live Fire Training Ranges: This applies to fires reported on any of the live-fire training ranges during active training days.

a. Wildland fire reported to Range Control.

b. Range Control requests an approximate location

c. Range Control will "check fire" all ranges affecting the wildland fire area

d. Range Control dispatches firefighters down range

e. Firefighters will notify Range Control when fire is extinguished and all firefighting personnel and equipment are clear

f. Range Control will declare range "Hot" and training will resume

8. Suppression

a. Staffing during ORANG Operations:

(1) During ORARNG live-fire range training operations, OMD seasonal firefighters and NWSTF Boardman firefighters in addition to the OMD Fire Captain will be available, especially during fire season. The firefighters will work as engine crews of two or more. The number of crews on duty at any time will depend on fire danger and range activity, although all firefighters will be scheduled for 40 hours per week.

(2) The Boardman Range OIC may determine that a fire watch is necessary during periods of high fire danger, when red flag warnings have been issued, or when night training activities are scheduled. The fire watch will be staffed by one fire crew; from 1200 to 2200 (exact times may change). Fires when Range Control is not on duty will be reported to the NASWI ODO and NRNW RDC. The fire crew on duty will then notify the Range CDO who will in turn notify dispatch for any additional firefighters.

b. Priorities:

(1) Personnel safety is the top priority.

(2) Because of the potential for a wildland fire to spread and escape the installation, suppression of all wildland fires is a priority. Suppression actions taken to protect infrastructure and to prevent wildland fires from reaching exclusion areas or progressing off site will be conducted as first priority and as quickly as safety permits. In addition, four types of natural resource areas have been identified as priority areas for protection, if possible

(Figure 10). Fire suppression at NWSTF Boardman is based on a Minimum Impact Suppression Techniques (MIST) strategy, such as using foam lines where possible to minimize impacts to natural resources. The priority for natural resources protections is the following:

(a) Areas containing juniper trees used as raptor nesting sites;

(b) Sagebrush stands which have not burned in recent fires;

(c) The three Research Natural Areas

(d) Areas which are showing good recovery after the recent wildland fires

c. Pre-positioning firefighting resources during ORANG Operations

(1) During ORARNG live-fire training and when staffing permits, one fire crew will be stationed by each range in use. If staffing is limited, one fire crew will be stationed by each of the active ranges with high fire danger or mid-way between two active ranges.

(2) On high, very high and extreme fire danger days, the OMD FMO will recommend pre-positioning of an ORARNG HH-60 Blackhawk helicopter with a “Bambi-bucket” at NWSTF Boardman during live-fire training; a CH-47 Chinook helicopter with water bucket on standby at the ORARNG Army Aviation Support Facility located in Pendleton. Any additional air assets can be requested IAW established agreements between agencies.

d. Hazards

(1) Firefighting on the NWSTF Boardman presents multiple hazards in addition to those typically present in the wildland fire environment. These hazards demand heightened situational awareness:

(a) Flashy fuels

(b) Frequent strong winds, typically from the southwest

(c) UXO or white phosphorous in areas shown in Figure 10 as “exclusion areas”

(d) Potential for stray fire from adjacent ranges

(e) Potential for accidental fire from range on which wildland fire is located

e. Fire suppression and post-fire reports

(1) All fires on NWSTF Boardman will be fought in accordance to NRNW F&ES SOG 117.07 and NWCG Standards.

(2) Once NWSTF Boardman Range Control dispatches firefighters downrange, the firefighters will:

(a) Contact NRNW RDC and NASWI ODO

(b) Provide a size-up that contains the following

(c) Estimate fire size

(d) Obtain 6-8 digit coordinates for fire

(e) Initiate fire suppression activities

(f) Call for additional resources if needed

(g) Ensure fire is extinguished

(h) Exit range

(i) Reservice vehicles and personnel

(3) If additional resources are needed for extended fire suppression activities the following matrix shall be followed:

(a) Level 1: OMD and immediate notification by RDC of Battalion 3 Assistant Chief of Operations and all NRNW Fire Chiefs.

(b) Level 2: Boardman Rural FD, Umatilla District 1, Ione Rural FPD, start Engines from NRNW.

(c) Level 3: WA State DoD mobilization.

(4) All fires will be reported to NASWI ODO and the NRNW F&ES A/C of Operations for Battalion 3 and be input into the National Fire Incident Reporting System as soon as possible by NRNW F&ES personnel. Report will include location, size, and expected time of control.

(5) NWSTF Boardman Personnel shall protect the origin of non-lightning caused wildland fires and request a fire investigator from NRNW F&ES as needed. Request for a fire investigator will be submitted to Range Control. Range Control will then contact CNRNW Regional Dispatch Center. Wildland fire causes are tracked by the ORARNG in the Range Facility Management Support System (RFMSS).

9. Communications Plan

a. All fire engines and fire personnel assigned to the NWSTF Boardman will have radios programmed with appropriate frequencies. Operators of equipment without mobile radios will be provided portable radios and all ground-to-ground fire traffic takes place on FM 140.450, all ground-to-air traffic will take place on either UHF 305.8 or VHF 126.2.

b. Extended attack procedures: The Incident Commander will report to Range Control any fire that cannot be controlled with OMD and Navy resources and will advise that additional resources are necessary. Range Control will contact appropriate Mutual Aid organizations and the CNRNW Regional Dispatch Center directly to request additional resources. The cooperative fire protection agreements with Mutual Aid organizations cover billing for assistance on wildland fires.

c. Records, reports and monitoring

(1) Firefighters call in a fire report to Range Control after every fire. These fire reports include:

(a) Date, time, location

(b) Approximate size

(c) Cause

(d) Fuel type

(e) Number of personnel and equipment, amount of water used

(2) Reports are stored by the ORARNG in the RFMSS. Fire perimeters are mapped and stored in a Geographic Information System (GIS).

(3) Year-end reporting to National Fire Incident Reporting System includes the total acreage burned on NWSTF Boardman and a breakdown of fire cause.

10. Rehabilitation needs and/or procedures. All fires over five acres will be evaluated by the Navy to determine rehabilitation needs. If deemed necessary, a seeding plan will be developed within 90 days of evaluation. Native seeds will be used if available. The Natural Resources Staffs determine post-rehabilitation monitoring needs on a site-by-site basis.

# APPENDIX A
# MUTUAL AID AGREEMENT

Memorandum of Agreement: N68742-20130124-0065

**DEPARTMENT OF THE NAVY**
**COMMANDER, NAVY REGION NORTHWEST**
**1100 HUNLEY ROAD, SILVERDALE WA 98315-1100**

**OREGON MILITARY DEPARTMENT**
**1776 MILITIA WAY**
**P.O. BOX 14350**
**SALEM, OR 97309-56047**

COMNAVREG NW
4000
Ser N80/ 1266
6 Sep 13

OMD

Ser

**MEMORANDUM OF AGREEMENT**
**BETWEEN**
**COMMANDER, NAVY REGION NORTHWEST**
**AND**
**OREGON MILITARY DEPARTMENT**

Subj: WILDLAND FIRE SUPPRESSION

Ref: (a) DoD Instruction 4000.19 of 25 April 2013
(b) CNICINST 4000.1B of 16 April 2012
(c) CNICINST 3440.17
(d) 44 CFR, Part 151
(e) DoD Instruction 6055.06 of 21 December 2006

1. Purpose. This agreement between Commander, Navy Region Northwest (COMNAVREG NW) and the Oregon Military Department (OMD), is prepared in accordance with references (a) through (e) to secure for each the benefits of mutual aid in the protection of life, property and the environment from wildland fire incidents on the Naval Weapons Systems Training Facility Bombing Range in Boardman, Oregon (hereinafter referred to as "NWSTF") and the Oregon National Guard Training Center located at Umatilla UMCD in Hermiston, Oregon (hereinafter referred to as "UTC").

2. Background. NWSTF does not have an organic career fire department but has six assigned Naval Air Station (NAS) Whidbey Island active duty Navy personnel who are also trained and certified under the direction of the COMNAVREG NW Fire & Emergency Services (F&EMS) program to the Wildland Firefighter II level in accordance with National Wildfire Coordination Group (NWCG) standards. These Navy personnel maintain NWCG red card certifications but do not possess any additional firefighting, hazardous material or EMS certifications. UTC has career OMD Fire & Emergency Service (F&EMS) personnel located on the facility to provide organic fire prevention and emergency response.

3. Scope. This MOA applies only to wildland fire support at NWSTF and UTC.

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4. Period of Performance. MOA shall cover period from DTBD 2013 to DTBT 2018.

5. Responsibilities.

a. NWSTF will:

(1) Dispatch available NWSTF firefighting equipment and personnel to the designated location within the UTC in response to a request of an OMD F&EMS or UTC Operations Center representative, absent any competing F&ES requirements occurring on NWSTF.

(2) Contact UTC F&EMS to request its assistance for wildland fire suppression support for any incidents occurring on NWSTF which exceed NWSTF capabilities.

b. UTC F&EMS will:

(1) Dispatch available UTC F&EMS firefighting equipment and personnel to the designated location within NWSTF in response to a request of a NWSTF or COMNAVREG NW Dispatch Center representative, absent any competing F&EMS requirements occurring on UTC.

(2) Contact COMNAVREG NW Regional Dispatch Center to request NWSTF assistance for wildland fire suppression support for any incidents occurring on UTC which exceed UTC F&EMS capabilities.

6. Other Provisions.

a. Any dispatch of equipment and personnel pursuant to this agreement is subject to the following conditions:

(1) All requests for assistance will identify the specific location to which equipment and personnel are to be dispatched; however, the type and quantity of equipment and number of personnel furnished will be determined by the responding organization.

(2) All personnel will report to and be subject to the orders and direction of the Incident Commander or Unified Command. The most qualified individual on scene (from either the requesting or responding organization) will assume the overall Incident Commander duties. Qualifications should be consistent with the NWCG certification process.

(3) The requesting organization will release the responding organization when the responding organization's services are no longer required, or when the responding organization's assets are needed within its own fire protection area.

(4) All services provided by the parties are subject to the constraints of available resources (personnel, funds, and equipment).

Subj: WILDLAND FIRE SUPPRESSION

(5) The Navy and OMD expressly agree to comply with all applicable federal or state laws, rules and regulations while upon or within NWSTF or UTC, or while undertaking action related to this MOA.

(6) The parties hereto waive all claims against each other for compensation for any loss, damage, personal injury, or death occurring as a consequence of the performance of the terms of this agreement.

(7) NWSTF and UTC F&ES personnel are invited and encouraged, on a reciprocal basis, to visit each other's installation for guided familiarization tours consistent with local security requirements and to participate in joint training drills.

(8) The parties' representatives are authorized and directed to meet and draft detailed plans and procedures of operation to implement this agreement. Such plans and procedures of operations shall become effective upon ratification by the signatory parties.

(9) Neither party is mandated to respond to a request for assistance under this agreement but a party receiving a request should immediately notify the requesting party whether the requested assistance can be provided..

7. Point(s) of Contact

a. NWSTF Bombing Range, Boardman Or.: 541-481-2565

b. COMNAVREG NW F&ES Fire Prevention Division: (360) 396-1143.

c. COMNAVREG NW F&ES Assistant Chief of Operations for Naval Air Station Whidbey Island: (360) 340-1340 (duty cell)

d. COMNAVREG NW Regional Support Agreement Manager: (360) 396-1935.

e. COMNAVREG NW Regional Dispatch Center: (360) 396-3333

f. ORNG Joint Operation Center: (503) 254-2813

g. OMD F&EMS Officer: (503) 584-2843

8. Effective Date.

a. This MOA is effective upon the affixation of all signatures and shall remain in force until modified or terminated by mutual consent of the parties. Each party shall conduct an annual review of this agreement to evaluate its effectiveness and determine the need for continuation or modification. Requests for modification or termination by either party shall be in writing, at least 30 days in advance of the proposed effective date.

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b. Unilateral termination by either party shall be forwarded by written notice to the other party at least 30 days in advance of the proposed termination date, unless mutually agreeable.

26 Jul 13
FERRE, DAVID L. Date
Adjutant General Deputy Director
Oregon Military Department

14 AUG 2013
M. K. NORTIER, CAPT, USN Date
Commanding Officer
Naval Air Station Whidbey Island

26 Jul 13
SWAFFORD, ROY Date
Deputy Director of Installations
Oregon Military Department

4 Sep 13
DAVID R. SLUSHER Date
Comptroller
Commander, Navy Region Northwest

05 SEP 13
A. P. VERHOFSTADT, P.E. Date
Executive Director
Commander, Navy Region Northwest

# APPENDIX B
# FIREFIGHTER QUALIFICATIONS DESCRIPTION

Wildland firefighting positions follow the Incident Command System (ICS). ICS places one person, the incident commander, in charge of all incident activities. The organization may be expanded or contracted based on incident complexity. For moderate to highly complex incidents, some or all command and general staff positions (safety, information, liaison, plans, logistics, finance/administration, operations) may be activated. Regardless of organization size, ICS seeks to maintain a ratio of one supervisor per three to seven personnel (NWCG 1994).

In wildland fire, ICS has pre-identified incident complexity levels, Type 5 through Type 1, that correspond to the minimum organization required for management. With both incident complexity and position level, a lower type number indicates higher complexity. For example, an Incident Commander Type 4 (ICT4) is qualified to manage a more complex incident than an Incident Commander Type 5 (ICT5). Similarly, a Type 1 firefighter (FFT1) has more qualifications than a Type 2 firefighter (FFT2). Qualification requirements for each position are described in PMS 310-1 (NWCG 2006).

Table 1 describes some of the characteristics of very low and low complexity incidents (typical for NWSTF Boardman), and Table 2 describes the primary function and responsibilities of the ICS positions recommended for NWSTF Boardman (NWCG 2004).

| Incident Type | Complexity | Characteristics |
|---|---|---|
| 5 | Very low | ▪ Resources vary from one five firefighters<br>▪ Incident is normally contained rapidly during initial attack<br>▪ A written action plan is not required<br>▪ Command and General staff positions are not activated |
| 4 | Low | ▪ Resources vary from a single firefighter to several single resources (staffed engines, helicopters, air tankers, for example)<br>▪ The incident is limited to one operational period in the control phase. Mop-up may extend into multiple periods<br>▪ A written plan is not required<br>▪ Command and General staff positions are not activated |

TABLE 1. Characteristics of low and moderate complexity incidents

| Position | Primary Function | Responsibilities |
|---|---|---|
| Incident Commander (IC) | Responsible for all incident activities. | • Ensure that safety receives priority consideration in the analysis of strategic alternatives, and in all incident activities.<br>• Assess incident situation, both immediate and potential.<br>• Conduct risk assessment for all strategic alternatives.<br>• Maintain command and control of the incident management organization.<br>• Ensure safety and welfare of all incident personnel and the public is maintained. |
| Single | Responsible for | • Review assignments with subordinates and assign work tasks. |
| Resource Boss- Engine (ENGB) | supervising and directing a fire suppression module. | • Review current and predicted weather conditions and brief subordinates on expected fire behavior.<br>• Ensure adequate communications with supervisor and subordinates.<br>• Set up a backup chain of command to function when boss is absent.<br>• Keep supervisor informed of progress and any changes.<br>• Inform supervisor of problems with assigned resources.<br>• Brief subordinates on safety items including escape routes and safety zones.<br>• Obtain necessary equipment and supplies.<br>• Provide for their welfare.<br>• Monitor work progress. |
| Advanced Firefighter/ Squad Boss (FFT1) | Working leader of a small group (<7) | • Understand exactly what the supervisor<br>• Ensure that personnel have proper safety equipment and tools and know how to care for and use them.<br>• Look after the safety of assigned personnel. |
| Firefighter (FFT2) | Basic resource used in the control and extinguishment of wildland fires | • Perform manual and semi-skilled labor as assigned.<br>• Ensure that objectives and instructions are understood.<br>• Perform all work in a safe manner.<br>• Keep personal clothing and equipment in serviceable condition.<br>• Report accidents or injuries to supervisor.<br>• Report hazardous conditions to supervisor. |

TABLE 2. Primary function and responsibilities of ICS positions recommended for NWSTF Boardman

# APPENDIX C
# FIRE DANGER RATING CARD

The Fire Danger PocketCard communicates information on fire danger to firefighters. The PocketCard describes seasonal changes in fire danger and gives firefighters a general indicator of the potential for the fuels to support extreme fire behavior. The PocketCard does NOT provide site specific fire behavior predictions. Daily fire danger indices, including the Burning Index (BI), are read as part of the weather forecast broadcast by the BLM Vale District Office.

Information contained on PocketCard and utility:

| Section | Interpretation | Utility |
|---|---|---|
| Fire Danger (Chart) | ▪ Title indicates area (Boise BLM) and fuel model (fuel model A, grass) that PocketCard applies to<br>▪ Chart graphs BI versus day<br>▪ Chart illustrates maximum and average daily values and plots 80$^{th}$ percentile BI<br>▪ Color background distinguishes extreme and moderate fire danger potential. | Firefighters can determine how the day's BI compares to the historical average and maximum |
| Years to Remember (Chart) | ▪ Plots BI versus day<br>▪ Labels days with large fire occurrence<br>▪ Color background distinguishes extreme and moderate fire danger potential. | Firefighters can see the indices and time of year that have allowed large fire growth in the past. |
| Fire Danger Area | ▪ Summarizes fuel model, fire weather zone, and weather stations used to create PocketCard | Firefighters can verify that they are looking at the appropriate card. |
| Fire Danger Interpretation | ▪ Describes color background for chats<br>▪ Describes thresholds for maximum, average, and 80$^{th}$ percentile fire danger | Helps firefighters understand i nformation contained on charts |

| | | |
|---|---|---|
| Local thresholds | ▪ Describes combinations of temperature, wind speed, relative humidity, and BI that greatly increase fire behavior | Gives firefighters thresholds for extreme fire behavior potential. |
| What fire danger tells you | ▪ Explains components of BI<br>▪ Describes additional factors contributing to extreme fire behavior | Allows interpretation by inexperienced firefighters |
| Past experience | ▪ Describes factors that have contributed to large fire growth in the past<br>▪ Gives large fire dates and acreages | Reminds firefighters of locally significant weather factors. In combination with 'Years to remember' chart, illustrates the potential for large fire growth under the right conditions. |

# APPENDIX D
# FIRE REPORT FORM

This form is the same as that used by the National Interagency Coordination Center and the Geographic Area Coordination Centers for tracking wildland fire activity on federal land. The common causes listed below the table are the same as those used and tracked in the Interagency (USDA Forest Service and USDOI Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and US Fish and Wildlife Service) wildland fire statistics database.

Unit Name: Naval Weapons System Training Facility Boardman
Agency: U.S. Navy

| | Wildland fire Activity | | | | Year to Date | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | New | | | Uncontrolled | Lightning | | Human | | Total | |
| | Cause | Fires | Acres | Fires | Fires | Acres | Fires | Acres | Fires | Acres |
| | | | | | | | | | | |

Common fire causes:
1. Military mission
2. Lightning
3. Equipment use (non-military)
4. Smoking
5. Campfire
6. Debris burning
7. Railroad
8. Arson
9. Children (playing with mt ches, or example)

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## APPENDIX F. NEPA Environmental Assessment and Finding of No Significant Impact

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**DEPARTMENT OF DEFENSE**
**DEPARTMENT OF THE NAVY**

**FINDING OF NO SIGNIFICANT IMPACT (FONSI) FOR THE ENVIRONMENTAL ASSESSMENT (EA) FOR THE IMPLEMENTATION OF AN UPDATED INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN (INRMP) AT NAVAL WEAPONS SYSTEMS TRAINING FACILITY (NWSTF) BOARDMAN, OREGON**

Pursuant to the Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508) implementing the National Environmental Policy Act (NEPA), and Chief of Naval Operations Instruction (OPNAVINST) 5090.1C, the Department of the Navy (Navy) gives notice that an EA has been prepared and an Environmental Impact Statement is not required for the implementation of an updated INRMP.

The Proposed Action is to implement all objectives and recommendations of the revised INRMP including high-, medium- and low-priority objectives. High-priority objectives include: monitor and control noxious weeds and invasive, non-native plants; conduct Washington ground squirrel surveys; conduct long-billed curlew surveys; and analyze and relocate firebreaks, if necessary. Medium-priority objectives include: map noxious weeds; count, measure, re-tag and map all junipers; use high-resolution aerial photography to map all vegetation; produce geographic information system (GIS) -based vegetation map; recover monumented vegetation plots and resurvey vegetation using established protocol; produce GIS-based data layers for inclusion into Boardman GIS maps; monitor previously burned areas for vegetation recovery; create a proposal to move Research Natural Area (RNA)-A from the main target and identify the specific boundaries of a new location that is more representative of the unique habitat types the RNAs are designed to protect; and map and assess annual wildfires. Low-priority objectives include: conduct large mammal and burrowing owl surveys.

The purpose of and need for the proposed action is to comply with the Sikes Act Improvement Act (SAIA) of 1997, provide management requirements for species listed under the Endangered Species Act, and meet the requirements of Department of Defense and Navy instructions. Moreover, the conservation program must be consistent with the mission-essential use of the installation and its lands and not cause a net loss of military land use. The SAIA requires the preparation of an INRMP to facilitate the conservation program. The INRMP must be cooperatively developed with the U.S Fish and Wildlife Service (USFWS) and the Oregon

Department of Fish and Wildlife (ODFW). Finally, the SAIA requires that the INRMP be reviewed with the USFWS and ODFW annually, as to its operation and effect, and revised or re-signed at least every 5 years.

**Existing Conditions:** The 47,400-acre NWSTF Boardman is located in northern Morrow County approximately 3 miles south of the town of Boardman in north-central Oregon. The installation is rectangular, with a size of 12 by 6 miles and consists of two target spotting towers, a headquarters compound consisting of several buildings that house offices and workshops, several wells and water pipelines, and gravel and dirt roads. The range has been in use as a military training area since 1941. Navy aircraft, as well as aircraft from the Oregon National Guard and other Department of Defense agencies, use the range area for operational training.

**Alternatives Analyzed:** The Preferred Alternative (to adopt and implement all objectives and recommendations of the revised INRMP), Alternative 2 (to adopt and implement only the high and medium priority objectives and recommendations), and the No-Action Alternative were evaluated in the EA. Under the No-Action Alternative, objectives and practices outlined in the existing INRMP completed in 1999 would continue to be implemented and the purpose of and need for the Proposed Action would not be met.

**Environmental Effects:** The EA analyzed the potential effects of the Preferred Alternative, Alternative 2 and the No-Action Alternative on the environment. Potential impacts to relevant resources were evaluated for each alternative and include land use, air quality, water resources, terrestrial biology, cultural resources, socioeconomics and environmental justice, and public health and safety. Each resource area evaluated is briefly described below.

*Land Use.* Implementation of the Preferred Alternative would have a positive impact on land condition at the NWSTF. Land formerly managed under agricultural leases would be managed for native species, providing an additional positive impact by restoring the native vegetation which provides habitat and food resources for native wildlife species. Environmentally sensitive areas are protected from livestock grazing, as this practice is no longer recommended in the revised INRMP.

*Air Quality*. Implementation of the Preferred Alternative would not have an effect on air quality. None of the recommendations in the updated INRMP would alter air quality in relation to the six criteria pollutants. The proposed land management and post fire restoration actions (i.e., alternative techniques such as "green stripping" with herbicide) should have a beneficial effect by reducing fugitive dust and blowing sand that occurs after wildfires or any vegetation removal on the range.

*Water Resources*. Implementation of the Preferred Alternative would not impact groundwater, drinking water, or wastewater due to the lack of discharge possibilities and proximity to surface water sources. The Preferred Alternative would have no effect on water quality or resources as none of the recommendations of the updated INRMP involve changes to water resource management.

*Terrestrial Biology*. Implementation of the Preferred Alternative would have a beneficial impact on terrestrial flora by increasing awareness of species present and implementing new projects to gain additional knowledge about the vegetation that exists, such as junipers and comprehensive vegetation mapping. Additionally, management strategies are provided for invasive species and noxious weed control. The revised INRMP recommendations also include additional goals for fire management and post wildfire restoration actions on the property, which would benefit the flora.

Implementation of the Preferred Alternative would have a positive effect on wildlife species by decreasing invasive species and increasing knowledge of their occurrence through surveys. The updated INRMP includes measures for conservation and protection of natural resources including the following: conduct Washington ground squirrel surveys; analyze and relocate firebreaks; conduct large mammal surveys; and conduct burrowing owl and long-billed curlew surveys and monitoring.

*Threatened and Endangered Species*. Implementation of the Preferred Alternative would not impact threatened and endangered species as there are no listed species that inhabit the NWSTF, nor is there any critical habitat. Implementation of the Preferred Alternative would have a beneficial impact to candidate species and other species of concern by decreasing invasive species and by conducting surveys of current populations and habitats, providing additional data to resource managers to effectively implement updated management strategies.

*Cultural Resources.* Some of the management techniques proposed by the Preferred Alternative, such as techniques that are invasive of soils or may cause erosion, have the potential to adversely affect historic properties. If and when decisions are made to use these invasive techniques, and locations where they may be used are defined, then cultural resource assessments and State Historic Preservation Officer and tribal consultations may be required under section 106 of the National Historic Preservation Act (NHPA). Implementation of the Preferred Alternative would comply with the requirements of NHPA and if needed, proposed management actions would be modified to avoid affects to historic resources. By complying with the NHPA during implementation, the Preferred Alternative would not have an adverse effect on historic properties.

*Socioeconomics and Environmental Justice.* Implementation of the Preferred Alternative would not have a disproportionate adverse affect on minority or low income populations in the area of the NWSTF. All recommendations in the updated INRMP would only affect NWSTF property and would not result in any negative effects to the neighboring properties.

*Public Health and Safety.* Implementation of the Preferred Alternative would have no effect on public or children's health and safety as children and public citizens are excluded by a fence around the perimeter of the property.

**Finding:** Based on the analysis presented in the EA, the Navy finds that implementation of the Proposed Action will not significantly impact the quality of the human or natural environment and an Environmental Impact Statement is not required.

The EA prepared by the Navy addressing this action is on file and interested parties may obtain a copy from: Naval Facilities Engineering Command Northwest, Public Works Department, 1115 West Lexington Drive, Oak Harbor, WA 98278 (Attention: Mrs. Jackie Queen, Environmental Planner).

5/25/2012
Date

D. Biesel
D. T. BIESEL
Rear Admiral, U.S. Navy
Commander, Navy Region Northwest

# ENVIRONMENTAL ASSESSMENT
## INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN FOR NAVAL WEAPONS SYSTEMS TRAINING FACILITY (NWSTF) BOARDMAN
## BOARDMAN, OREGON

**February 2012**

# ENVIRONMENTAL ASSESSMENT
# INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN
# NAVAL WEAPONS SYSTEMS TRAINING FACILITY (NWSTF) BOARDMAN
# BOARDMAN, OREGON

## EXECUTIVE SUMMARY

The proposed action is to adopt and implement an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF), Boardman, Oregon for the years 2012 to 2016. The INRMP was updated in a manner that is consistent with the military use of the property and the goals and objectives established in the Sikes Act Improvement Act (SAIA) of 1997. The purpose of and need for the proposed action is to meet statutory requirements imposed by the SAIA, provide management requirements for flora and fauna species of concern, and meet the requirements of Department of Defense (DoD) and United States Navy (USN) instructions.

The Preferred Alternative (Alternative 1) is to implement all objectives and recommendations of the revised INRMP including:

- High-priority objectives
  - Monitor and control noxious weeds and invasive, non-native plants.
  - Conduct Washington ground squirrel surveys.
  - Analyze and relocate firebreaks, if necessary.
- Medium-priority objectives
  - Map noxious weeds.
  - Count, measure, re-tag and map all junipers.
  - Use high-resolution aerial photography to map all vegetation; produce geographic information system- (GIS)-based vegetation map.
  - Recover monumented vegetation plots and resurvey vegetation using established protocol; produce GIS data layers for inclusion into Boardman GIS maps.
  - Monitor previously burned areas for vegetation recovery.
  - Create a proposal to move Research Natural Area (RNA)-A from the main target and identify the specific boundaries of a new location that is more representative of the unique habitat types the RNAs are designed to protect.
  - Map and assess annual wildfires.
- Low-priority objectives
  - Conduct large mammal surveys.
  - Conduct burrowing owl and long-billed curlew surveys.

With approval of the revised INRMP, the implementation of all objectives and recommendations would effectively manage natural resources at the NWSTF. Alternative 2 would adopt and implement only the high- and medium-priority objectives and recommendations of the revised INRMP. The No-Action Alternative would continue to utilize the existing INRMP (1999) as a management tool. On-going practices for natural resources management at the NWSTF would continue. Many of the management practices of the 1999 INRMP are the same as the revised INRMP, but the 1999 INRMP lacked emphasis on increasing wildlife habitat, threatened and endangered species protection, and range management thus not meeting the purpose and need to meet statutory requirements imposed by the SAIA, provide management requirements for flora and fauna species of concern and meet the requirements of DOD and USN instructions.

The Environmental Assessment was made available for public review and no comments were received.

Based on the analysis in this Environmental Assessment, the Navy has concluded that implementation of the Preferred Alternative and adoption of all recommendations of the updated INRMP would have no significant impact on the human environment and preparation of an Environmental Impact Statement is not required.

## Table of Contents

## Figures



## Tables

## Acronyms and Abbreviations

| | |
|---|---|
| BMP | Best Management Practice |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| DOD | Department of Defense |
| EA | Environmental Assessment |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FONSI | Finding of No Significant Impact |
| FUDS | Formerly Used Defense Sites |
| GIS | Geographic Information System |
| INRMP | Integrated Natural Resource Management Plan |
| MBTA | Migratory Bird Treaty Act |
| NAS | Naval Air Station |
| NAVFAC | Naval Facilities Engineering Command |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| $NO_2$ | Nitrogen Dioxide |
| NRHP | National Register of Historic Places |
| NWSTF | Naval Weapons Systems Training Facility |
| $O_3$ | Ozone |
| ODEQ | Oregon Department of Environmental Quality |
| ODFW | Oregon Department of Fish and Wildlife |
| OPNAVINST | Chief of Naval Operations Instruction |
| OWRD | Oregon Water Resources Department |
| RNA | Research Natural Area |
| SAIA | Sikes Act Improvement Act |
| SECNAVINST | Secretary of the Navy Instruction |
| $SO_2$ | Sulfur Dioxide |
| SPCC | Spill Prevention Control and Countermeasures |
| T&E | Threatened and Endangered |
| TES | Threatened, Endangered and Sensitive |
| USC | United States Code |
| USFWS | United States Fish and Wildlife Service |
| USN | United States Navy |
| UXO | Unexploded Ordnance |

# CHAPTER 1
# PURPOSE AND NEED FOR PROPOSED ACTION

## 1.1 INTRODUCTION

Naval Air Station (NAS) Whidbey Island proposes to adopt and implement an updated Integrated Natural Resources Management Plan (INRMP) for the Naval Weapons Systems Training Facility (NWSTF) located in Boardman, Oregon. An INRMP is a long-range strategic planning document that guides ecologically sound and cost-effective management of natural resources consistent with military land use of the installation.

The Proposed Action is to modify the previous INRMP for the NWSTF executed in 1999 (U.S. Navy 1999) and develop and implement a new INRMP consistent with current military use of the property. The updated INRMP was written from 2010 through 2012 in accordance with the Sikes Act Improvement Act (SAIA) of 1997, as amended (U.S. Navy 2010). It will be approved by the NAS Whidbey Island Command, U.S. Fish and Wildlife Service (USFWS) and the Oregon Department of Fish and Wildlife (ODFW). The purpose of this Environmental Assessment (EA) is to analyze potential environmental impacts associated with each alternative and their effect on the quality of the human environment.

## 1.2 LOCATION AND DESCRIPTION OF NWSTF BOARDMAN

The NWSTF is a detachment activity of NAS Whidbey Island, Oak Harbor, Washington. The 47,400-acre NWSTF is located in northern Morrow County, eastern Oregon, approximately 3 miles south of the town of Boardman (Figure 1-1). Morrow County is located east of the Cascades in north-central Oregon and contains more than one million acres of gently rolling plains and broad plateaus south of the Columbia River. This fertile agricultural land can be roughly divided into three occupational zones—irrigated farming in the north; dry land wheat fields yielding to cattle ranches in the center; and timber products in the south.

The NWSTF is located within the transition zone of irrigated and dry land farming and is bordered to the north, east and part of the northwest by irrigated agricultural properties and to the south by dry land agricultural property. The installation is bordered to the west by land owned by Three Mile Farms; which, from the west central to southwest border, is undeveloped. This undeveloped 23,000-acre portion of the adjoining property is known as the Boardman Conservation Area and is managed by The Nature Conservancy (under a multiple species candidate conservation agreement with assurances between Three Mile Farms and the USFWS) as habitat for the Washington ground squirrel (state endangered/federal candidate for the Endangered Species Act) and multiple bird and plant species. The NWSTF and Boardman Conservation Area are one of the few remaining large, contiguous, undeveloped and native grassland and shrub steppe habitats in the Columbia Plateau. It is a significant native habitat resource on a regional landscape scale.

The NWSTF is rectangular measuring 12 by 6 miles as depicted in Figure 1-1. Infrastructure consists of three metal buildings, dirt roads, an office/trailer and utility services (e.g., telephone, water and electrical).

### 1.3 MILITARY MISSION

Military use of the NWSTF began in 1943 when the U.S. Army Air Corps obtained the land from the Bureau of Land Management and private landowners. The U.S. Army Air Corps and U.S. Air Force practiced aerial bombing and gunnery training until 1958 when it was transferred to the Navy for aerial bombing practice. Until 1996, the range was used regularly for bombing practice by naval aircraft from NAS Whidbey Island and gunnery practice for U.S. Air Force and Oregon Air National Guard aircraft using the strafing pit. After 1996 the range remained active, but was infrequently used by the Navy for bombing practice. Navy aircraft, as well as the Oregon National Guard and other Department of Defense agencies, continue to utilize the range area and restricted airspace for operational training.

The previous Air Force owned portions of the entire range is included in the U.S. Army Corps of Engineers inventory of Formerly Used Defense Sites (FUDS) under the title Boardman Air Force Range. Two potential ordnance sites have been located on land now belonging to non-military owners. This property is known or expected to contain military munitions and explosives of concern (i.e., unexploded ordnance).

### 1.4 PURPOSE AND NEED

The purpose and need of the proposed action is to comply with the SAIA of 1997, provide management requirements for species listed under the Endangered Species Act (ESA) and meet the requirements of the Department of Defense (DOD) and Navy instructions. The SAIA states that the primary purposes of a military conservation program are conservation and rehabilitation of natural resources, sustainable multipurpose use of those resources and public access to military lands subject to safety requirements and military security (16 USC.670a et seq.).

Moreover, the conservation program must be consistent with the mission-essential use of the installation and its lands and not cause a net loss of military land use. The SAIA requires the preparation of an INRMP to facilitate the conservation program. The INRMP must be cooperatively developed with the USFWS and appropriate state fish and game agency (ODFW). The resulting plan reflects the mutual agreement of these parties concerning conservation, protection, and management of natural resources on NWSTF Boardman. Finally, the SAIA requires that the INRMP be reviewed with the USFWS and ODFW annually, as to its operation and effect, and revised or resigned at least every 5 years.

The NWSTF INRMP implements an ecosystem-based conservation program that:

- Provides for conservation and rehabilitation of natural resources in a manner that is consistent with the military mission;
- Integrates and coordinates all natural resources management activities;
- Provides for sustainable, multipurpose uses of natural resources; and provides for public access of natural resources subject to safety and military security considerations. The management objectives are to integrate range management, fish and wildlife management and land management, as practicable and consistent with the military mission and established land uses.

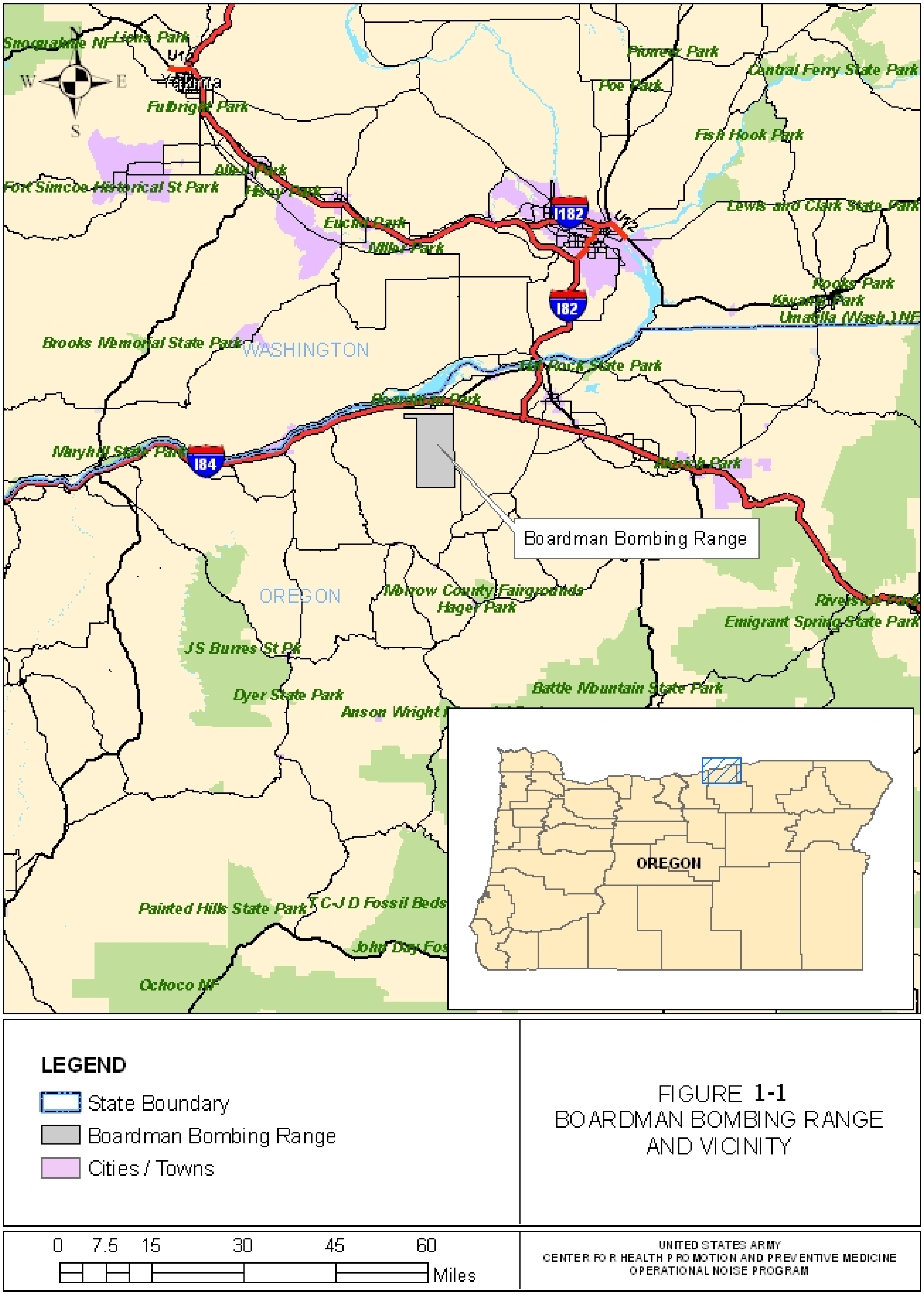


**Figure 1-1. NWSTF Boardman Vicinity Map**

This EA documents the NWSTF's proposal to manage its natural resources under a revised INRMP by evaluating potential impacts on the human environment. The EA evaluates the Proposed Action and alternatives to the Proposed Action in accordance with NEPA, Navy regulations implementing NEPA and OPNAVINST 5090.1C. The EA was also developed to determine whether the action warrants preparation of an environmental impact statement (EIS) or supports a finding of no significant impact (FONSI).

## 1.5 SUMMARY OF KEY ENVIRONMENTAL COMPLIANCE REQUIREMENTS

### 1.5.1 National Environmental Policy Act

Chapter 5 of the Department of the Navy *Environmental and Natural Resources Program Manual* (OPNAVINST 5090.1c) states that the Navy must comply with all applicable federal, state, and local environmental laws and regulations, including NEPA. The intent of NEPA is to help decision makers make well-informed decisions based on an understanding of the potential environmental consequences and to take actions to protect, restore or enhance the environment.

The Act also established the Council on Environmental Quality (CEQ) which is charged with developing and implementing regulations and ensuring federal agency compliance with NEPA. The CEQ regulations mandate that all federal agencies use a prescribed, structured approach to environmental impact analysis. This approach also requires federal agencies to use an interdisciplinary and systematic approach in their decision-making process. This process evaluates potential environmental consequences associated with a Proposed Action and considers alternative courses of action.

The process for implementing NEPA is codified in 40 Code of Federal Regulations (CFR) 1500-1508, *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*. These regulations specify that an EA be prepared to briefly provide evidence and analysis for determining whether a FONSI or an EIS should be prepared. The EA can aid an agency's compliance with NEPA when an EIS is unnecessary and facilitates preparation of an EIS when one is required.

### 1.5.2 Other Key Environmental Compliance Requirements

The planning and decision-making process for federal agencies also involves all applicable environmental statutes and regulations. The NEPA process, however, does not replace procedural or substantive requirements of other environmental statutes and regulations. It addresses them collectively in the form of an EA or EIS, which enables the decision-maker to have a comprehensive view of major environmental issues and requirements associated with a Proposed Action. According to CEQ regulations, the requirements of NEPA must be integrated "with other planning and environmental review procedures required by law or by agency so that all such procedures run concurrently rather than consecutively" (CEQ 1978).

## 1.6 INTERAGENCY COORDINATION AND PUBLIC INVOLVEMENT

NEPA requirements promote the availability of environmental information to the public during the decision-making process and prior to actions being taken. The premise of NEPA is that the quality of federal decisions would be enhanced if proponents provide information to the public and involve the public in the planning process. The Intergovernmental

Cooperation Act, as amended (42 USC. 4231 et seq.) and Executive Order 12372, *Intergovernmental Review of Federal Programs*, require federal agencies to cooperate with and consider state and local views in implementing a federal proposal.

As part of the process, the Navy will notify federal, state and local agencies of the Proposed Action (Alternative 1) and will request input regarding environmental concerns they might have regarding the Proposed Action. Input from agency responses will be incorporated into the analysis of potential environmental impacts and included in Appendix A.

NEPA requirements also help ensure that environmental information is made available to the public during the decision making process and prior to actions being taken. The public involvement process augments the Navy opportunity to cooperate with and consider state and local views in implementing a federal proposal. In accordance with precedent in the Ninth Circuit, the draft EA will be made available for public comment and review prior to a FONSI being issued.

### 1.7 Organization of the EA

The EA is organized into six sections:

**Chapter 1** contains background information on NWSTF Boardman, a statement of the purpose of and need for the Proposed Action, a summary of applicable regulatory requirements, a discussion of agency coordination and public involvement, and an introduction to the organization of the EA.

**Chapter 2** provides a detailed description of the Proposed Action and a discussion of the alternatives considered, including the No-Action Alternative; and a description of the decision to be made.

**Chapter 3** contains a characterization of the affected environment, or baseline environmental conditions, and addresses potential environmental consequences associated with the Preferred Alternative (Alternative 1), Alternative 2 and No-Action Alternative.

**Chapter 4** provides an analysis of the potential cumulative impacts.

**Chapter 5** presents a list of preparers and distribution list.

**Chapter 6** lists the reference documents used in the preparation of the EA. In addition, various appendices that support these six sections of the EA and provide additional data and information will be included.

### 1.8 Resource Areas Excluded from Detailed Analysis

In compliance with NEPA, CEQ guidelines, and 32 CFR Part 775, the evaluation of environmental impacts focuses on those resources and conditions potentially subject to impacts, and on potentially relevant environmental issues deserving of study, and deemphasizes irrelevant issues. Environmental resources that are unlikely to have impacts or impacts are negligible have been omitted from detailed analysis. Table 1-1 provides the basis for these exclusions.

**Table 1-1. Issues Eliminated from Analysis**

| Issue Eliminated | Reason for Elimination |
|---|---|
| Geology and Soils | No impacts to geology and soils would occur as the result of the implementation of the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |
| Noise | No modification or impacts to noise levels would occur as the result of the implementation of the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |
| Airspace | No modification or impacts to the airspace would occur as a result of the implementation of the Preferred Alternative (Alternative 1), Alternative 2 and No-Action Alternative as the alternatives are land-based. |
| Safety | No safety concerns are expected from the implementation of the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |
| Utilities (including electricity, natural gas, water, sewer, solid waste) | No modification or impacts on infrastructure or utilities would occur as a result of the implementation of the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |
| Transportation | Transportation users include enlisted personnel and various support staff and the general public is not permitted on NWSTF property. No traffic issues or effects on transportation systems would be anticipated under the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |
| Hazardous materials/hazardous waste/installation restoration | The use of hazardous materials or generation of hazardous wastes is not anticipated under the Preferred Alternative (Alternative 1), Alternative 2 or No-Action Alternative. |

# CHAPTER 2
# PROPOSED ACTION AND ALTERNATIVES

## 2.1 BACKGROUND

The revised INRMP replaces the previous INRMP executed in 1999 (U.S. Navy 1999). This plan satisfied the 1996 DOD requirements and involved appropriate state and federal agencies in the cooperative management of natural and outdoor recreation resources at the NWSTF.

Since 1996, some installation operations and land uses have changed. In addition, natural resource laws and DOD and Navy guidance and protocols have changed. The Washington ground squirrel has become a candidate species for federal listing as threatened or endangered since the 1999 INRMP. Protection of federally listed threatened and endangered species (T&E) is a high priority for Navy natural resource management.

The Sikes Act (16 USC 670 et seq.), amended by the SAIA in November 1997, requires the Secretary of Defense to carry out a program to provide for the conservation of natural resources on military installations. To facilitate this program, the SAIA states that all DOD facilities with natural resources will cooperate with USFWS and the appropriate state fish and wildlife agency to develop and implement an INRMP that provides sound management planning. The INRMP is to be reviewed annually and updated, or re-written or resigned, as circumstances dictate at least every 5 years. NWSTF Boardman's current INRMP was written and implemented in 1999. As mentioned in Section 1.1, the newly updated INRMP was written in collaboration with USFWS and ODFW and will be approved by all parties in 2012. The updated INRMP will be implemented upon completion of the EA process. Navy policy states that either an EA or an EIS will be prepared for the adoption and implementation of a revised INRMP.

The management objectives of the revised INRMP are to integrate range management, fish and wildlife management, and land management and outdoor recreation management. Special consideration is given to T&E species and their habitats and to the Bird Aircraft Strike Hazard management program. General management changes in the revised INRMP include:

- Initiate additional plant and wildlife surveys.
- Enhance natural resources management through best management practices (BMPs) as recommended in the INRMP.

## 2.2 PROPOSED ACTION

The proposed action is to adopt and implement an updated INRMP for the NWSTF in a manner that is consistent with the military use of the property to ensure a no net loss of military training capabilities and the goals and objectives established in the Sikes Act (as amended). The updated INRMP will be implemented in FY 2012 and remain in effect through FY 2016, with annual updates as needed. In FY 2017, the INRMP will be thoroughly reviewed for currency and effectiveness, and revised or resigned as necessary.

The goal of the updated INRMP is to implement an ecosystem-based conservation program that provides for conservation and rehabilitation of natural resources in a manner that is consistent with the military mission; integrates and coordinates all natural resources management activities; provides for sustainable, multipurpose uses of natural resources; and provides for public access for use of natural resources subject to safety and military security considerations. The management objectives are designed to integrate fish and wildlife management, land management and outdoor recreation management, as practicable and consistent with the military mission and established land uses.

In addition to meeting the purpose and need, the Proposed Action will have additional benefits that include: (1) better integration of the INRMP with other installation planning documents; (2) improved integration of the natural resources program with other NWSTF activities; (3) explicit goals and objectives under which ongoing and future natural resources projects will be implemented; and (4) a systematic approach to integrated natural resources management that documents present and future program implementation.

The NWSTF INRMP has developed management goals that are consistent with DOD, Navy and installation policies and guidance on how natural resources should be managed, sustained and rehabilitated where applicable. These goals are:

- **Goal 1.** Protect, conserve and manage the watersheds, wetlands, natural landscapes, soils, forests, fish and wildlife and other natural resources, as vital elements of a natural resources program.
- **Goal 2.** Protect threatened, endangered and sensitive (TES) species and critical habitats regulated by the ESA.
- **Goal 3.** Manage natural resources to provide outdoor recreation opportunities that are compatible with security, safety and operations.
- **Goal 4.** Use of and care for natural resources for the present and future needs of the U.S. and its people.
- **Goal 5.** Provide for the optimum use of land and water areas and access thereto while maintaining ecological integrity.
- **Goal 6.** Interact with the surrounding community to develop positive and productive community involvement, participation and educational opportunities.
- **Goal 7.** Increase awareness of natural resources issues, programs and responsibilities for sustaining those resources among the NWSTF employees.
- **Goal 8.** Integrate the NWSTF natural resources program with local, state and regional environmental programs and initiatives to the maximum extent practicable.
- **Goal 9.** Augment management of natural resources on the NWSTF through the installation of a Geographic Information Systems (GIS) database.

Significant changes from the 1999 INRMP include:

1. Agricultural outleases for both ranching (cattle and sheep) and croplands were halted in 2002 and have not occurred since. Livestock have been removed from the NWSTF and the removal has altered the existing land conditions and major land use. Under

the land use management recommendations of the 1999 INRMP, all grazing management recommendations are obsolete as grazing no longer occurs on the NWSTF.

2. Additional recommendations for natural resources management issues have been identified since the 1999 INRMP. There are new recommendations based on current issues, such as protection of the Washington ground squirrel. Additionally, the updated INRMP has prioritized the recommendations (high, medium and low) and proposes a schedule for implementation. The updated INRMP uses the Navy's Environmental Readiness Level (ERL) system to assess priority levels for recommended actions. ERL is also used for prioritizing funding, linking implementation need with funding need. For this analysis, ERL 4 equates to a high priority level, ERL 3 to a medium priority level and ERL 2 to a low priority level. It is expected that NWSTF Boardman will seek funding through NAS Whidbey Island and implement the high priority recommendations first, then the medium priority recommendations and finally the low priority recommendations. The recommendations are listed in Table 2.1.

**Table 2-1. INRMP Recommendations**

| Project Recommendations | ERL | Estimated Cost | Implementation Year |
|---|---|---|---|
| **Vegetation Management** | | | |
| **V-1: Monitor and control noxious weeds and invasive, non-native plants.** Primary efforts of control will consist of herbicide spraying spot applied directly to plants, not broadcast from trucks or from the air. Secondary control is with manual and/or mechanical removal. | 4 | $125,000 ($25,000 each year) | FY 2012, 2013, 2014, 2015, 2016 |
| **V-2: Count, measure, re-tag and map all junipers.** Junipers provide important habitat for nesting birds and shade habitat for other species. Mapping and tagging of junipers occurred previously. An inspection in 2006 found new, unmapped recruitment and dead, tagged trees. On the ground field mapping of the junipers will help identify area expansion/reduction trends (when compared to the last mapping effort) and provide data as to the health of the trees. | 3 | $6,000 and in-house labor | FY 2012 |

**Table 2-1. INRMP Recommendations**

| Project Recommendations | ERL | Estimated Cost | Implementation Year |
|---|---|---|---|
| **V-3: Use high-resolution aerial photography to map all vegetation; produce GIS-based vegetation map.** The last vegetation map was produced at least ten years ago. Since then, grazing leases have been terminated, resulting in a change in vegetation. Wildfires have also swept parts of the range. A new mapping effort is required to identify and quantify the changes, to provide data for management purposes. The cost reflects the acquisition of imagery, ground truthing, and the production of a GIS data set for maps. | 4 | $70,000 | FY 2014 |
| **V-4: Recover monumented vegetation plots and resurvey vegetation using established protocol; produce GIS data layers for inclusion into Boardman GIS maps.** Oregon State University established vegetation survey plots in the 1980s. These plots have been marked with monuments for recovery. This project will use the original methods to resurvey the plots. This will provide 1) ground truthing for V-3 above; 2) trend analysis for vegetation change due to the termination of grazing and to wildfire impacts; and 3) permanent locations to measure future vegetation change or stability. | 4 | $60,000 ($20,000 each year) | FY 2012, 2014, 2016 |
| **V-5: Monitor previously burned areas for vegetation recovery.** Conduct pedestrian surveys through the previous wildfire areas and assess natural vegetation recovery. Areas that are not recovering naturally back to the desired pre-fire habitat types will be assessed for restoration success and priority ranked for potential restoration measures to be implemented in project V-6 below. | 3 | In-house labor | FY 2012, 2013 |
| **V-6: Restore native vegetation.** Areas previously impacted by Navy mission, land management activities, or wildfire will be treated to re-establish native plant communities. This will not apply to areas encumbered by unexploded ordnance (UXO). | 3 | $260,000 ($130,000 each year) | FY 2014, 2016 |
| **V-7: Move Resource Natural Area (RNA)-A.** NWSTF Boardman will coordinate with The Nature Conservancy to move RNA-A from the main target and identify the specific boundaries of a new location that is more representative of the unique habitat types the RNAs are designed to protect. New fencing to surround the new location will need to be installed. | 2 | $15,000 | FY 2013 |

**Table 2-1. INRMP Recommendations**

| Project Recommendations | ERL | Estimated Cost | Implementation Year |
|---|---|---|---|
| **V-8: Map noxious weeds.** Perform an installation-wide mapping of noxious weeds/invasive plant species following the protocols used in the 1997 survey. This includes creating a GIS map layer to prioritize control. | 3 | $30,000 | FY 2014 |
| **Wildlife** | | | |
| **WL-1: Conduct large mammal surveys.** Pronghorn antelope have recently moved onto the range and may be permanent or semi-permanent residents. Rocky Mountain elk may also occasionally use the installation. Mule deer inhabit the range but the extent of the herd is unknown. Conduct surveys to identify the extent of the herds and to help identify impacts to range vegetation and provide data for herd management. | 2 | $12,500 for equipment ($2,500 for two surveys each year) and in-house labor | FY 2012, 2013, 2014, 2015, 2016 |
| **WL-2: Conduct Washington ground squirrel surveys.** Washington ground squirrels are a state protected species (in addition to a candidate federal species). Military training can impact the ground squirrel population on the installation. Burrow and population estimate data is available from past surveys, but new data is required to assess changes or stability due to 1) termination of grazing and resulting changes in vegetation, 2) recent fires, and 3) new mission requirements. | 4 | $80,000 ($20,000 per year) | FY 2013, 2014, 2015, 2016 |
| **WL-3: Conduct burrowing owl surveys and monitoring.** Burrowing owls nest in excavations in the ground and thus are susceptible to disturbance or injury from vehicles and/or training. New data is needed to identify habitat use areas for management and military training decisions, to track population trends, and to evaluate and/or alter NR enhancement actions. | 2 | $30,000 ($10,000 per year) | FY 2012, 2014, 2016 |
| **WL-4: Conduct long-billed curlew surveys and monitoring.** Curlews nest on the ground in open grassland areas and thus are susceptible to disturbance or injury from vehicles and/or training. New data is needed to identify current habitat use areas for management and military training decisions, to track population trends, and to evaluate and/or alter NR enhancement actions. | 4 | $45,000 ($15,000 per year) | FY 2012, 2014, 2016 |

**Table 2-1. INRMP Recommendations**

| Project Recommendations | ERL | Estimated Cost | Implementation Year |
|---|---|---|---|
| **Fire Management** | | | |
| **FM-1: Analyze and relocate fire breaks.** Develop a comprehensive assessment of firebreaks for the installation. Include the results of firebreak success from the 2008 fire and alternative techniques such as "green stripping" with herbicide or fire resistant vegetation. | 3 | $20,000 | FY 2013 |
| **FM-2: Map and assess annual wildfires.** Annually, as needed, map all wildfire perimeters and assess natural resource damage from the event to be used for future monitoring needs and restoration prioritization. | 3 | In-house labor | FY 2012, 2013, 2014, 2015, 2016 |

## 2.3 ALTERNATIVES

### 2.3.1 Alternative 1 (Preferred Alternative)

Alternative 1 (the Preferred Alternative) is to adopt and implement all objectives and recommendations (described in Table 2-1) of the revised INRMP. The implementation of all objectives and recommendations would effectively manage natural resources at the NWSTF and would include wildlife and habitat surveys that would assist in future project planning and development with benefits to all wildlife species regardless of listed or protected status.

### 2.3.2 Alternative 2

Alternative 2 is to adopt and implement only the high and medium priority (ERL 4 and 3) objectives and recommendations (described in Table 2-1) of the revised INRMP. The implementation of only the high and medium priority objectives and recommendations would maintain the current natural resources management conditions at the NWSTF, but would focus primarily on regulatory driven resources under the ESA and Migratory Bird Treaty Act (MBTA) requirements.

### 2.3.3 No-Action Alternative

The No-Action Alternative continues implementation of the objectives and practices outlined in the existing INRMP completed in 1999. On-going practices used for natural resources management at NWSTF Boardman would continue. Many of the management practices of the 1999 INRMP are the same as the revised INRMP, but lacks emphasis on increasing wildlife habitat, threatened and endangered species protection and range management thus not meeting the purpose and need to meet statutory requirements imposed by the SAIA, provide management requirements for flora and fauna species of concern and meet the requirements of DOD and USN instructions.

# CHAPTER 3
# AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

The baseline for this environmental analysis is the current conditions at NWSTF Boardman and management methods of natural resources on NWSTF Boardman property under the 1999 INRMP (U.S. Navy).

## 3.1 LAND USE

### 3.1.1 Affected Environment

The 47,400-acre NWSTF Boardman is located in northern Morrow County approximately 3 miles south of the town of Boardman (Figure 1-1). Morrow County is located on the Columbia Plateau east of the Cascades in north-central Oregon, which contains more than one million acres of gently rolling plains and broad plateaus. This rich agricultural land can be roughly divided into three occupational zones—irrigation farming in the north; vast fields of dry land wheat yielding to cattle ranches in the center; and timber products in the south. The NWSTF land area is rectangular, with a size of 12 by 6 miles. The installation consists of two target spotting towers, a headquarters compound consisting of several buildings that house offices and workshops, several wells and water pipelines, gravel and dirt roads. The northern two-thirds of the facility gently rises in broad, flat alluvial terraces from approximately 400 feet in elevation to approximately 700 feet (U.S. Navy, 1999). The southern one-third of the facility consists of rolling hills and varies in elevation from 700 to 950 feet. Several canyons provide topographic relief. The range has been in use as a military training area since 1941. Navy aircraft, as well as the Oregon National Guard and other Department of Defense agencies, utilize the range area for operational training.

The NWSTF is largely surrounded by areas developed for various agricultural uses and remains essentially undeveloped and has one of the largest stands of Columbia Basin shrub steppe habitat in Oregon. Range vegetation consists of desert shrubs, such as sagebrush and antelope bitterbrush, and grasses, such as bluebunch wheatgrass. In former grazing and agricultural areas, cheatgrass is prominent.

Prior to 2002, agricultural outleases for grazing covered approximately 42,000 of the 47,400 acres of the NWSTF. An additional 240 acres were leased as agricultural cropland parcels. In 2002, all agricultural outlease agreements on the property were terminated. In the years that have passed, the areas once utilized for agricultural outleases have changed significantly. Without the disturbance of cattle, sheep, and agriculture, both native and invasive vegetation, has taken over these sites. Many of these areas contain a high density of exotic and invasive species.

Currently, NWSTF land is used as a military training/operations area.

### 3.1.2 Environmental Consequences

The implementation of Alternatives 1 or 2 would have a positive impact on land condition at the NWSTF. Under Alternative 1, land formerly managed under agricultural leases would be managed for native species, providing an additional positive impact by restoring the vegetation native conditions therefore providing habitat and food resources for native wildlife species. All updated INRMP recommendations maintain current management processes in regards to land use. Environmentally sensitive areas are protected from livestock grazing, as this practice is no longer recommended in the revised INRMP. Under Alternative 2, large mammal and burrowing owl surveys would not be conducted as management would be focused on regulatory ESA and MBTA requirements. Surveys provide baseline data to assist in the development of management surveys as well as identify and protect breeding and foraging habitat. No new construction is planned as part of either Alternative 1 or 2.

The updated INRMP contains recommendations that address current issues at the NWSTF, including Washington ground squirrel and burrowing owl habitat, vegetation, and fire management. These recommendations provide a comprehensive look at the NWSTF's natural resources and their relationship to land use practices on the property, giving natural resource managers the tools to effectively manage Navy natural resources.

The No-Action Alternative would have a negative effect on land use because the outdated INRMP (approved in 1999) recommendations would remain the only land use management tool for natural resources. The 1999 INRMP is based on a joint land use of agricultural and military training/operations; however, because grazing no longer occurs at the NWSTF, grazing recommendations are not applicable. By not implementing the updated INRMP, the Navy will not establish updated management recommendations for land use, therefore not meeting the purpose and need to meet statutory requirements imposed by the SAIA, provide management requirements for flora and fauna species of concern and meet the requirements of DOD and USN instructions.

## 3.2 AIR QUALITY

### 3.2.1 Affected Environment

The six criteria pollutants identified by the U.S. Environmental Protection Agency (EPA) are: sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide, ozone ($O_3$), lead, and particulate matter less than 10 microns in diameter ($PM_{10}$), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). The proposed action air basin is considered to be an air quality attainment area of the National Ambient Air Quality Standards for all criteria pollutants; therefore, a General Conformity Determination is not required. The area is regulated by the EPA, the Oregon Department of Environmental Quality (ODEQ) and the Oregon Department of Agriculture. NWSTF Boardman does not have stationary emission sources as defined in the regulations. No air pollution sources are located on the range itself.

### 3.2.2 Environmental Consequences

Neither of the action alternatives would have an effect on air quality. None of the recommendations in the updated INRMP involve any actions relating to an alteration in air quality in relation to the six criteria pollutants. The proposed land management and post fire restoration actions (i.e., alternative techniques such as "green stripping" with herbicide) should have a beneficial effect on fugitive dust and blowing sand that occurs after wildfires or any vegetation removal on the range.

The No-Action Alternative would have no effect on air quality as none of the management strategies under the 1999 INRMP related to air quality in relation to the six criteria pollutants due to the lack of stationary emission sources at NWSTF Boardman. There would be no improvement in fugitive dust and blowing sand as the 1999 INRMP has no recommended post fire and general land restoration actions.

## 3.3 WATER RESOURCES

### 3.3.1 Affected Environment

Water resources on NWSTF Boardman are predominantly human-made, with several water wells that historically were used for drinking water or livestock watering. Operable water wells occur at four locations, and are utilized to provide firefighting water to the range. Exposed risers (capped, above-ground extensions of the waterline system) occur intermittently along the waterlines. In the past, one of the risers fed a small depression in Juniper Canyon (Toad Pond) for six to eight weeks during April and May.

Two ephemeral ponds excavated for past livestock use capture seasonal rainwater and are located at the head of Well Springs Canyon and east of Juniper Canyon (Oregon Trail Pond). These ponds also provide seasonal water for wildlife. The only natural water occurs as rainfall runoff creating intermittent ponding in Juniper and Well Springs canyons. In some years the flow is sufficient enough to leave behind pools of standing water. Other than shallow depressions that may contain seasonal precipitation, no surface water exists on the facility (see Figure 3-1). The Columbia River is approximately 2 miles north of the range, and in an arid climate with little runoff and porous soil, this water supply is too distant to be affected by stormwater runoff. There are no industrial wastewater discharges at the range.

**Groundwater**

Groundwater quality has been a concern in the NWSTF region in recent years, particularly for nitrates, explosives compounds and perchlorate. The range facility, including administrative offices, uses bottled water as its potable water source. An on-site well supplied drinking water to the range facility until the mid-1990s, but drinking water use was discontinued when nitrates exceeded the 10-milligram-per-liter (mg/L) state drinking water standard. The well is still used for non-potable purposes (e.g., fire protection). Documentation of groundwater sampling and analysis for this well is available in NAS Whidbey Island Environmental Division files.

The Lower Umatilla Basin Groundwater Management Area was established in 1990 because elevated nitrate levels (above the 7 mg/L trigger) were detected in many wells within a 352,000-acre portion of Umatilla and Morrow Counties. The Columbia River basalt aquifer, which underlies the installation, is a confined aquifer. The Oregon Water Resources Department (OWRD) has designated a large Critical Groundwater Area just east of the range's eastern boundary and a Classified Groundwater Area just south of the range's southern boundary (OWRD 2009). Additional groundwater pumping in a Classified Groundwater Area is restricted to a few designated uses (OWRD 2003). A Critical Groundwater Area is one where pumping of groundwater exceeds the long-term natural replenishment of the underground water reservoir. This legal designation is designed to prevent excessive declines in ground water levels.

ODEQ has had a groundwater sampling program in this area of the Lower Umatilla Basin for a number of years, monitoring nitrate levels in the area groundwater. It is believed that agricultural practices (e.g., fertilizer use) cause the elevated nitrate concentrations. In June 2003, ODEQ performed a round of sampling at three wells on Port of Morrow property just north, and down gradient, of NWSTF Boardman's northern boundary. The samples were analyzed for nitrates and explosive compounds. Results for explosive compounds were below detection levels in all three wells, with one exception; a single detection of 10 parts per billion 1, 3-dinitrobenzene was reported in one well. However, because the compound was also detected in the associated method blank, and the detection could have been a false positive, the result was categorized as inconclusive by ODEQ.

In September 2003, ODEQ performed groundwater sampling at 133 wells in the vicinity of NWSTF Boardman. Perchlorate was detected in just over half of the wells, distributed among irrigation wells, monitoring wells and private drinking water wells. ODEQ and the Navy have been corresponding and meeting about the ODEQ sampling program since May of 2002. Although the Navy acknowledges the possibility that some undocumented use of perchlorate-based munitions may have occurred in the past, to date, the Navy is not part of the ODEQ sampling program due to a lack of documented evidence of the use of such munitions at the range.

The most recent groundwater sampling effort occurred June 2010 (USN 2011). Two new monitoring wells, plus seven monitoring wells installed in 2005, and one historical well were sampled for explosive compounds, nitroguanidine, perchlorate, nitrate, nitrite, chloride, sulfate, and bicarbonate alkalinity. Positive detections are summarized in the following bullets:

- Perchlorate was detected in all monitoring wells, except for Border Well (BW)-3, Open Burn/Open Detonation (OB/OD)-1, and the Demo Area Well. Concentrations ranged from 0.68 micrograms per liter (μg/L) at OB/OD-2 to 4.4 μg/L at BW-5. All detected concentrations for perchlorate were below the screening concentration value of 15 μg/L.
- Explosive compounds were detected at monitoring well BW-5. Nitroglycerin was detected at a concentration of 0.690 μg/L (method detection limit [MDL] - 0.15 μg/L) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine was detected at a concentration of 0.059 μg/L (MDL - 0.027 μg/L). BW-5 is in the northeast corner of the range and distant from all range related activities.
- All four anions were detected at virtually all the monitoring wells. The only exception was that nitrate-nitrite was not detected at monitoring well BW-3. At the nine monitoring wells where nitrate-nitrite was detected, the concentrations ranged from 0.065 mg/L at OB/OD-1 to 54.20 mg/L at BW-4.

### 3.3.2 Environmental Consequences

No impacts to groundwater, drinking water or wastewater are anticipated from either action alternative due to the lack of discharge possibilities and proximity to surface water sources.

Both the Preferred Alternative and Alternative 2 would have no effect on water quality or resources as none of the recommendations of the updated INRMP involve any alteration to management of water resources.

The No-Action Alternative would have no effect on water quality or water resources as none of the management strategies under the 1999 INRMP addressed water quality at the NWSTF due to the lack of permanent surface water, no use of groundwater except in limited circumstances, and no wastewater discharge sources on site.

## 3.4 TERRESTRIAL BIOLOGY

### 3.4.1 Affected Environment

**Cooperative Agreement**

A Cooperative Agreement was signed in September 1998 between the U.S. Navy, USFWS and ODFW. The purpose of the Agreement was to "provide a framework for the USFWS and ODFW to assist NWSTF in the coordination, development, and implementation of a Cooperative Plan for natural resources management." The Agreement opened discussions and built relationships between state and federal agencies allowing for a more collaboration and effective management of the NWSTF natural resources and land use, especially TES species.

**Flora**

Vegetation on the NWSTF is described broadly as shrub-steppe. Shrub-steppe is the largest natural grassland in North America, extending from southeastern Washington and eastern Oregon, through Idaho, Nevada, and Utah, and into western Wyoming and Colorado. Shrub refers to the most abundant plant species that grows in this ecoregion. "Steppe" is a Russian word that means a vast treeless plain. In the Mid-Columbia Basin, shrub-steppe winters are cold and wet with strong winds and blowing snow. Summers are hot and dry with temperatures that can reach above 100 degrees Fahrenheit during the day and cool at night. The dominant shrubs include sagebrush (*Artemisia spp.*), spiny hopsage, bitterbrush (*Purshia tridentata*), rabbitbrush (*Crysothamnus spp*.), black greasewood, western juniper and threetip sagebrush. Native grasses are mostly large bunchgrasses. Vegetation also includes flowering forbs. However, large portions of nearly all of these native species on the NWSTF are heavily encroached with cheatgrass, an invasive annual grass species. Other invasive species on NWSTF property include Russian thistle, tumblemustard, and whitlow-grass. There are also some largely unvegetated sand dune and "alkali" areas on the NWSTF.

In 2003 and 2004, field surveys of NWSTF Boardman were conducted to update information on all special status plant species to meet preservation requirements under the ESA and management techniques of the SAIA. Table 3-1 summarizes the results of this rare plant study. This survey also mapped out the NWSTF in terms of habitat quality for plant species.

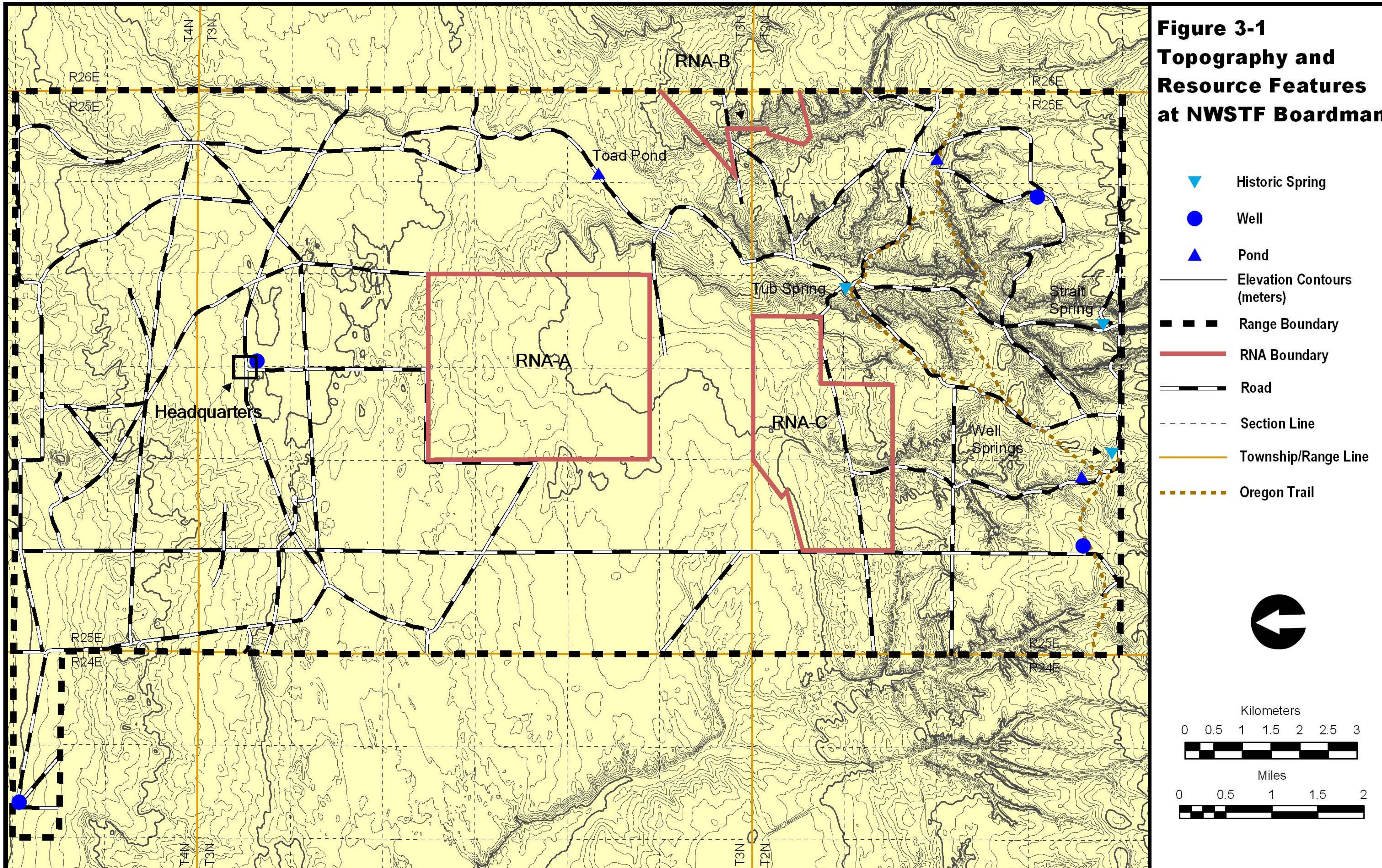


**Figure 3-1 Topography and Resource Features at NWSTF Boardman**

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**Table 3-1. Results of the Rare Plant Survey Conducted by the Navy in 2003-2004**

| Species Name | Common Name | Number of plants identified |
|---|---|---|
| *Astragalus sclerocarpus* | Dalles milkvetch | 520 |
| *Astragalus succumbens* | Crouching milkvetch | 477 |
| *A. sclerocarpus & A. succumbens* | Both of the above together | 58 |
| *Astragalus caricinus* | Buckwheat milkvetch | 2 |
| *Hymenopappus filifolius filifolius* | Columbia Cut-Leaf | 5 |
| **Total Number of Rare Plants Identified** | | **1062** |

Habitat conditions were evaluated with values of Low to High based on concentrations of exotic plant species versus concentrations of native plant species. Figure 3-2 portrays the results based on the following criteria:

- L Low – Area entirely comprised of exotic species
- ML Medium Low – Exotic species dominate with native plant species evident
- M Medium – Area a mix of native plant species and exotic species
- MH Medium High – Native species dominate but few exotic species present
- H High – A full component of native grasses with no exotic species present.

Wildfires are an irregular event during the hot, dry summer months and much of the vegetative structure on the facility is a result of pattern burns by wildfires. Wildfires are a natural event that in many ways can cause long-term improvements to the vegetative community by controlling invasive vegetation and reducing fuel loading. However, large uncontrolled wildfires can disrupt management strategies completely alter the vegetation stand for many years and sometime permanently unless intensive restoration actions are implemented. Since the 1999 INRMP was developed, three large wildfires and several smaller ones have burned much of the NWSTF (except for the northwest corner) and altered vegetative conditions.

Three Research Natural Areas (RNAs) exist on NWSTF Boardman (Figure 3-1). The RNAs are part of a federal government system established for research and educational purposes. Natural features are preserved for scientific purposes and natural processes are allowed to dominate. The objectives of the RNAs are to serve as baseline areas against which effects of human activities can be measured; sites for study of natural processes in undisturbed ecosystems; and as gene pool preserves of organisms, especially rare and endangered types.

## Fauna

NWSTF Boardman supports an exceptional number of wildlife species. At least 81 species of birds, 21 mammals, 6 reptiles and 1 amphibian have been recorded on the facility by investigating biologists. Of these, 33 species of birds, 19 mammals, 6 reptiles and 1 amphibian are known to breed at the NWSTF. Table 3-2 shows these species, separated into the above groupings.

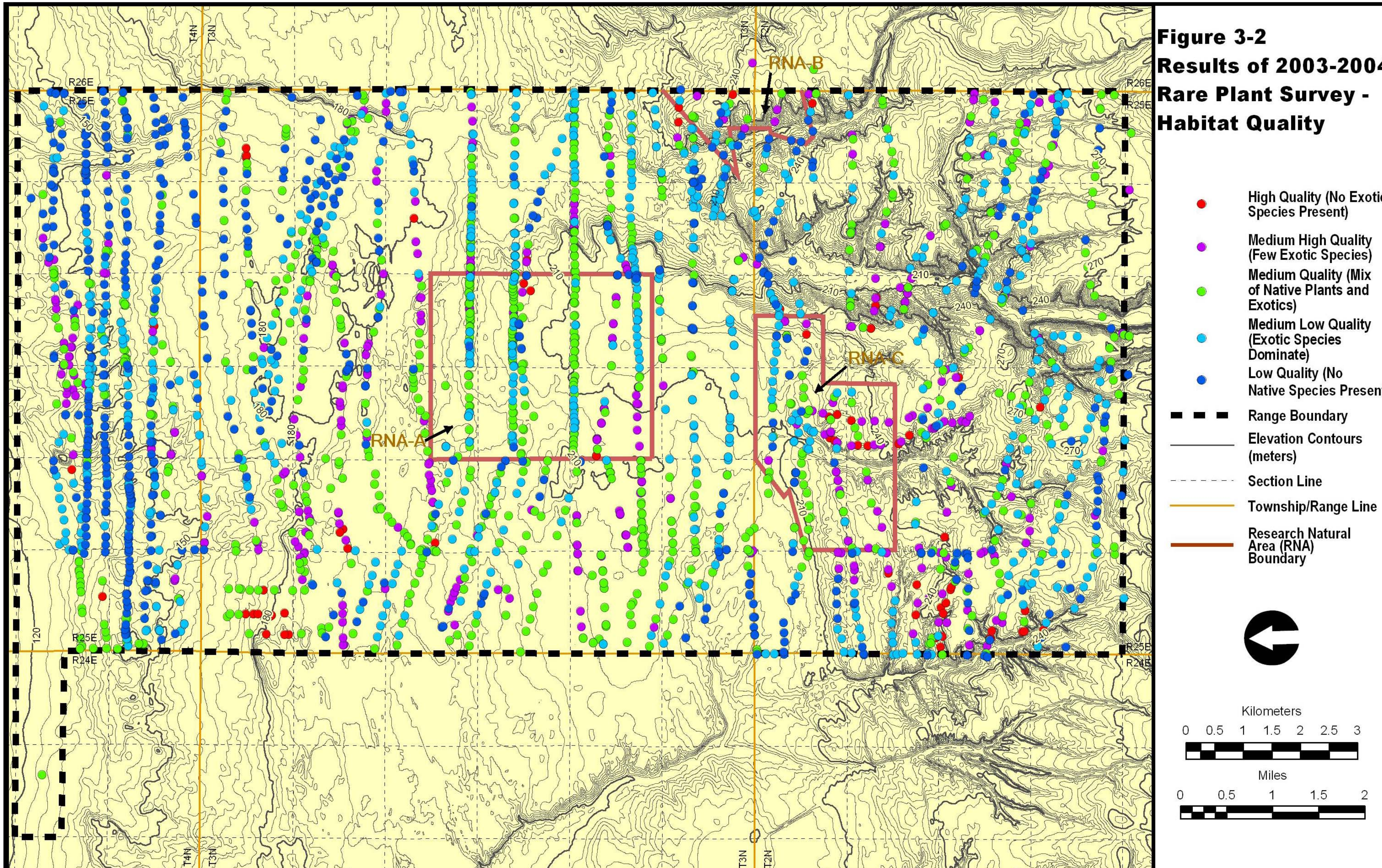
Figure 3-2
Results of 2003-2004 Rare Plant Survey - Habitat Quality
High Quality (No Exotic Species Present)
Medium High Quality (Few Exotic Species)
Medium Quality (Mix of Native Plants and Exotics)
Medium Low Quality (Exotic Species Dominate)
Low Quality (No Native Species Present)
Range Boundary
Elevation Contours (meters)
Section Line
Township/Range Line
Research Natural Area (RNA) Boundary
Kilometers
0 0.5 1 1.5 2 2.5 3
Miles
0 0.5 1 1.5 2
RNA-A
RNA-B
RNA-C
R26E
R25E
R24E
T4N
T3N
T2N

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The only amphibian on the NWSTF is the Great Basin spadefoot toad, which is a unique amphibian that is adapted to arid deserts and shrub-steppe habitat. No other amphibians have been recorded, or are expected to occur on the facility due to a lack of surface water sources. In the past, a small depression in Juniper Canyon (Toad Pond) was watered for six to eight weeks during April and May, forming a small seasonal breeding habitat for spadefoot toads. Three lizards and three snakes have been verified as occurring on the NWSTF.

At least 21 species of mammals occur on the facility, 18 of which are expected to breed and occur year-round. Presently, pronghorn antelope are increasing in numbers in south Morrow County and some of these animals may have moved to northern Morrow County. Pronghorn are now spotted with some regularity on the NWSTF, and there may be 2 distinct herds, with a total of approximately 30 animals.

Since 1979, at least 81 species of birds have been recorded on the facility, 33 of which nest there. Bird species listed in Table 3-2 (except for the European starling and house sparrow) are protected under the Migratory Bird Treaty Act. Sagebrush habitats support the highest number of species (54) and confirmed breeders (21) followed by annual grass/forb (35/8), bitterbrush (33/9), and juniper habitats (27/9). Sagebrush, bitterbrush, and juniper habitats exhibit high structural diversity and, consequently, more niches for different bird species. In general, species diversity was highest in the shrub habitats, while densities of breeding birds were highest in the grassland habitats (Holmes and Geupel 1998). Four species alone (western meadowlark, grasshopper sparrow, horned lark, and long-billed curlew) comprised over 98 percent of the breeding pairs found in grassland and open low shrub (rabbitbrush) habitats (Holmes and Geupel 1998).

**Table 3-2. Wildlife Species Present at NWSTF Boardman**

| | | |
|---|---|---|
| Amphibian | | |
| Great Basin Spadefoot Toad | | |
| Reptiles | | |
| Short-horned Lizard | Side-blotched Lizard | Racer |
| Northern Sagebrush Lizard | Gopher Snake | Western Rattlesnake |
| Mammals | | |
| Vagrant Shrew | Western Harvest Mouse | Red Fox |
| Black-Tailed Jackrabbit | Deer Mouse | Coyote |
| Nuttall's Cottontail | Northern Grasshopper Mouse | Long-Tailed Weasel |
| Washington Ground Squirrel | Sagebrush Vole | Badger |
| Northern Pocket Gopher | Montana Vole | Rocky Mountain Elk |
| Great Basin Pocket Mouse | House Mouse | Mule Deer |
| Ord's Kangaroo Rat | Porcupine | Pronghorn Antelope |
| Birds | | |
| American Crow | European Starling | Red-tailed Hawk |
| American Goldfinch | Ferruginous Hawk | Red-winged Blackbird |
| American Kestrel | Fox Sparrow | Ring-billed Gull |
| American Robin | Golden-crowned Kinglet | Ring-necked Pheasant |
| Barn Owl | Golden Eagle | Rock Wren |

**Table 3-2. Wildlife Species Present at NWSTF Boardman**

| Birds (continued) | | |
|---|---|---|
| Barn Swallow | Gray Flycatcher | Rough-legged Hawk |
| Black-billed Magpie | Gray Partridge | Sage Sparrow |
| Brown-headed cowbird | Grasshopper Sparrow | Sage Thrasher |
| Brewer's Blackbird | Horned Lark | Say's Phoebe |
| Brewer's Sparrow | House Sparrow | Savannah Sparrow |
| Black-crowned Night Heron | Killdeer | Sharp-shinned Hawk |
| Black-Throated Sparrow | Lark Sparrow | Short-eared Owl |
| Blue-Winged Teal | Lewis' Woodpecker | Spotted Sandpiper |
| Bullock's Oriole | Loggerhead Shrike | Spotted Towhee |
| Burrowing Owl | Long-billed Curlew | Swainson's Hawk |
| California Gull | Long-eared Owl | Townsend's Solitaire |
| California Quail | Macgillivray's Warbler | Turkey Vulture |
| Caspian Tern | Mallard | Upland Sandpiper |
| Chipping Sparrow | Merlin | Vesper Sparrow |
| Chukar | Mountain Bluebird | Violet-green Swallow |
| Cliff Swallow | Mourning Dove | Western Kingbird |
| Common Nighthawk | Northern Flicker | Western Meadowlark |
| Common Poorwill | Northern Harrier | Western Sandpiper |
| Common Raven | Northern Pintail | Wilson's Warbler |
| Cooper's Hawk | Northern Rough-winged | White-crowned Sparrow |
| Dark-Eyed Junco | Orange-crowned Warbler | Western Tanager |
| Eastern Kingbird | Prairie Falcon | Yellow-headed Blackbird |

### 3.4.2 Environmental Consequences

**Flora**

Alternatives 1 and 2 would have a beneficial impact on terrestrial flora. Overall, the updated INRMP recommendations protect flora on the NWSTF by increasing awareness of species present and implementing new projects to gain additional knowledge about the vegetation that exists, such as junipers and comprehensive vegetation mapping. Additionally, management strategies are provided for invasive species and noxious weed control. The revised INRMP recommendations also include additional goals for fire management and post wildfire restoration actions on the property, which would benefit the flora.

The No-Action Alternative would maintain existing conditions for flora at the NWSTF as there would be no change from the outdated vegetation management strategies under the 1999 INRMP, which focused on largely agricultural land use and vegetation management for that land use regime. Since no additional measures for post-wildfire restoration would be implemented, this alternative would have a negative impact on flora.

**Fauna**

Recommendations in Alternative 1 of the updated INRMP would have a positive effect on wildlife species by decreasing invasive species and increasing knowledge of their occurrence through surveys. The updated INRMP includes measures for conservation and protection of natural resources including the following: conduct Washington ground squirrel surveys; analyze and relocate firebreaks; conduct large mammal surveys; and conduct burrowing owl and long-billed curlew surveys and monitoring.

Alternative 2 would have a beneficial impact on wildlife at the NWSTF as the medium and high priority projects and recommendations of the revised INRMP would be implemented. The updated INRMP contains recommendations that include additional surveys for important fauna in order to better supplement management of these species on the property. This would have a positive impact on the ESA and MBTA protected species.

By not implementing the revised INRMP, the No-Action Alternative would maintain existing conditions for fauna at the NWSTF. There would be no change from the outdated management strategies under the 1999 INRMP, which focused on agricultural land use and species management for that land use.

## 3.5 THREATENED AND ENDANGERED SPECIES

### 3.5.1 Affected Environment

There are no federally listed T&E species that are documented to occur on the NWSTF. Table 3-3 provides a list of threatened, endangered, candidate and species of concern that are found or potentially found on the NWSTF. The Washington ground squirrel *(Spermophilis washingtoni)* is a federal candidate species, meaning that the USFWS is evaluating whether it should be federally listed as a threatened or endangered species. The Washington ground squirrel inhabits the arid sagebrush and grassland regions of the Oregon and Washington Columbia Plateau. Presently, the largest collection of Washington ground squirrel colonies occurs at NWSTF Boardman (Quade 1994), where it has become a focal species in recent years because of its candidate species status. Results of recent studies indicate the following: (1) Washington ground squirrel populations have rebounded at NWSTF Boardman after an apparent decline in the 1980s and early 1990s (probably due to drought conditions during those years); and (2) the facility supports the majority of Oregon's remaining populations of this squirrel species.

There are no wetlands on the property and the surface water streams on the property are seasonal. No critical habitat for threatened and endangered species has been designated at the NWSTF.

There are no federally listed threatened or endangered species of plants, lichen or fungi occurring on the NWSTF. The only rare plant with federal status occurring in the Columbia River Basin portion of Morrow County that could occur on the range is Laurence’s milk-vetch (*Astragalus collinus var. laurentii)*, a federal species of concern. However, a rare plant survey conducted by the Navy in 2003 and 2004 found no specimens of this species.

**Table 3-3. Threatened, Endangered, Candidate, and Species of Concern**

| Species | Status | |
|---|---|---|
| *Fauna* | Federal | State of Oregon |
| Peregrine Falcon [1] | - - | Endangered |
| Northern Sagebrush Lizard | Species of Concern | Sensitive - Vulnerable |
| Ferruginous Hawk | Species of Concern | Sensitive - Critical |
| Swainson's Hawk | - - | Sensitive - Vulnerable |
| Upland Sandpiper | Species of Concern | Sensitive - Critical |
| Long-billed Curlew | - - | Sensitive - Vulnerable |
| Burrowing Owl | Species of Concern | Sensitive - Critical |
| Loggerhead Shrike | - - | Sensitive - Vulnerable |
| Black-throated Sparrow | - - | Sensitive - Peripheral |
| Sage Sparrow | - - | Sensitive - Critical |
| Grasshopper Sparrow | - - | Sensitive - Vulnerable |
| Washington Ground Squirrel | Candidate for Listing | Endangered |
| *Flora* | Federal | State of Oregon |
| Laurence's Milk-vetch[1] (*Astragalus collinus* var. *laurentii*) | Species of Concern | Threatened |

[1] Potentially occurring at NWSTF Boardman.

### 3.5.2 Environmental Consequences

Alternatives 1 and 2 and the No-Action Alternative would have no impacts on threatened and endangered species as there are no listed species that inhabit the NWSTF, nor is there any critical habitat. Alternatives 1 and 2 would have a beneficial impact to candidate species and other species of concern by decreasing invasive species and conducting surveys of current populations and habitats, providing additional data to resource managers to effectively implement updated management strategies.

The No-Action Alternative would maintain existing conditions for candidate species and other species of concern. Although it provides management requirements for flora and fauna species of concern, the No-Action Alternative does not meet statutory requirements imposed by the SAIA or requirements of DOD and USN instructions.

## 3.6 CULTURAL RESOURCES

### 3.6.1 Affected Environment

Early Americans inhabited the central Columbia River basin since at least the last of the great Bretz floods 12,000 years ago (Allen et al. 1986), but little is known of the history of these people before the first European explorers arrived in the early 1800s. By this time, distinct tribes and territorial boundaries had become fully established. In 1850, the present day location of the NWSTF fell fully within the Umatilla Tribe territory, although the Cayuse claimed land to within a very few miles of the eastern boundary of the facility (Ray 1936, 1938). Well Springs played an important role in the history of the Oregon Trail as it was the only significant source of water in the nearly 30-mile stretch between Butter and Willow creeks. Emigrants crossing this stretch in the 1840s and 1850s described the land as a barren, sandy desert and one of the worst stretches encountered during the entire journey, probably owing to the fact most wagon trains passed during the dry late summer and early fall (French 1971).

Well Springs is actually a collection of three springs. Two of the springs are a quarter mile apart and are located on the main trail. Together they are called Upper Well Spring. These two springs are bisected by the southern boundary of the facility. The third spring, Tub Spring, was originally called Lower Well Spring and is located in Juniper Canyon on the Lower Well Springs Diversion of the Oregon Trail approximately three miles north of Upper Well Spring (Lewarch et al. 1997; see Figure 3-1). The Oregon Trail ruts leading to and from these springs are clearly visible today.

Homesteading on the facility began in the 1880s when George Swaggart established a 160-acre homestead at Tub Springs. The extent to which Swaggart developed this site is unknown, although historical records show that one of his children was born at Tub Springs in 1888. Swaggart eventually lost the property in a mortgage foreclosure, when John S. Kilkenny and James Carty purchased it in a sheriff's sale in 1898. In 1900, Carty bought out Kilkenny and moved his family from Sand Hollow to Tub Springs. It is reported that Carty built a house, barn, and sheep shed at Tub Spring, although structures from the Swaggart settlement were probably still present. Carty lived at this site until about 1940 when the military acquired the land from his son (who purchased that land from his father in 1936) and demolished the buildings. Another house was built at Well Springs in the 1910s by John Harbke. This house was continuously used until it too was acquired by the military and removed in 1940. Traces of a third home site can be found in Juniper Canyon approximately two miles south of Tub Spring; however, its history is unknown. Several temporary sheep camps also occupied various locations on the facility in the late 1800s and early 1900s.

There are multiple archaeological and cultural sites present on NWSTF Boardman. The Well Spring Segment of the Oregon Trail (containing Upper Well Spring) was listed on the National Register for Historic Places (NRHP) in 1978. Additionally, there are archaeological sites at Tub Spring, the Juniper Canyon site (the “Mounds”), and the Jim Carty Homestead site. Evidence of temporary sheep camps can be found throughout the facility. There are also various remains (towers, bunkers, bomb craters, etc.) from past military activity. Also, Native American cultural sites may occur. However, a thorough facility-wide cultural resource investigation has not been conducted.

### 3.6.2 Environmental Consequences

Adopting the updated INRMP as a management tool under Alternatives 1 or 2 is not an undertaking under the National Historic Preservation Act (NHPA) that will have an adverse effect on historic properties because it does not designate any specific tasks at specific locations that can be evaluated or consulted for impacts. Thus, SHPO consultation for the adoption of the INRMP is not required.

However, some of the management techniques that are proposed within the Alternatives may affect historic properties if they are implemented. Any technique that is invasive of soils or may cause erosion (such as manual or mechanical vegetation removal, creating new fire breaks, etc.) has the potential to adversely affect historic properties. If and when decisions are made to use these invasive techniques, and locations are defined, then cultural resource assessments and SHPO and tribal consultations may be required under section 106 of the NHPA.

All alternatives will comply with the requirements of NHPA and if needed, proposed management actions would be modified to avoid affects to historic resources. No affect is anticipated to historic resources from any of the alternatives.

## 3.7 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

### 3.7.1 Affected Environment

The NWSTF is located in Morrow County, Oregon, in census tract 9701, an area that includes the towns of Boardman and Irrigon and the land area south and west of Boardman that encompasses the NWSTF. The U.S. Census data from the year 2000 lists this census tract population at 7,597 people. Of this total, 61.8% (4,698 people) classify themselves as Caucasian and 34% (2,586 people) classify themselves as Hispanic or Latino. The poverty level of Census Tract 9701 is 13.3% of families and 17.3% for individuals. The median household income is $36,845.00. No residences exist on the NWSTF property.

### 3.7.2 Environmental Consequences

The implementation of either action alternative will not have a disproportionate adverse affect on minority or low income populations in the area of the NWSTF. All recommendations in the updated INRMP would only affect NWSTF property and would not result in any negative effects to the neighboring properties. The No-Action Alternative would have no effect on socioeconomics and environmental justice since there would be no change from present management strategies under the 1999 INRMP.

## 3.8 PUBLIC HEALTH AND SAFETY

### 3.8.1 Affected Environment

33.1% of the population in Census Tract 9701 including Boardman and Irrigon is under the age of 18 (2,516 people). Access to the NWSTF is restricted by fences around the property lines on all four sides. No children or public citizens are permitted access to the property.

NWSTF has been used as an active bombing range in its history, and therefore the property has the potential for UXO to be present. The Boardman Air Force Range FUDS, 59,000 acres bordering the NWSTF directly to the west, has been the focus of a Preliminary Assessment / Site Investigation administered by the EPA. No metals were reported that significantly exceeded background concentrations.

Munitions removed in the past during range maintenance activities were inspected, certified free of energetic fillers, and subjected to recycling; therefore, they were characterized and determined not to be hazardous wastes.

### 3.8.2 Environmental Consequences

Implementation of either action alternative would have no effect on public or children's health and safety. Children and public citizens are excluded by a fence around the perimeter of the property. No aspects of either action alternative would have the potential to affect children. The No-Action Alternative would have no effect on public or children's health and safety since there would be no change from present management strategies under the 1999 INRMP.

# CHAPTER 4
# CUMULATIVE IMPACTS

## 4.1 CUMULATIVE EFFECTS

The CEQ regulations (40 CFR 1500-1508) define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions…". Cumulative effects are typically defined as two or more individual affects which, when considered together, compound or increase other environmental effects. The cumulative effects may go unnoticed when examined individually, but can become magnified when other projects are incorporated.

### 4.1.1 Identified Cumulative Actions

The Navy, in cooperation with the Oregon Military Department, is undergoing an analysis of current and future military training activities on NWSTF Boardman by the Navy and other military users. This initiative was started in October 2010 with the publication of the Notice of Intent to prepare and EIS and is scheduled to complete by the end of 2013. Depending on the scope of alternatives developed and the final alternative selected, there could be an increase in military training activities and military training facilities on NWSTF Boardman.

The Bureau of Land Management is proposing to construct a power transmission line from Hemmingway, Idaho, to Boardman, Oregon, that proposes to use NWSTF property or be located immediately adjacent to the range. The project is proposing to install an additional regional power transmission line and is currently going through EIS review with the Navy serving as a Cooperating Agency.

The U.S. Forest Service is also proposing to construct the Cascade Crossing power transmission line that proposes to use or be located immediately adjacent to the NWSTF. The project is proposing to install an additional regional power transmission line.

There are several wind power projects that have been constructed and others have been proposed near the NWSTF area, but not immediately adjacent to the boundaries of the property.

No other major projects have occurred at or near the NWSTF in the past, are presently ongoing, or are expected to occur in the reasonably foreseeable future. Routine maintenance and repairs of buildings and grounds and routine reoccurring military training are on-going activities.

### 4.1.2 Cumulative Effects Analysis

Development and implementation of the INRMP should have a beneficial effect to natural resources on the property by implementing a management strategy that improves natural resources on the range and supports surrounding projects by providing information on sensitive habitats and resources. Since the proposed action is expected to result in overall conservation and improvement in natural resources management on NWSTF, the project would not contribute to cumulative impacts.

## 4.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Implementation of the INRMP under Alternative 1 or 2 would commit resources to survey and map resources, as well as to perform vegetation restoration and removal of invasive species; it would also incorporate updated protection and conservation measures for the natural resources that exist on the NWSTF. These are identified and planned management actions that do not represent an irreversible and irretrievable commitment of resources.

Implementation of the No-Action Alternative would involve no irreversible or irretrievable commitment of resources; it would simply revert to ongoing natural resource management practices on the NWSTF.

## 4.3 LONG-TERM USE

The implementation of the INRMP under Alternative 1 or 2 would have long-term beneficial impacts on natural resources at the NWSTF. These alternatives would maintain and conserve and improve the natural resources present on NWSTF property and update effective management practices for these resources.

Implementation of the No-Action Alternative would continue to have some long-term beneficial impacts to the natural resources at the NWSTF. However, the beneficial impacts to natural resources would be less than with implementation of either action alternative, since the No-Action Alternative would not update conservation and management practices for natural resources from outdated 1999 conditions and practices.

## 4.4 COMPARISON OF IMPACTS

No significant impacts would occur to the physical environment, the biological environment, or the human environment for the Proposed Action, Alternative Action and No-Action Alternative. Table 4-1 compares the various activities under each alternative.

Based on the analysis in this EA, the Navy has concluded that implementation of the updated INRMP for the NWSTF under Alternative 1; the Preferred Alternative would have no significant impact on the human environment.

**Table 4-1. Summary of Environmental Consequences**

| Alternatives | Preferred Alternative<br>Implement all objectives and recommendations | Alternative 2<br>Implement only high and medium priority objectives and recommendations | No-Action Alternative<br>Maintain 1999 INRMP mgmt practices |
|---|---|---|---|
| **Land Use** | Land formerly managed under agricultural leases would be managed towards restoration of native vegetation, providing an additional positive impact. Multiple recommendations to increase wildlife habitat and reduce soil erosion potential through plant and range management practices. | Same as Alternative 1 | Possible negative affect from continued current management practices |
| **Air Quality** | No affect | No affect | Possible negative affect from continued current management practices |
| **Water Resources** | No affect | No affect | Continued current management practices |
| **Terrestrial Biology** | Beneficial affect from possible natural restoration of native vegetation due to projects and management plans providing increased habitat diversity from restoration actions. Also increase species monitoring to evaluate success of management actions. | Similar to Alternative 1, but primarily focused on ESA and priority MBTA species. | Continued current management practices |
| **Threatened and Endangered Species** | Beneficial affect from enhancement of ESA species through habitat and vegetation restoration and species monitoring. | Same as Alternative 1 | Continued current management practices |
| **Cultural Resources** | No affect | No affect | No affect |

**Table 4-1. Summary of Environmental Consequences**

| Alternatives | Preferred Alternative<br>Implement all objectives and recommendations | Alternative 2<br>Implement only high and medium priority objectives and recommendations | No-Action Alternative<br>Maintain 1999 INRMP mgmt practices |
|---|---|---|---|
| **Socioeconomics and Environmental Justice** | Minority or low income populations would not be disproportionately affected. | Same as Alternative 1 | No affect |
| **Public Health and Safety** | Public health and safety would not be disproportionately affected. | Same as Alternative 1 | No affect |
| **Cumulative Effects** | Would not incrementally add to cumulative impacts in the area from now projects. Beneficial impacts towards natural resources on the property would occur from implementation of various BMPs and restoration projects | Same as Alternative 1 | No affect |
| **Irreversible and Irretrievable Commitment of Resources** | None anticipated | None anticipated | None anticipated |
| **Long-Term Use** | Beneficial impact | Beneficial impact | Some beneficial impact |

# CHAPTER 5
# LIST OF PREPARERS AND DISTRIBUTION LIST

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## 5.3 NEWSPAPER NOTICES

East Oregonian, publication date of March 13, 2011

# CHAPTER 6
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# APPENDIX A. EA CORRESPONDENCE AND COORDINATION LETTERS

**DEPARTMENT OF THE NAVY**
NAVAL AIR STATION WHIDBEY ISLAND
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N44/0346
March 16, 2011

Ms. Carey Miller
Tribal Historic Preservation Officer
P.O. Box 638
Pendleton, OR 97801

Dear Ms. Miller:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman, Oregon. An INRMP is prepared under the Sikes Act to guide the management of natural resources on NWSTF Boardman. INRMPs are broadly scoped strategic management plans that set the goals and objectives for the natural resources program. The current INRMP was signed and approved in 1999 and the plan needs to be updated to comply with current Department of Defense and Navy requirements/policies and to be consistent with current natural resource issues and military training uses of the range. The updated INRMP proposes to implement projects and initiatives to meet its objectives which are classified by priority as low (ERL 2), medium (ERL 3) and high (ERL 4) priority projects.

We appreciate any comments or considerations you may have in regards to finalizing the INRMP or preparation of the EA. The projects listed in the INRMP update are developed to a coarse scale concept without sufficient detail to evaluate action specific impacts at this time. Once project development has started, we will coordinate with you directly for project specific impacts and comments to comply with Sec. 106 of the National Historic Preservation Act for each specific action to be funded and implemented. You can review a copy of the final draft of the Boardman INRMP dated January 2010 at: https://www.cnic.navy.mil/Whidbey/Programs/DepartmentsSpecialAssistants/PublicWorksEnvironmnetal/PulicNotices/index.htm.

The EA will address two action alternatives and a No Action Alternative. Alternative 1 (the Preferred Alternative) is to adopt and implement objectives and recommendations of the updated INRMP. Under Alternative 1, all proposed projects and management actions will be implemented and there should be a benefit to both natural resources compliance requirements and natural resources conservation issues.

Alternative 2 is to adopt and implement only the high and medium priority objectives and recommendations of the updated INRMP. Under Alternative 2, only high and medium priority projects will be implemented. Most of those projects are focused towards sensitive natural resources that are subject to listing pressures. This will provide benefits mostly for resources subjected to compliance requirements, but very little would be done for general conservation or land management initiatives.

The No Action Alternative continues implementation of the objectives and practices outlined in the existing INRMP of 1999. On-going practices used for natural resources management at NWSTF Boardman would continue as well as annual reviews and updates. The No Action Alternative would not improve management practices at NWSTF Boardman as there would be no change from the natural resources management practices implemented by the 1999 INRMP. By not implementing the updated INRMP, the Navy will not be successful in implementing current INRMP policies and objectives at NWSTF Boardman.

We would like to get your input on any comments or concerns you would like us to consider in regards to preparation of the EA or finalizing the NWSTF Boardman INRMP. To keep the NEPA process progressing, please respond to this request within 30 days. If you have questions regarding this request or need additional information, please contact my NWSTF Boardman Natural Resources Manager, Mr. John Philips at (360) 257-8873 or john.r.phillips1@navy.mil.

Sincerely,

M. DYSART
Commander, U.S. Navy
Public Works Officer
By direction of the
Commanding Officer

DEPARTMENT OF THE NAVY
NAVAL AIR STATION WHIDBEY ISLAND
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N44/0345
March 16, 2011

Mr. Roger Roper
Deputy State Historic Preservation Officer
725 Summer Street NE Suite C
Salem, OR 97301

Dear Mr. Roper:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman, Oregon. An INRMP is prepared under the Sikes Act to guide the management of natural resources on NWSTF Boardman. INRMPs are broadly scoped strategic management plans that set the goals and objectives for the natural resources program. The current INRMP was signed and approved in 1999 and the plan needs to be updated to comply with current Department of Defense and Navy requirements/policies and to be consistent with current natural resource issues and military training uses of the range. The updated INRMP proposes to implement projects and initiatives to meet its objectives which are classified by priority as low (ERL 2), medium (ERL 3) and high (ERL 4) priority projects.

We appreciate any comments or considerations you may have in regards to finalizing the INRMP or preparation of the EA. The projects listed in the INRMP update are developed to a coarse scale concept without sufficient detail to evaluate action specific impacts at this time. Once project development has started, we will coordinate with you directly for project specific impacts and comments to comply with Sec. 106 of the National Historic Preservation Act for each specific action to be funded and implemented. You can review a copy of the final draft of the Boardman INRMP dated January 2010 at: https://www.cnic.navy.mil/Whidbey/Programs/DepartmentsSpecialAssistants/PublicWorksEnvironmnetal/PulicNotices/index.htm.

The EA will address two action alternatives and a No Action Alternative. Alternative 1 (the Preferred Alternative) is to adopt and implement objectives and recommendations of the updated INRMP. Under Alternative 1, all proposed projects and management actions will be implemented and there should be a benefit to both natural resources compliance requirements and natural resources conservation issues.

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Sincerely,

M. DYSART
Commander, U.S. Navy
Public Works Officer
By direction of the
Commanding Officer

DEPARTMENT OF THE NAVY
NAVAL AIR STATION WHIDBEY ISLAND
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N44/0344
March 16, 2011

Mr. Steve Cherry
District Biologist
Oregon Department of Fish and Wildlife
P.O. Box 363
Heppner, OR 97836

Dear Mr. Cherry:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman, Oregon. An INRMP is prepared under the Sikes Act to guide the management of natural resources on NWSTF Boardman. INRMPs are broadly scoped strategic management plans that set the goals and objectives for the natural resources program. The current INRMP was signed and approved in 1999 and the plan needs to be updated to comply with current Department of Defense and Navy requirements/policies and to be consistent with current natural resource issues and military training uses of the range. The updated INRMP proposes to implement projects and initiatives to meet its objectives which are classified by priority as low (ERL 2), medium (ERL 3) and high (ERL 4) priority projects.

We appreciate any comments or considerations you may have in regards to finalizing the INRMP or preparation of the EA. The projects listed in the INRMP update are developed to a coarse scale concept without sufficient detail to evaluate action specific impacts at this time. Once project development has started, we will coordinate with you annually for project specific impacts and comments during the annual natural resources metrics review to address concerns and compliance issues. You can review a copy of the final draft of the Boardman INRMP dated January 2010 at:
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5090
Ser N44/0344
March 16, 2011

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We would like to get your input on any comments or concerns you would like us to consider in regards to preparation of the EA or finalizing the NWSTF Boardman INRMP. To keep the NEPA process progressing, please respond to this request within 30 days. If you have questions regarding this request or need additional information, please contact my NWSTF Boardman Natural Resources Manager, Mr. John Philips at (360) 257-8873 or john.r.phillips1@navy.mil.

Sincerely,

M. DYSART
Commander, U.S. Navy
Public Works Officer
By direction of the
Commanding Officer

Oregon
John A. Kitzhaber, MD, Governor

**Department of Fish and Wildlife**
Heppner District Office
PO Box 363
54173 Hwy 74
Heppner, OR 97836
(541) 676-5230
(541) 676-9075

April 6, 2011

John Phillips, Environmental Division
Naval Air Station Whidbey Island
Oak Harbor, WA 98278

Dear John:

This letter is in regards to your request for comments on the final draft of the Integrated Natural Resource Management Plan (INRMP) for the Boardman Bombing Range and the associated Environmental Assessment (EA). I have read through the draft plan and only really have one comment to make regarding the INRMP. I appreciate the changes that were made in the draft plan to address the concerns raised by ODFW during the first comment period.

In the section regarding wildfire control and protection the INRMP suggests the use of green stripping using herbicides. I would also recommend considering using another form of green stripping using fire resistant plant species. Forage kochia (not related to the weed) has been used effectively in other shrub steppe arid areas to create firebreaks. Forage kochia stays green throughout the summer and if planted in the proper densities can provide a fire break while also still providing wildlife habitat. I would recommend that the plan include this practice as a potential use for creating firebreaks in the future.

The Oregon Department of Fish and Wildlife (ODFW) would also like to recommend that the Navy choose Alternative One in the EA. ODFW recognizes that money to complete projects is becoming increasingly difficult to secure but we would like to have the opportunity if money is available to implement all of the proposed activities in the INRMP.

I appreciate the opportunity to comment on this draft final plan and look forward to working with you on the implementation of the final plan. Please feel free to contact me at (541) 676-5230 if you have any questions on my comments or would like to discuss any other issues.

Respectfully,

Steve Cherry
District Biologist

DEPARTMENT OF THE NAVY
NAVAL AIR STATION WHIDBEY ISLAND
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N44/0343
March 16, 2011

Mr. Gary Miller
U.S. Fish and Wildlife Service
La Grande Field Office
3502 Hwy 30
La Grande, OR 97850

Dear Mr. Miller:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman, Oregon. An INRMP is prepared under the Sikes Act to guide the management of natural resources on NWSTF Boardman. INRMPs are broadly scoped strategic management plans that set the goals and objectives for the natural resources program. The current INRMP was signed and approved in 1999 and the plan needs to be updated to comply with current Department of Defense and Navy requirements/policies and to be consistent with current natural resource issues and military training uses of the range. The updated INRMP proposes to implement projects and initiatives to meet its objectives which are classified by priority as low (ERL 2), medium (ERL 3) and high (ERL 4) priority projects.

We appreciate any comments or considerations you may have in regards to finalizing the INRMP or preparation of the EA. The projects listed in the INRMP update are developed to a coarse scale concept without sufficient detail to evaluate action specific impacts at this time. Once project development has started, we will coordinate with you annually for project specific impacts and comments during the annual natural resources metrics review to address concerns and compliance issues. You can review a copy of the final draft of the Boardman INRMP dated January 2010 at:
https://www.cnic.navy.mil/Whidbey/Programs/DepartmentsSpecialAssistants/PublicWorksEnvironmnetal/PulicNotices/index.htm.

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We would like to get your input on any comments or concerns you would like us to consider in regards to preparation of the EA or finalizing the NWSTF Boardman INRMP. To keep the NEPA process progressing, please respond to this request within 30 days. If you have questions regarding this request or need additional information, please contact my NWSTF Boardman Natural Resources Manager, Mr. John Philips at (360) 257-8873 or john.r.phillips1@navy.mil.

Sincerely,

M. DYSART
Commander, U.S. Navy
Public Works Officer
By direction of the
Commanding Officer

DEPARTMENT OF THE NAVY
NAVAL AIR STATION WHIDBEY ISLAND
OAK HARBOR, WASHINGTON 98278-5000

5090
Ser N44/0342
March 16, 2011

Ms. Leslie Nelson
Columbia Basin Stewardship Coordinator
The Nature Conservancy
P.O. Box 314
The Dalles, OR 97058

Dear Ms. Nelson:

In accordance with the National Environmental Policy Act (NEPA), the Department of the Navy (Navy) is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman, Oregon. An INRMP is prepared under the Sikes Act to guide the management of natural resources on NWSTF Boardman. INRMPs are broadly scoped strategic management plans that set the goals and objectives for the natural resources program. The current INRMP was signed and approved in 1999 and the plan needs to be updated to comply with current Department of Defense and Navy requirements/policies and to be consistent with current natural resource issues and military training uses of the range. The updated INRMP proposes to implement projects and initiatives to meet its objectives which are classified by priority as low (ERL 2), medium (ERL 3) and high (ERL 4) priority projects.

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Sincerely,

M. DYSART
Commander, U.S. Navy
Public Works Officer
By direction of the
Commanding Officer

# Naval Air Station Whidbey Island

*Kimberly A. Martin*
*Public Affairs Officer*
(360) 257-2286 FAX (360) 257-3972
E-mail: whdb_naswi_pao@navy.mil

**NEWS**

**FOR IMMEDIATE RELEASE** **RELEASE 11-03**
**Mar. 11, 2011**

**Comments requested on Environmental Assessment**

NAVAL AIR STATION WHIDBEY ISLAND, Wash. – The Navy is preparing an Environmental Assessment (EA) for the development of an updated Integrated Natural Resources Management Plan (INRMP) for Naval Weapons Systems Training Facility (NWSTF) Boardman in Boardman, Ore.
Per the Sikes Act, an INRMP is prepared to guide the management of natural resources on NWSTF Boardman. INRMPs are broad-scoped strategic management plans that set the goals and objectives for the natural resources program. The INRMP currently in place was signed and approved in 1999 and requires update to comply Department of Defense and Navy policies and be consistent with current natural resource issues and military training uses of the range.

The EA addresses a variety of Action Alternatives with associated impact levels on the land condition and wildlife resources on the Boardman range. The No Action Alternative continues implementation of the objectives and practices outlined in the existing INRMP of 1999. On-going practices used for natural resources management at NWSTF Boardman would continue as well as annual reviews and updates.

The Navy would like to incorporate and consider the public's comments and concerns as they prepare the EA and finalize the INRMP. A copy of the final draft of the Boardman INRMP dated January 2010 can be reviewed on the NAS Whidbey Island web site:
https://www.cnic.navy.mil/Whidbey/Programs/DepartmentsSpecialAssistants/PublicWorksEnvironmental/PublicNotices/index.htm

Submit comments by Mar. 25, 2011 to:

NAS Whidbey Island
Public Works Department, Natural Resources Management Program
1115 W. Lexington Street, Bldg. 103
Oak Harbor, WA 98278-3500

Please direct questions to John Phillips, Natural Resources Program Manager at (360) 257-8873.

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EAST OREGONIAN
1-800-522-0255

# Navy asks opinions on management plan

Posted: Sunday, March 13, 2011 3:13 am

BOARDMAN — The U.S. Navy is preparing an environmental assessment in preparation for updating its management plan for the Naval Weapons Systems Training Facility near Boardman.

The plan will guide management of natural resources on the Boardman Bombing Range, which is south of Boardman.

John Phillips, the Navy's natural resource manager, said the current plan was approved in 1999. It must be updated to comply with federal policies.

He said the environmental assessment addresses a variety of alternatives with varying impacts on the land and wildlife resources.

"The Navy would like to incorporate and consider the public's comments and concerns," Phillips said.

A copy of the final draft of the management plan dated January 2010 can be reviewed at the Naval Air Station Whidbey Island website: www.cnic.navy.mil.

Comments should be submitted by March 25 to NAS Whidbey Island, Public Works Department, Natural Resources Management Program, 1115 W. Lexington St., Building 103, Oak Harbor, Wash. 98278-3500.

—Dean Brickey

IN THE CIRCUIT COURT OF THE STATE OF OREGON
FOR UMATILLA COUNTY

} AFFIDAVIT OF PUBLICATION

STATE OF OREGON
County of Umatilla } ss

I, Dayle Stinson being duly sworn, depose and say that I am the principal clerk of the publisher of the East Oregonia[n] a newspaper of general circulation, as defined by ORS 193.010 and published at 211 SE Byers Avenue, Pendleton, OR 97801, in the afor[esaid county]; that the

EO-5670 NOTICE OF AVAILABILITY

a printed copy of which is hereto annexed; was published in the entire issue of said newspaper for 3 successive and consecutive issues in the following issues:

FEBRUARY 24, 26, 28, 2012

Subscribed and sworn to before me on this 27 day of

MARCH, 2012

Dayle Stinson

OFFICIAL SEAL
STACEY D BEAVER
NOTARY PUBLIC-OREGON
COMMISSION NO. 438623
MY COMMISSION EXPIRES APRIL 29, 2013

Stacey D Beaver
Notary Public of Oregon

EO-5670
NOTICE OF AVAILABILITY
Draft Environmental Assessment (EA) for Naval Air Station Whidbey Island for the Integrated Natural Resources Management Plan (INRMP) for Naval Weapons System Training Facility (NWSTF) Boardman, Oregon.

Pursuant to Section 102 (2) (C) of the National Environmental Policy Act (NEPA) 1969, as implemented by the Council on Environmental Quality Regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508), the U.S. Department of the Navy (Navy) announces the availability for public review and comment of a Draft Environmental Assessment (EA) to implement all objectives and recommendations of the revised Integrated Natural Resources Management Plan (INRMP) including high-, medium- and low-priority objectives at Naval Weapons System Training Facility (NWSTF) Boardman, Oregon.
A 15-day public comment period is being held to receive written comments on the Draft EA. Members of the public, government agencies, and tribes are invited to review and comment on the Draft EA. An electronic version can be viewed or downloaded at the following website:
*https://www.cnic.navy.mil/Whidbey/OperationsAndManagemetn/EnvironmentalSupport/index.htm*
The EA identifies and evaluates the potential effects of implementing objectives and recommendations of the INRMP. The EA analyzes two alternatives and a No-Action alternative. The purpose of and need for the proposed action is to comply with the Sikes Act Improvement Act of 1997, provide management requirements for species listed under the Endangered Species Act and meet the requirements of the Department of Defense and Navy instructions. Moreover, the conservation program must be consistent with the mission- essential use of the installation and its lands and not cause a net loss of military land use. The EA analyses potential direct and indirect impacts to land use, air quality, water resources, terrestrial biology, threatened and endangered species, cultural resources and socioeconomics and environmental justice. Additionally, cumulative impacts and mitigation measures are addressed in the document. There is no cooperating agency for this EA.
Comments on the Draft EA can be made in writing via mail or email. All comments should be forwarded to:
Jackie Queen, Environmental Planner
Naval Facilities Engineering Command Northwest
1115 West Lexington Drive
Oak Harbor, WA 98278
Email:
*Jackie.queen@navy.mil*
To be considered, all comments must be received by 12 March 2012..
February 24, 26, 28, 2012