Integrated Natural Resources Management Plan Update

Maine Army National Guard Hollis Training Site, Hollis, Maine

Plan Period FY 2021 Through FY 2026

Maine Army National Guard
Directorate of Facilities Engineering
Camp Keyes, Augusta, Maine 04333-0033

Maine Army National Guard Review and Coordination Signature Page

2021 – 2026 Integrated Natural Resources Management Plan

Hollis Training Site, Hollis, Maine

Certifying Authority: Date:

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Hollis Training Site, Hollis, Maine

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1.0 Executive Summary

This Integrated Natural Resources Management Plan (INRMP or Plan) provides guidance and procedures to enable the Maine Army National Guard (MEARNG) to meet its legal responsibilities for managing the natural resources at the 412 acre (ac) Hollis Training Site (Hollis site) located in the Town of Hollis, York County, Maine (Appendix B, Figure 1). The initial 2008–2013 INRMP prepared for this facility is considered the implementing document for the MEARNG natural resources management program at the Hollis site. MEARNG staff reviewed this INRMP for operational effect in 2014, extending the operational period of this document through 2019. The INRMP is intended to support and complement the military mission of MEARNG while also promoting sound natural resource stewardship principles.

The primary mission of MEARNG is to provide the best military training environment possible to National Guard units in Maine and to enhance MEARNG's readiness for its Federal, state and community missions. In accordance with this mission, this INRMP helps ensure the maintenance of quality training lands to accomplish Hollis's critical military mission on a sustained basis and to ensure that natural resources conservation measures and Army activities on mission land are integrated and consistent with Federal stewardship requirements.

Natural resource management will be driven by the land's primary use, which is military training. This INRMP incorporates the goals and objectives of MEARNG's Integrated Training Area Management (ITAM) program, and various other MEARNG conservation programs to manage the natural resources at Hollis and subsequently implement the INRMP. The goals and objectives of the following programs are integrated in this Plan (and summarized in Appendix A, Table 5) to ensure the sustainability of training lands and management of natural resources to support the military mission:

1) Training Area Management.

2) Training Site Resource Information Management.

3) Natural Resource Management, which includes (but is not limited to):

- Terrestrial Community Management;
- Fish and Wildlife Management;
- Threatened and Endangered Species Management;
- Surface Water and Wetlands Management;
- Pest and Invasive Species Management;

The planning process used in developing the original INRMP focused on involving key stakeholders from MEARNG, Maine's Department of Agriculture, Conservation and Forestry's Natural Areas Program (MNAP), the U.S. Fish and Wildlife Service (USFWS), Maine Department of Inland Fisheries and Wildlife (MDIFW), Maine Historic Preservation Commission (MHPC) and other interested parties that include The Nature Conservancy (TNC) and the University of Massachusetts (UMASS).

The changes required in this INRMP are not expected to result in consequences materially different from the existing INRMP, therefore an INRMP Update is the appropriate path forward. An INRMP Update does not require conducting an Environmental Assessment (EA) but instead will be documented with a Record of Environmental Consideration (REC) per ARNG G9 Memorandum "Army National Guard (ARNG) Installations and Environment (I&E) Directorate Policy for Integrated Natural Resource Management Plans (INRMP)" dated 20 March 2019. In accordance with this memorandum and the Sikes Act, this INRMP will be reviewed again for operation and effect no later than 5 years from the approval date.

2.0 General Information

2.1 Purpose

The initial INRMP guided the implementation of the natural resources program at the Hollis site between 2008 and 2013. A review for Operation and Effect conducted in 2014 extended the operational aspects of this plan through 2019. This Review for Operation and Effect is for the period of 2021 through 2026. Cultural resources also are discussed, however, specific management of these resources are directed under MEARNG's Integrated Cultural Resources Management Plan (ICRMP). The INRMP program will conserve land and natural resources and will help ensure compatibility with military activities and compliance with environmental laws and regulations. Further, the INRMP will help ensure the maintenance of quality training lands to accomplish MEARNG's critical military mission on the Hollis site on a sustained basis and to ensure that natural resources conservation measures and military activities on mission land are integrated and consistent with Federal stewardship requirements. This INRMP is designed to protect and enhance the training lands upon which the military mission is dependent. It uses an integrated approach to natural resources management and demonstrates that MEARNG is a committed steward of the land.

This Plan is not designed to evaluate MEARNG's military mission, nor is it intended to replace any requirements for environmental documentation of the military mission.

In accordance with U.S. Army Policy, this INRMP includes narrative that addresses the following:

- Fish and wildlife management, land management, forest management and wildlife-oriented recreation and enforcement;
- Fish and wildlife habitat enhancement or modifications;
- Wetland protection, enhancement and restoration where necessary for support of fish, wildlife or plants;
- Integration of, and consistency among, the various activities conducted under the INRMP;
- Establishment of specific natural resources management goals and objectives and time frames for proposed action;
- Sustainable use by the public of natural resources to the extent that the use is not inconsistent with the needs of fish and wildlife resources;
- Public access to the military installation that is necessary or appropriate for sustainable use by the public of natural resources to the extent that the use is not inconsistent with the needs of fish and wildlife resources, subject to requirements necessary to ensure safety and military security;
- Enforcement of applicable natural resource laws;
- No net loss in the capability of military installation lands to support the military mission of the installation;
- Regular review of this INRMP and its effects, not less often than every 5 years.

2.2 Authority

Preparation and implementation INRMP's is required by the Sikes Act (16 USC §670 et seq.). MEARNG staff and contractors prepared this INRMP using Guidelines to Prepare Integrated Natural Resources Management Plans for Army Installations and Activities, as modified by Forces Command. This plan describes how MEARNG will implement provisions of AR 200-1 and local regulations. This INRMP will help to ensure MEARNG compliance with other Federal and state laws, most notably laws associated with environmental documentation, wetlands, endangered species, and wildlife management including the following:

- American Indian Religious Freedom Act (42 United States Code (USC)

- Bald Eagle Protection Act (PL 86-70, as amended)
- Clean Air Act (as amended through 1990)
- Clean Water Act of 1978
- Conservation Programs on Military Reservations (PL 90-465)
- DoD Instruction 4715.03, Environmental Conservation Program, 2011
- DoD Instruction 5000.13 Natural Resources Endangered Species Act of 1973 (PL 95¬632, as amended)
- DoD/Migratory Bird Treaty Act (50 CFR 21)
- Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds and Associated USFWS MOU
- Federal Insecticide, Fungicide and Rodenticide Act (7 USC 136 et seq.)
- Federal Noxious Weed Act of 1973 (PL 93-629)
- Federal Water Pollution Control Act Amendments of 1972 (PL 92-522)
- Fish and Wildlife Coordination Act (PL 85-624)
- Fish and Wildlife Conservation Act of 1980 (PL 96-366; 16 USC 2901)
- Migratory Bird Treaty Act (PL 65-186; 16 USC 703 et seq.)
- Maine Natural Resources Protection Act (NRPA) (Title 38 MRSA §480)
- Maine Shoreline Zoning Act (Title 38 MRSA §438-A)
- Maine Standards for Stream Classification (Title 38 MRSA §465)
- Maine Department of Human Services, Subsurface Wastewater Disposal Systems (Title 22 MRSA §42)
- Native American Graves Protection and Repatriation Act (25 USC, Section 3001 et seq.)
- National Environmental Policy Act of 1969 (as amended, PL 91-190; 42 USC 4321 et seq.)
- National Historic Preservation Act of 1966 (as amended, PL 89-665; 16 USC 470 et seq.)
- Non-game Act (PL 93-366)

- Noxious Plant Control Act (PL 90-583)
- Sikes Act (16 U.S.C. 670 et. seq.)
- Watershed Protection and Flood Prevention Act (PL 92419; 68 Stat 666, as amended & 86 Stat 667; 16 USC 1001)

In addition, the National Environmental Policy Act (NEPA) established a mandate for Federal agencies to consider the potential environmental consequences of proposed activities, document the analysis, and make this information available to the public for comment prior to implementation of a project. NEPA requires, to the fullest extent possible, that the policies, regulations and laws of the Federal government be interpreted and administered in accordance with its environmental protection goals. NEPA also requires Federal agencies to use an interdisciplinary approach in planning and decision making for any action that adversely impacts the environment.

In accordance with NEPA regulation 32 CFR 651 Environmental Effects of Army Actions and the Council on Environmental Quality (Implementing Guidelines for NEPA, 40 CFR Parts 1500¬1508), an EA must be completed for natural resources management plans. 32 CFR 651 outlines NEPA compliance requirements of proposed Army actions and an environmental assessment is used to evaluate the environmental consequences of an INRMP.

This INRMP, upon signature, has the approval of the NGB, USFWS, MNAP and MDIFW. Approval from these agencies includes agreement that the INRMP complies with both the Federal and Maine Endangered Species Acts and other applicable laws. Review of the INRMP is informal consultation with regard to the Endangered Species Act. Within the spirit and intent of the Sikes Act Amendments of 1997 and the Endangered Species Act, this INRMP serves to provide adequate management or protection for endangered species and their habitats. Agency correspondence is provided in Appendix C.

All actions contemplated in this INRMP are subject to the availability of funds properly authorized and appropriated under federal law. Nothing in this INRMP is intended to be nor shall be construed to be a violation of the Anti-Deficiency Act, 31 USC § 1341.

2.3 Responsibilities

The successful management of natural resources and implementation of this INRMP requires cooperation among all responsible parties. The level of success can be enhanced by developing partnerships among other parties that have a vested interest in natural resources management at Hollis.

The Adjutant General of MEARNG is directly responsible for operating and maintaining Hollis, including implementing and enforcing this INRMP. The Adjutant General may be held personally liable for noncompliance with environmental laws. Thus, the Adjutant General has a vested interest in assuring that this INRMP is properly implemented.

The Construction and Facility Management Officer (CFMO) of MEARNG is responsible for the management of all services supporting the installation mission including grounds, roads, training lands and facilities at Hollis.

The MEARNG Environmental Branch Chief is responsible for assuring that all regulations and legislation applicable to natural resource management on the site are adhered to, including all environmental programs encompassing fish and wildlife management, endangered species management, land management, woodcutting, water quality protection, NEPA compliance, cultural resources conservation, hazardous waste management and site cleanup. The Branch Chief's responsibilities also include assurance that all appropriate environmental documentation is prepared and reviewed for all Federal actions (e.g., military training, new technology/equipment testing, construction projects and real property actions).

The Natural Resources Manager reports directly to the Environmental Branch Chief and is responsible for implementation of the INRMP including wildlife management, hunting and fishing programs, endangered species management, land management, forestry, water quality and wetlands protection and wildland fire.

The Deputy Chief of Staff Operations (DCSOPS) serve as the interface between the Environmental Division and troops training in the field. The DCSOPS staff is responsible for managing range complexes, coordinating military training, implementing ITAM, and releasing training areas for land restoration and recreational use. DCSOPS staff provide control of military activities needed to conserve and protect natural resources. The DSCOPS's responsibilities also include providing access to facilities to accomplish natural resources management, providing opportunities for wildlife-related recreation, and enforcing environmental requirements involving training area use.

The MEARNG Training Site Manager has the responsibility of specific day-to-day operations during annual training, weekend drills and maintenance at the site. Specific responsibilities include control and work assignments of all personnel, issuance of directives, overall supervision of the training site safety and orders pertaining to military operation and at Hollis.

Per 10 USC sec. 10501, NGB is a joint activity of the Department of Defense. NGB is the higher headquarters for the MEARNG. Two Directorates are involved in the management of natural resources: ARNG G9 and the Director of Operations, Training, and Readiness (ARNG-TRS).

The Natural Resources Manager at ARNG-G9 is responsible for reviewing the INRMP and advising the Environmental Office before formally submitting the Plan to the USFWS and the MEDIFW. ARNG-G9 ensures operational readiness by sustaining environmental quality and promoting the environmental ethic and is also responsible for tracking projects, providing technical assistance, quality assurance and execution of funds.

ARNG-G9 provides policy guidance and resources to create, sustain, and operate facilities that support the Army National Guard. ARNG-G9 coordinates proposed construction projects with ARNG-TRS and provides design and construction support, as well as environmental management that are directly related to property maintenance (e.g., grounds maintenance, pest control).

ARNG-TRS is responsible for training and training site support to include sustainable range management.

Major cooperative efforts with the USFWS, MNAP, and MDIFW address threatened and endangered species and communities. Personnel from these agencies have identified rare, threatened and endangered (RTE) species and communities of concern at Hollis as summarized in this report. Furthermore, the Maine Department of Agriculture, Conservation and Forestry, under MNAP, manages and maintains a database in which sensitive species location information is stored and made available to the public and research entities. The MDIFW is also the primary state agency regarding fish and wildlife management and establish fishing and hunting regulations for Hollis. Agency correspondence is provided in Appendix C.

2.4 Management Philosophy

MEARNG strives to manage the natural resources at its training facilities in a manner that ensures the sustainable uses of facilities for the training needs of military as well as to restore, protect, and conserve the natural biodiversity within these areas. INRMP's and other planning documents serve to support this philosophy by facilitating long-range planning efforts and development as well as ensuring the long-term sustainable use of training lands. To facilitate this, the INRMP for the Hollis site was developed in an interdisciplinary manner and in close coordination with relevant agencies and interested parties. Resources included staff from various disciplines from MEARNG, USFWS, TNC, MNAP, MDIFW, MHPC, UMASS, and environmental consultants.

Key to MEARNG's management philosophy is an ecosystem management approach whereby management of natural resources (e.g., soils, wetlands, and wildlife) takes place on a community level, rather than a species specific or resource specific level, to help to ensure regional biodiversity enhancement occurs rather than enhancement of a single resource or

species. In addition, the following are integral components of MEARNG's management philosophy:

- Develop an understanding of the site and its relationship to local and regional natural and cultural resources;
- Understand the military mission, potential effects of the mission on natural and cultural resources, and providing solutions to conflicts between the military mission and natural and cultural resource management;
- Ensure no net loss in the capability of military installation lands to support the mission of the site;
- Document the presence of natural resources on the site;
- Identify methods that will increase environmental awareness of MEARNG and its training facilities;
- Develop management guidelines that will be effective in maintaining and improving the sustainability and biological diversity of terrestrial and wetland ecosystems on the training site, support the military mission, and emphasize public involvement and partnerships; and,
- Avoid and/or limit impacts to natural and cultural resources and provide recommendations that may better protect and/or restore natural and cultural resources.

2.5 Conditions for Implementation and Review

Personnel in the Environmental Section of MEARNG are closely involved in the planning and design phase of many projects. Involvement early in the planning process allows personnel to suggest and promote alternative actions and to make recommendations for avoidance of impacts and possible mitigation scenarios. Through this process, MEARNG will ensure that INRMP activities are properly assessed and planned to avoid and minimize impacts. Environmental reviews are conducted by an interdisciplinary team that investigate the proposed action for potential impacts to land, water, vegetation, air, quality-of-life, cultural resources, etc. Interagency agreement and recommendations for avoidance, minimization, and mitigation also are made through this process.

The INRMP balances the installations' requirements to meet the training mission and applicable natural resources legal mandates. This document is a cooperative agreement between MEARNG, MDIFW, MNAP and USFWS that outlines issues and strategies, goals, objectives and actions required to meet the installations mission and legal mandates. An on-site trained natural resources staff is recommended to adequately balance the mission with legal

requirements and to oversee INRMP development, implementation, annual evaluation, 5-year review for operation and effect and interagency coordination. Effective plan implementation must include, but is not limited to, the following regular oversight by on-site trained professionals:

- Coordination of resource management and military training actions between installation directorates and between the installation, regulatory agencies and the public to ensure that the mission and legal requirements are met;

- Development and implementation of conservation and mitigation strategies for endangered species and for all wildlife and habitats, but especially for ecologically critical, sensitive and rare habitats;

- Providing a key role in the environmental review process to evaluate the environmental effects of proposed actions by the installation and its tenants, and to achieve, monitor and maintain compliance with all applicable legal requirements; and,

- Evaluation of recreational use impacts to natural resources, installation security, human safety, fiscal soundness and weekly training schedules to allow limited public recreation use of the Hollis site.

The INRMP goals and actions provide a basis for evaluating plan implementation. An annual report will be prepared and may include funds requested and received, future funds requested, a list of projects implemented with a brief summary of results and recommendations for changes, projects not implemented and why, a review of Hollis activities to include a brief summary of training activities and a description of changes proposed or incorporated into the INRMP.

3.0 Installation Overview

3.1 Location and Area

The 412 ac (167 hectares), state-owned military training site, is located in York County, in the Town of Hollis, Maine (Appendix B, Figure 1). The site is part of the Killick Pond Focus Area, one of the most significant conservation areas in the State of Maine (MNAP 2006b, c). The Town of Limington borders the training site on the northwest. To the north and east, the site is surrounded by the Killick Pond (Maynard F. Marsh) WMA (MDIFW 2006). The Killick Pond WMA is owned and managed by the MDIFW. The site is designated as a state game preserve and is used for military training activities by the MEARNG.

The site is located within the Saco River drainage basin and contains a large diversity of upland and wetland plant communities and animals. Topography is relatively level to gentle sloping

with elevations ranging from 280 feet to 300 feet. As identified in Appendix B, Figure 9, the entire site is comprised of ecosystems or communities of state and global significance including pitch pine–scrub oak barrens, pitch pine bog, three-way sedge–goldenrod outwash plain pondshore, the kettlehole bog-pond ecosystem, and the unpatterned fen ecosystem, as well as numerous rare species (Grossman et al. 1994, Gawler et al. 1996, Sneddon et al. 1996, MDIFW 2005, MNAP 2020).

Access to the Hollis site is via Hard Scrabble Road, a primarily gravel road that intersects Route 117. Locked gates and concrete barriers located at the north and south entrances to the property restrict most vehicular access into the site. A new ATV trail to the east of the site and connecting north and south trails has significantly reduced illegal ATV use of the site.

Several hard structures exist on the site, including concrete tent pad sites and remnant foundation sites and debris left over from former concrete and wood structures that have deteriorated as a result of non-use and vandalism by unauthorized personnel. Two open latrine pits (sites of former latrine structures) are located on the site and were capped in 2006.

3.2 Installation History

The Hollis site was purchased in 1969 by the State of Maine for Army National Guard Engineer Battalion-sized training activities and was used extensively for training activities through the mid-1980's. During that time, the site contained numerous concrete pads, outhouses, a sand airstrip, several concrete and wooden buildings, and a 25-meter (m) baffled small arms range. During the 1990's few military training activities were conducted on the site. As a result of this inactivity, unauthorized personnel used the site extensively and most of the hard structures on site were ultimately destroyed and/or removed by vandals. Some concrete slabs and scattered rubble from dismantled structures and buildings remain scattered throughout the site.

Currently, the most common activities at the site are military training, prescribed fire and other authorized activities such as horseback riding, walking/jogging and dog walking. Although access to the site is somewhat restricted by gates and barriers, the MEARNG has allowed recreational use of the area via several trails and works with local officials to ensure responsible use of the property. In the past, extensive ATV use, debris dumping, car burning and other activities occurred at the site. These activities have been drastically reduced over the last 5 years.

3.3 Military Mission

The primary mission of MEARNG is to provide training facilities and services to U.S. Armed Forces and the National Guard units within the State of Maine that require land and airspace to practice combat skills, operations and logistical support on a year-round basis. However,

MEARNG currently uses the site only 20 to 30 days per year. When utilized, the operations include small arms tactical firing with blanks, orienteering activities, small-scale pyrotechnics, bivouacs, convoy training, engineer equipment training and dismounted maneuvers. Live ammunition is no longer used at this site. Vehicles used in training activities are restricted to existing cleared areas and sandy roads and trails. Aviation training may occur in large open areas on the site.

3.4 Surrounding Communities

Private land borders the site along the south and east, most of which is zoned for agriculture and residential purposes. The closest two communities adjacent to the Hollis military site include the townships of Hollis and Limington, ME. Hollis center is approximately 5.5 miles (mi) east on Route 117 and reports a population of 4,281 residents. The Town of Limington is 6 mi away and has a population of 3,713 people (USCB 2010).

3.5 Regional Land Use

Historically, the regional land use was agricultural and undisturbed forests. Roads, development and succession have fragmented much of those land uses. Current land use surrounding the installation is rural, open space and agricultural with concentrations of residential, commercial and industrial uses in the towns.

3.6 Local and Regional Natural Areas

The Hollis site is part of the Killick Pond Focus Area, one of the most significant conservation areas in the State of Maine (MNAP 2006b, 2006c). The entire Hollis site is mapped by MNAP as containing significant natural communities or ecosystems (MNAP 2020). The Killick Pond Focus Area is used for recreation such as fishing, hunting, hiking, canoeing and wildlife viewing; however, hunting is not permitted within the Hollis Training Site.

Directly adjacent to the site to the north is the Maynard F. Marsh Wildlife Management Area, a 600-ac parcel of land, owned and managed by the MDIFW (Appendix B, Figure 1). The management area consists of wetlands, forested shoreline and upland forested habitats and several sensitive natural ecosystems and communities such as the kettlehole bog-pond ecosystem, unpatterned fen ecosystem, pitch pine–scrub oak barrens community, pitch pine bog and the three way sedge–goldenrod outwash plain pondshore community (Appendix B, Figure 3). The MDIFW also manages a 1,139-ac parcel of land west of the site referred to as the Little Ossipee River Tract (Appendix B, Figure 1).

4.0 Physical Environment

4.1 Climate

The Hollis site is located in a region with a primarily humid, continental climate with relatively long, cold winters and short, warm and often humid summers. The climate in this region is described as a cold winter climate with a warm summer. The climate in this region has 4 to 7 months when temperatures exceed 50 F (10 C), with no dry season. The average temperature during the coldest month is below 32 F (0 C). The warm summer has an average temperature during its hottest month that never exceeds 72 F (22 C). The mean annual precipitation near Hollis is about 41 inches, and precipitation is well distributed throughout the year. November is typically the wettest month. Temperatures fall rapidly in the evenings, making for cool and comfortable nights during summer. The warmest months are June, July and August, with mean monthly maximum temperatures of 63, 68 and 66.5 F, respectively (NOAA 2000). The extreme maximum temperature in the past 30 years, measured near the Hollis weather station, was 98 F (in 1991).

The mean annual temperature for the region over the past 30 years is 42 F. January is the coldest month, closely followed by February and December. Below-freezing temperatures occur on about 115 days from November to March (NOAA 2000). Winter temperatures can present a severe hazard to personnel exposed to the outdoors. With a wind chill, the temperature may fall below the record low temperature of -39 F (in 1933), and flesh may freeze within one minute of exposure. Snow and ice cover generally thaws from late March to mid-May. Snowfall is fairly heavy, with an annual average of 69.8 inches (in) near Hollis station (Gawler and Jesse 1997, NOAA 2000). However, snowfall is quite variable, not only from year to year but also from place to place as a result of slope, elevation, and other factors.

Cloudiness and snow are characteristic features of winter weather in the Hollis area. The amount of sunshine is low throughout the year with about 50 percent (%) of the days being mostly cloudy to overcast and about 20% percent being partly cloudy. Wind velocities near Hollis are moderate, averaging 8.7 miles per hour (mph). The most violent winds are those that may accompany thunderstorms in late spring, with severe winds of 40–50 mph. In winter there are numerous days with sufficient wind to cause blowing and drifting snow.

Climate change is expected to impact Hollis Training Site. A summary of expected climate change impacts using the US Army Climate Assessment Tool can be found in Appendix F.

4.2 Landforms

The Hollis site is located in the Gulf of Maine Coastal Plain physiographic region (Keys and Carpenter 1995), which extends along Maine's southern coast into New Hampshire and Massachusetts. Landforms of this physiographic region generally have low relief with rolling hills (monadnocks) occurring in many places. Lakes, poorly drained depressions, morainic hills, drumlins, eskers, outwash plains and other glacial features are typical of the area, which was

entirely covered by glaciers during parts of the Pleistocene. Elevations of this physiographic region range from sea level to 2,400 feet (730 m). Mass wasting and fluvial erosion, transport and deposition are the primary operating geomorphic processes of the area (Bailey 1994).

Specifically, the Hollis site is located in the southeastern portion of the 1,700 mi2 Saco River drainage basin between Killick Pond and the Little Ossipee River, which flows and empties into the Atlantic Ocean near Saco, Maine, about 20 mi to the east. The topography of the site ranges from level (0 to 8% slopes), associated with the river basin, to gentle sloping (8 to 15%) land, which is associated with upland/wetland transition areas (Appendix B, Figure 1). Elevations range between 260 feet to 300 feet above mean sea level (msl) (NRCS 1999, 2000).

4.3 Geology and Soils

The site is located on a large, sandy plain of glacial deposits (MGS 1995). The geological unit gradually descends in a series of broad, hilly plateaus to the coastal zone. Numerous glacial features, such as small to large delta plains, lacustrine basins, eskers, and extensive drumlin fields, characterize the geomorphology in the region. Bedrock underlying the Hollis site is undifferentiated sedimentary rock of the Devonian-silurian age (MGS 1985). However, Gawler and Jesse (1997) have suggested that the surficial geology influences the facilities geomorphology far more then this underlying bedrock.

The soils are primarily deep sands, excessively drained and contain little organic matter (Appendix B, Figure 2) (NRCS 2016). Upland soils occupy 364 acres (88%) of the site, wetland soils occupy 47 acres (11%) of the site. Upland soils on the site are comprised primarily of Adams loamy sand (AdB) with 0 to 8% slopes, which are found on 274 acres (67%) of the site. Other upland soil types include Adams loamy sand (AdC) with 8 to 15% slopes and found on 13% of the site, and Adams loamy sand (AdD) with 15 to 40% slopes and found on about 9% of the site. Adams soils are generally formed in sandy outwash deposits from predominantly crystalline rock or sandstone.

Wetlands are comprised of Vassalboro peats (Va), which are poorly drained, acidic peats, that typically develop in glacial kettleholes and on outwash plains. The Vassalboro series at Hollis consists of very deep, very poorly drained organic, hydric soils that formed in a mixture of herbaceous, woody and sphagnum material and where the slope is generally level (0 to 2%). These soils are found primarily in open bogs such as those found on Hollis and contain low growing shrubs and herbs that thrive in nutrient poor habitats (NRCS 2016). Depressions on the site have a high water table that retains moisture and facilitates the formation of wetlands and waterbodies. Decomposition is slow and organic material accumulates in these areas creating unconsolidated bottoms.

Soil Erosion Potential

The ability of a soil type to tolerate disturbances such as vehicular traffic, foot traffic and other related training activities is an important characteristic for military facilities. Soil characteristics such as texture, organic content, moisture regime, structure and depth, all contribute to a soil's ability to withstand disturbances, infiltrate water and aid in determining a soil's erosion potential. Other factors such as precipitation and flooding, slope, wind and vegetative cover, also may affect soil erosion. The three primary types of erosion include:

- Gully Erosion - The erosion process whereby water accumulates and often recurs in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, often defined for agricultural land in terms of channels too deep to easily ameliorate with ordinary farm tillage equipment, typically ranging from 0.5 m to as much as 25 to 30 m.

- Rill Erosion - The removal of soil by concentrated water running through little streamlets or head cuts. Detachment in a rill occurs if the sediment in the flow is below the amount the load can transport and if the flow exceeds the soil's resistance to detachment. As detachment continues or flow increases, rills will become wider and deeper.

- Sheet Erosion - Erosion of thin layers of earth-surface material, more or less evenly, from extended areas of gently sloping land by broad continuous sheets of running water, without the formation of rills, gullies, or other channelized flow.

Based on the NRCS Soil Information, no soils identified at Hollis are particularly susceptible to erosion (NRCS 2016). However, sandy soils are generally relatively unstable and are susceptible to erosion in areas with high vehicular or human traffic, non-vegetated areas where there is vehicle use and areas of non-vegetated soils associated with construction or training activities.

4.3.1 Identified Soil Erosion

Erosion has been identified as a relatively significant issue in areas associated with ATV use, particularly in sandy areas and trails near the waterfront. Specifically, several trails leading directly up to the water's edge of the kettlehole bog and pond, the unpatterned fen, and the three-way sedge–goldenrod outwash plain pondshore, were identified in 2001 (MEARNG 2004). Trails such as these allow sediment to enter these sensitive waters through erosion and increase the potential for gasoline and oil deposits in these waterways. In addition, ATV use throughout the site has resulted in mud holes and deep ruts on heavily used trails. As ATV riders steer around those spots, they create parallel tracks. What begins as a narrow lane through the woods or adjacent to water resources becomes a widening braid of trails. With brush destroyed and tree roots damaged, these trails are susceptible to erosion.

MEARNG recognizes that the loss of soil and moisture resources as a result of soil erosion negatively impacts the natural resources of the surrounding areas. Therefore, MEARNG has conducted, and will continue to conduct, surveys, investigations, and research to evaluate soil erosion on the site and to identify any preventive measures that may be needed. MEARNG has nearly eliminated unauthorized ATV use of the site and has prevented many of these erosion issues related to ATV use. Blocking access, allowing natural revegetation and grading in certain areas has significantly reduced erosion on the site. Another area of erosion concern lies within the former runway. MEARNG Engineer units use this area for engineer equipment training involving soil disturbance and some minor erosion at the southern end of the runway has been observed. As a corrective action, MEARNG has required units to finish grade the area to a bowl shape to encourage internal drainage and eliminate further erosion. Annual soil erosion surveys are conducted and documented and corrective actions taken if necessary.

4.3.2 Prime Farmland

Prime farmland, as defined by the USDA, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops and is available for these uses (NRCS 1999). Because high quality farmland is in limited supply in the United States, prime farmland is identified to ensure that a long-term supply of food and fiber is available. Several soil properties are characteristic of prime farmland, including texture, organic matter content (i.e., nutrient levels) and moisture regime. In addition, several climatic and physiographic properties aid in identifying prime farmland including precipitation, temperature and slope. Based on the aforementioned criteria, no soils mapped at the Hollis site meet this requirement (Appendix B, Figure 2). However, the Adams series are considered to be farmland of local importance by the NRCS. These soils are not currently farmed.

4.4 Hydrology

The Maine Geological Survey (MGS) has identified and mapped a significant sand and gravel aquifer underlying the Hollis site. The aquifer contains surficial deposits with a moderate to good potential ground water yield (i.e., yields greater than 10 gallons per minute to a properly constructed well). Deposits consist of glacial sand and gravel, but also include areas of sandy till and alluvium. The yield may exceed 50 gallons per minute in deposits hydraulically connected with surface-water bodies, or in extensive deposits.

Historically, two drilled wells existed within the Hollis boundary. However, the wells were closed by cutting below the ground and then filled with concrete in May 2002 and no longer supply water to the site.

4.5 Surface Water

Three surface waterbodies, covering approximately 13 acres, are located on the Hollis property (Appendix B, Figure 7). These include one 2.5-acre pond associated with the kettlehole bog-pond ecosystem, one 10.2-acre pond associated with the three-way sedge–goldenrod outwash plain pondshore community and an unnamed ephemeral stream. These ecosystems and communities are detailed in Section 5.5. Wetlands.

The unnamed ephemeral stream is a tributary of the Saco River and is located in the southwestern portion of the site (Appendix B, Figure 7). This stream flows through the mapped pitch pine–white pine–gray birch habitat covering approximately 1 acre of the site. The stream terminates in the wetland associated with the kettlehole bog-pond ecosystem.

5.0 Ecosystems and the Biotic Environment

5.1 Ecosystem Classification

Regional Overview

The ecoregion of Hollis is classified by Bailey (1995) as Humid Temperate Domain, specifically in the Warm Continental Division and in the Laurentian Mixed Forest Province. This low-lying province lies between the boreal forest and the broadleaf deciduous forest zones and is therefore considered transitional. Part of the Laurentian Mixed Forest Province consists of mixed stands of coniferous species (mainly pine) and a few deciduous species (mainly yellow birch, sugar maple, and American beech). The remainder of the province is a mosaic of deciduous forest occurring on favorable sites containing relatively fertile soils and coniferous forest occurring on sites with lower soil fertility. Pine trees are often the pioneer woody species in burned-over areas or on abandoned arable land. Because they grow more rapidly than deciduous species where soils are poor, they quickly form a forest canopy. However, where soils are less exposed and deciduous undergrowth is dense, pines often have difficulty regenerating, and remain successful only where fire or other disturbance recurs. Fires started by lightning are common in this province, and can spread quickly, particularly where soils are sandy and there is a layer of dry litter in summer.

Hollis Site

Specific ecosystems within the boundaries of the Hollis site are generally similar to those described above for the larger region. However, more specifically, the Hollis site contains several upland and wetland types which have been identified by the MNAP as being of statewide significance (MNAP 2005, 2006a, 2010). Specific ecosystems, or community types occurring at the Hollis site, including those of statewide importance, are described in detail in the following sections.

5.2 Vegetation

5.2.1 Historic Vegetative Cover

Prior to European settlement, the Hollis area likely consisted of various un-fragmented forest, grassland and wetland cover types. These cover types included pine, hemlock, spruce, northern hardwood forests and grassland habitats, as well as ecologically significant wetlands. Forest types likely included both closed northern hardwood and spruce-hemlock stands in lowland or more protected areas and relatively open pine or pine-oak stands on exposed ridges or flats. Open forest stands were typically characterized by pitch pine–scrub oak barrens, a community type dependent upon periodic fires to ensure maintenance and regeneration of the habitat. Wild fires in the Hollis area shaped the landscape and resulted in unique communities of plants and animals that over thousands of years had developed adaptations to enable them to thrive in areas of periodic fires. More recently, however, the landscape and natural communities of the Hollis area have been dramatically altered as a result of human activities including fire suppression, logging, farming and commercial/residential development.

The Maine Forest Service has recorded over 79 wildfires near the Hollis site since 1902. Among the 79 fires, five burned more than 1,000 acres of forest with the largest consuming more than 4,700 acres (Patterson 1997, MEARNG 2004). In 1991, the MNAP recognized the impact and ecological importance of fire to the local physiographic area and created a contractual agreement with MEARNG to become involved in the restoration and conservation of the Hollis Barrens. The purpose of using prescribed fire as a management tool at the Hollis Barrens is to achieve the dual goal of restoring pitch pine–scrub oak barren habitat while simultaneously improving the usefulness of the site as a training site by reducing the cover of scrub oak and especially gray birch. Sixty five (65) controlled fires have been completed by MEARNG from 1995 through 2020 on the Hollis site (878 acres) and these have altered the local vegetation cover.

In recent history, the increase in population and development near town centers has also decreased the vegetation cover. Forests have been cleared and converted to business districts and agricultural land. Relative to the population growth of the surrounding towns, an increase in recreational use of the Hollis site has also significantly impacted the vegetation on the site. Currently the most common recreational use of the Hollis site is hiking and horseback riding.

5.2.2 Current Vegetative Cover

All of the 412 acre Hollis site is mapped as significant habitat by the MNAP (MNAP 2005, 2006a, b, c, 2010, 2020), including approximately 364 acres of upland habitat (most of which includes the critically imperiled pitch pine scrub oak barren community) and 47 acres of wetland communities (Appendix B, Figures 3 and 4). Approximately 298 acres (72%) of the site is

dominated by second growth forests that were previously disturbed mainly as a result of natural and human-induced fires, and to a lesser extent, military training activities and recreational uses of the site. Table 4 summarizes the current vegetative communities at the Hollis site.

Based on previously mapped areas within the original 412 acre site, approximately 306 acre, or 74%, of the Hollis parcel is forested (Appendix B, Figure 4). Five distinct forest stand types were distinguished (Appendix A, Table 1). Mixed wood stands collectively account for approximately 165 acres (54%) of the total forested area. Hardwood stands make up approximately 142 acres (46%) of the forested area at Hollis. Other habitats include sand roadways and several open sandy training areas, which collectively cover approximately 48 acres (12%) of the site, low-growing herb or shrub communities which cover 10 acres (< 1% of the site) and 58-acres (14%) of low-growing wetland communities and waterbodies (Appendix B, Figures 3 and 4).

During the winter of 2017/2018, an effort was made to remove most white pine and some grey birch from the southern 120+/- acres of the site. This area had the highest concentration of white pine and larger grey birch stands. The intent of this project was to remove white pine seed trees and remove larger grey birch that were both merchantable, reduce these species within pitch pine-scrub oak natural communities and reduce the shading of the forest floor for better prescribed fire effects in the future.

A Forest Stewardship Management Plan was created for the MEARNG in 2012 which describes tree stands, volumes, management strategies and value for all of the stands on the Hollis Training Site. Copies of this plan are available for review in the DFE-ENV office or can be accessed from the MEARNG SharePoint website.

In addition, it should be noted that the forest stand classification subdivides forest stands based on dominant species and structural characteristics and differs from the broader MNAP natural community classification system. For example, as shown in Appendix B, Figure 4 many habitat types (classified based on dominant species), fall within the broader MNAP pitch pine–scrub oak barren classification. However, these additional forest habitat types occurring within the MNAP mapped pitch pine-scrub oak community may be the result of a lack of fire that has allowed portions of this community type to become colonized by other tree species that would ordinarily be eliminated by recurring fire. Regardless of the forest type classification assigned, it is noted that the entire site is mapped by MNAP as some kind of significant natural community or ecosystem.

MEARNG began active fire management activities on the site in 1995 (Appendix B, Figure 5). Through 2020, 65 prescribed burns have been conducted on the site and a total of 878 acres have been burned (Patterson and Duveneck 2004, Patterson 2005, MEARNG 2020). Thirty-two

(32) prescribed burns were conducted on 23 different days between June 1995 and August 1999, with a total of 138 acres burned (Patterson and Duveneck 2004, MEARNG 2020). Approximately 97.5 acres (24% of the site) have been burned once; 148 acres (36% of the site) were burned multiple times. The location of fire management units and the year each stand was burned are presented in Appendix B, Figure 5.

The critically imperiled MNAP-designated pitch pine–scrub oak barren community dominates the Hollis site (Appendix B, Figure 4) (MEARNG 2005, 2006a, 2010, 2020). As noted, the plants and animals of this unique community type have adapted over thousands of years to tolerate periodic fires and fire is needed to ensure long-term maintenance and regeneration of the habitat.

Over 200 plant and fungus species have been identified throughout the site during surveys conducted in 1991, 1996, 2004, 2012, 2017 and 2018. Two of these species [the narrow-leaved goldenrod (*Euthamia caroliniana*), and although not documented on the site since 1996, includes northern blazing star (*Liatris novae-angliae*)] are listed as threatened in Maine (MNAP 2020). In addition, fall fimbry (*Fimbristylis autumnalis*) is considered rare. A list of plant species (including rare species) documented on the site is provided in Appendix D.

The following provides a detailed description of the various terrestrial upland habitat types on the Hollis site. Wetlands and their associated vegetative communities are detailed in section 5.5.

Upland Communities

Pitch Pine – Scrub Oak Barren

The Pitch Pine – Scrub Oak Barren community dominates the Site and covers approximately 330 acres (Appendix B, Figure 3). The community is rare statewide, and is ranked S2, or imperiled, by MNAP (Gawler and Cutko 2010, MNAP 2020). The occurrences of this community on the Site are outstanding, and possibly exemplary, examples of this type. This is a fire-dependent community, and the prescribed burning program on the property is having clear positive impacts on the health of this community. Most of the upland communities found are representative of the Pitch Pine – Scrub Oak type, although some areas are more ecologically intact than others. In general, this community is healthier to the north and east where prescribed burns have taken place several times since the 1990's, and less intact to the south and west where forests have less history of burns. Gray birch is often present as a shrub in healthy barrens, but its presence in the canopy is a good indicator that fire frequency is too low. White pine and black cherry also occur in the canopy in these unburned areas. In general, areas along the property boundaries show the least ecological integrity, presumably because

they are the most difficult to burn safely. This is particularly true in the northwestern corner, along the western boundary and to the south of the kettlehole bog.

In 2019, firebreaks were cut along the southern and western boundary of the site to expand prescribed fire capability. In addition, a 6 acre section of the northern tip of the site was mowed of all vegetation with the exception of pitch pine and larger tree species not within the capability of the forestry mulchers on site. This area was dominated by successional tree species and is the subject of a pitch pine-scrub oak restoration effort.

Healthy examples of this community, such as that found in the northeast portion of the Site, have open canopies, with closure usually ranging between 25% and 50%. Pitch pine is strongly dominant in the canopy and in many areas it is the only canopy species present. In other areas, red maple and gray birch also occur. The shrub layer is typically dense and dominated by scrub oak. Other shrubs include gray birch, early low blueberry, wild raisin, velvet-leaved blueberry, hillside blueberry and sweetfern. Black chokeberry is locally abundant and is the dominant shrub in some locations. Herbs include poverty oatgrass, ticklegrass, whorled loosestrife, stiff aster and forked blue curls. Other herbaceous species in this type include wood lily, sweet everlasting, pineweed, blue toadflax, arrowhead violet, Houghton's sedge and path rush. A total of 91 plant species were documented in this community type (Appendix D, Table 1).

The Pitch Pine – Scrub Oak Barren community is naturally patchy. However, as was noted in the 2004 Conservation Plan and 2012 assessment, some patches within the barrens are dominated by species atypical of the Pitch Pine – Scrub Oak type (NEA 2004, NewEarth 2012). These areas lack scrub oak and/or contain enough graminoid or heath shrub indicator species to resemble the rare communities known as Sandplain Grassland (S1) and Pitch Pine – Heath Barren (S1). Occurrences of these rare communities on the Hollis Training Site have changed little in spatial extent or distribution since the 2012 assessment and are typically less than half an acre in size. In accordance with MNAP recommendations, areas smaller than an acre are to be included within the communities where they occur (Gawler and Cutko 2010), therefore these areas are included within the Pitch Pine – Scrub Oak type.

White Oak – Red Oak Forest

This forested community type is ranked S3, or rare, by MNAP, and only occurs in the southern part of the state (Gawler and Cutcko 2010, MNAP 2108). On the site, it occurs as a small fragment community (9 acres) located along the northern shore of the pond (Appendix B, Figure 4). This area has relatively low ecological integrity but is still recognizable as this type.

The canopy is dominated by white oak and red oak, each at about 30% cover. Pitch pine also occurs in the canopy at up to 25% cover. This is more conifer coverage than is typical for this community type. Black oak is also present in the canopy along the shoreline of the pond, and

may be locally dominant. The understory is quite open, and vegetated primarily by saplings of canopy species. Dwarf shrubs include early low blueberry, hillside blueberry, wintergreen and sweetfern. Herbs include wild oats, whorled loosestrife, wild sarsaparilla, bracken fern and several species of sedge. Several of these herbaceous species are strong indicators of the type. This community shares a broad ecotone with the surrounding forested communities, much of which appear to be Pitch Pine – Scrub Oak Barren that has not been burned in many decades. This community type has changed little in distribution or spatial extent since the 2012 assessment, although maps from 2012 mistakenly identified a second occurrence of this community on Site. The second occurrence was closely evaluated in 2017 and was confirmed to be characteristic of Pitch Pine – Scrub Oak Barrens that had not burned in many years. A total of 23 plant species have been recorded in the White Oak – Red Oak community type (Appendix D, Table 1).

Cleared/Developed

Cleared/open areas have generally been altered by humans and primarily through human activities are maintained in a bare condition or one of low herbaceous cover. This community was previously identified as "Sand" (NEA 2004). Cleared/open areas cover approximately 21 acres and are located primarily along road edges, within a former airstrip and at former locations of buildings and training infrastructure (Appendix B, Figure 4). Additional cleared sandy roads and small (< 1 acre) open areas also occur throughout the Site but were not mapped as separate entities on the community type map due to their small size.

Most Cleared/open areas are sparsely vegetated and dominated by the sand material that underlies much of the Site. When present, dominant plant species include a diversity of native grasses and weedy species such as crabgrass, goosegrass, clover, cow vetch, yarrow, common mullein, cinquefoil, beggars tick, wild strawberry, dandelion, thistle, orange hawkweed, plantain, wild carrot, goldenrods, milkweed and mosses. Shrubs and early successional trees may also be present and include sweet fern, pin cherry, blackberry, raspberry and gray birch. The runway contains a small area of pitch pine regeneration. Several open sandy areas are used extensively by turtles for nesting.

A 2018 study (Corbin & Thiet; 2020) of temperate biological soil crusts was conducted on eastern sandplain sites across New England, New Jersey and New York, including Hollis TS. This study describes the roles of temperate biocrusts in sandplain and similar sites and their frequent association with rare plant and animal species (Appendix E).

Wetlands and Waterbodies

Approximately 51 acres of wetlands were identified on the Site. Collectively, 4 acres of which are defined as palustrine forest, 31 acres of palustrine scrub-shrub wetland, and 16 acres of

palustrine emergent wetland and eutrophic pond (which includes both emergent and aquatic vegetation).

Palustrine Forest

Spruce – Larch Wooded Bog

This forested peatland community occurs to the west of the kettlehole bog in the southern portion of the Hollis Training Site and covers approximately 4 acres (Appendix B, Figure 4). This is a relatively common type statewide, and is ranked S4, or apparently secure, by MNAP. All wetlands in the kettlehole bog complex appear to have been impacted by beaver activity. In the Spruce – Larch Wooded Bog, there are many large dead trees that may be the result of an increase in water level. Most of the core of the community appears to be relatively intact. A total of 36 plant species have been documented in this community type (Appendix D, Table 1). This community type has changed little in distribution or spatial extent since 2012, although the boundary was refined in several areas to better reflect conditions on the ground.

The canopy is dominated by tamarack and black spruce. White pine is also present, particularly along upland edges and in transition zones. Red maple is more significant part of the canopy to the west and approaches co-dominance in some areas. Heath shrubs are strongly dominant in the understory. Common species include rhodora, sheep laurel, huckleberry and velvet-leaved blueberry. Common herbs include three-seeded sedge, white beak-rush, tawny cottongrass, crested woodfern, two-seeded sedge and dewdrop, all growing on a lush and continuous carpet of *Sphagnum* mosses. Populations of highbush blueberry appear to have increased since 2012 and two new species (bog laurel and star sedge) were observed in this community in 2017.

Pitch Pine Bog

The Pitch Pine Bog community covers approximately 15 acres within the site boundary but extends offsite as a part of a larger 37 acre feature. This community is located along the western boundary of the training site near the north extent of the property (Appendix B, Figure 3). MNAP ranks this community type as an S2 or imperiled due to rarity (Gawler and Cutcko 2010). Pitch pine is the dominant tree species within this community type though quite sparse. Shrub presence includes leatherleaf, bog rosemary, black chokeberry, rhodora, sheep laurel and dwarf huckleberry. Large and small cranberry are typical dwarf shrub species occurring within the community. Herbs include tawny cottongrass, three-way sedge, swollen-beaked sedge, white beak rush, pod-grass, round-leaved sundew, pitcher plant and spatulate-leaved sundew.

Palustrine Scrub-Shrub

Leatherleaf Boggy Fen

This peatland community is ranked S4, or apparently secure, by MNAP. It collectively covers 29 acres on the Site and occurs in four locations: along the northwestern boundary, to the south of the pond, around the shoreline of the kettlehole bog and along the southwestern boundary (Appendix B, Figure 3). These occurrences vary somewhat in terms of hydrology and species composition, but overall display high levels of ecological integrity. The first occurrence along the northwestern boundary is in a shallow, poorly drained basin, and is the driest of the four. The second occurrence is essentially a lakeshore fen and occupies the large drainage basin to the south of the pond. This is a very wet occurrence, with several pools, floating peat and a wide area of open water around the perimeter. It has experienced some floristic changes since 2012, including an expansion of narrow-leaved goldenrod into the fen along drainage channels. The third occurrence is another shoreline fen around the perimeter of the kettlehole bog. This area is in transition due to beaver activity. The fourth occurrence is in a poorly drained basin along the southwestern boundary of the property. Overall, this community type has changed little in distribution or spatial extent since 2012. A total of 36 plant species have been documented in this community type, including four species (green alder, wild calla, royal fern and narrow-leaved goldenrod) that were not observed in 2012 (Appendix D, Table 1).

This is a shrubby peatland type, with occasional trees and dense coverage of heath shrubs. Trees are either absent or extremely sparse, with pitch pine, tamarack, and black spruce occurring at very low density. Shrub species include leatherleaf, bog rosemary, black chokeberry, rhodora, sheep laurel and dwarf huckleberry. The southern occurrences also include some sweetgale. Dwarf shrubs are present in many areas, with both large cranberry and small cranberry the typical species. Herbs include tawny cottongrass, three-way sedge, swollen-beaked sedge, white beak rush, podgrass, round-leaved sundew, pitcher plant and spatulate-leaved sundew. Sphagnum coverage is typically dense throughout the entire site. A dense thicket of maleberry surrounds most of these wetlands.

During the 2017 Flora & Fauna Assessment (NEA), this community includes the area formerly identified as the Pitch Pine Bog mentioned above as the “northwestern occurrence”. The MNAP still identifies this occurrence as Pitch Pine Bog.

Sweetgale Mixed Shrub Fen

This common open wetland type is ranked S4, or apparently secure, by MNAP (Gawler and Cutko 2011). It occurs in a single area (3 acres) on the Site; to the east of the kettlehole bog (Appendix B, Figure 3). The beaver dam at the eastern end of the bog forms the western extremity of this community. An ephemeral drainage channel flows west to east through the center of this community. Deep accumulations of peat were noted in this area, particularly toward the western end of the wetland. Around the perimeter of the wetland, and to the east, peat accumulations appear to be shallower and a few areas may be transitional with more

generic Mixed Graminoid – Shrub Marsh. A total of 45 plant species were documented in this community type (Appendix D, Table 1). Overall, this community type has changed little in distribution or spatial extent since 2012, although ongoing changes in hydrology may lead to gradual shifts in this community over time.

This wetland is dominated by shrubs and tall graminoids, with most vegetation around a meter in height (Appendix D, Table 1). Common shrubs include sweet gale, meadowsweet, leatherleaf, steeplebush and rhodora. The herb layer in this wetland is extremely diverse. A gradual shift in herb species composition was noted from east to west through this wetland, with bog species more common to the west. In the eastern portion of the wetland, common herbs include rattlesnake mannagrass, reed mannagrass, common woolgrass, sharp-fruited rush, grass-leaved goldenrod, rice cutgrass, swamp candles and short-tailed rush. Other species include boneset, white beak-rush, marsh fern, hairy-rosette panic grass, spatulate-leaved sundew, autumn bentgrass and northern water-horehound. The rare fall fimbry noted in this area in 2012, was no longer present in 2017. To the west, herb composition shifts somewhat to species more typical of bogs. These include white beak-rush, bog bean, three-leaved false solomon's seal, bog aster and tawny cottongrass. New species documented in 2017 include star sedge, swamp milkweed and three-petaled bedstraw.

This community has experienced some significant changes in hydrology since surveys in 2012. The entire wetland is drier overall, and this is particularly true in the eastern portion of the wetland. Bluejoint is more abundant, and some larger patches may be transitional with Bluejoint Meadow, although the community remains characteristic of the Sweetgale Mixed Shrub Fen type. The changes may result in a transition in community type in some areas but appear to be the natural result of beaver activity.

Palustrine Emergent

Three-way Sedge – Goldenrod Outwash Plain Pondshore

This is an extremely rare natural community type in Maine and is ranked S1 by MNAP (MNAP 2020). The Three-way Sedge – Goldenrod Outwash Plain Pondshore on the Hollis Site is one of the highest quality examples of this community in the state and was used to develop ecological descriptions of the type (Appendix B, Figure 3). The community covers 13.8 acres and a total of 49 plant species have been documented in this community (Appendix D, Table 1). This area occupied by this community has expanded substantially since 2012, although this expansion may be transient and simply due to naturally changing water levels in the pond.

This community displays strong patterns of vegetation zonation. The upper banks surrounding the pond are dominated by buttonbush, with lesser amounts of maleberry, fox grape, sweet gale, meadowsweet and silky dogwood. Invasive Japanese barberry is encroaching upon native

vegetation in this zone along the western shore. It does not appear to have expanded its range significantly since 2012 but remains an urgent priority for management and was initially treated in 2020. Further treatments are expected in future years. Just below the buttonbush zone, around the seasonal high-water line, taller herbs are dominant. These include meadow beauty, rice cutgrass, umbrella sedge, brown-fruited rush, blunt mannagrass, blue-flag iris, northern water-horehound and the rare narrow-leaved goldenrod. The lowest zone included dwarf spikerush, blunt spikerush, water smartweed, common pipewort and floating pondweed that had been stranded by the receding water levels. Two new species were documented in this community type in 2017; American water horehound and stalked woolgrass.

Significant changes noted in this community in 2017 included a significant expansion in the distribution of rare narrow-leaved goldenrod. In 2012, this species was documented in seven small patches, with a few hundred individuals total (NewEarth 2012). In 2017, narrow-leaved goldenrod was the dominant species around most of the lower pondshore, with hundreds of thousands, possibly millions, of individuals. This rapid expansion may be due to changes in hydrology or other unknown factors. In the lower zones of the community, this species formed a near-monoculture. Populations of three-way sedge and other indicator species of this community type were significantly lower than in 2012. Despite the fact that narrow-leaved goldenrod is threatened in Maine, these changes may represent a decrease in the health and integrity of the Three-way Sedge – Goldenrod Outwash Plain Pondshore community. Since this is considered an exemplary occurrence of the type, ongoing monitoring is recommended to determine whether these changes in community composition persist. It would also be worth considering whether any recent human activity at the site could have caused these changes, and if so, how those activities fit with broader management goals for the property. MNAP believes that the behavior of this species is characteristic for the community type in the context of a prolonged drawdown cycle.

Water-lily – Macrophyte Aquatic Bed

This aquatic community occurs in open water areas of the pond and covers an estimated 10 acres (Appendix B, Figure 3). It is very common statewide and is ranked S5, or demonstrably secure, by MNAP (Gawler and Cutko 2010, MNAP 2017a). Vegetation is restricted to aquatic herbs, and typically includes both floating and emergent species. Characteristics and dominant species can change dramatically depending on pond water depth, nutrient regime and disturbance. Dominant species include white pond lily, floating pondweed, water shield, common pipewort as well as a wide variety of algae. Tall emergent vegetation such as broad-leaved cattail and common wool-sedge are occasionally present in shallow water or mud along the periphery. This community intergrades with surrounding wetland types, especially during times of fluctuation in water levels.

5.3 Fish and Wildlife

Several assessments and guild-specific inventories have been conducted on the Site to date (Gawler and Jessee 1997; Meehan et al. 1991 as cited in NEA 2004; NEA 2004; NewEarth 2012; Schweitzer 1992; Sneddon et. al., 1996; Stantec 2016; Tetra Tech 2016, Corbin 2018), which including invertebrates, have collectively confirmed the occurrence of 273 species. This includes 11 new species documented during this 2017 assessment; two reptiles, three amphibians and six birds (Appendix D, Table 2). Four of the documented fauna are federal or state-listed TE species (BwH 2017, MDIFW 2015, USFWS 2018). Thirty species (three mammals, 20 birds, one amphibian, one reptile and five invertebrates) are Maine Species of Special Concern (MDIFW 2020).

Excluding invertebrates, the 2017 assessment confirmed the presence of 67 out of the 99-wildlife species (68 %) previously documented on the Site from the 1990's through 2012, and as noted, added an additional 11 species that were previously not reported on the site (Appendix D, Table 2). Prior studies by Schweitzer 1992, Sneddon et al. 1996 and Gawler and Jessee 1997, reportedly documented over 100 invertebrate species. Lists of those species could not be located for a comparison with invertebrate data from 2016. Based on the report summary two state-listed moth species, *Xystopeplus rufago* and *Zale obliqua*, were found, but these species were not detected during 2017 survey efforts (Tetra Tech 2016). The species not documented in 2017 are most likely still present on the property but were simply not detected during the limited survey effort. As with the flora surveys, intensive and focused efforts (rather than short-term general assessments) would be needed to develop a more comprehensive list of species; particularly secretive species, nocturnal species and those that are rare or uncommon. Species detections are primarily the result of being in the right place at the instant an individual is active or vocalizing. Higher numbers of sample events, planned during periods of peak activities, would increase the likelihood of such encounters.

5.3.1 Mammals

Excluding ocean-dwelling species, 58 non-domestic mammals are known to reside in Maine (MDIFW 2013a). General assessments, and targeted surveys for bats (Stantec 2016) have confirmed a total of 18 mammal species (Appendix D, Table 2). In addition, direct evidence (i.e., scat, hair, tracks, etc.) of fox, mouse, mole/vole/shrew and weasel species have also been documented, but these could not be identified to the genus level.

Two of the mammal species (Eastern small-footed bat and Little brown bat) found on the Hollis Site to date are federally or state-listed species (MDIFW 2015; USFWS 2018), three (Eastern red bat, Hoary bat and Silver-haired bat) are Species of Special Concern in Maine (MDIFW 2011)

and eight are listed as Species of Greatest Conservation Need (Maine State Wildlife Action Plan, MDIFW 2015).

Key habitat features for mammals on the Hollis site include dense shrubby vegetation for food and cover, open trails for easy navigation and access to freshwater sources. Micro-habitat features were relatively uncommon, most likely as a result of past fire management activities. Notable features include tip-up mounds and brush piles for denning and cover, and dead standing and downed trees as cavity nests and food sources. Several active ground-based den sites (unknown species) were observed on the Site in 2017 (Appendix B, Figure 6).

5.3.2 Birds

The upland and wetland forest, shrub and open habitats of the site, as well as the edge habitats found along areas cleared for training facilities and roads, provide suitable breeding, nesting and/or foraging habitat for dozens of bird species. Excluding aberrant visitors and extremely rare species, 146 bird species have been documented in non-costal habitats of York County during the May through July breeding/nesting season (MDIFW 2013b; eBird 2018). Of these, 92 species (63%) have been documented on the Site to date.

None of the birds reported are federal or state-listed species (MDIFW 2015; USFWS 2018), but twenty are USFWS Birds of Conservation Concern (USFWS 2018) and/or Species of Special Concern in Maine (MDIFW 2011, USFWS 2008) and 35 are listed as Species of Greatest Conservation Need (Maine State Wildlife Action Plan; MDIFW 2015). One species, European starling, is a non-native invasive species (Cornell 2016). Another, brown-headed cowbird, is a species native to the United States but is considered a noxious species in the northeast (Cornell 2016).

Bird observations include documentation of calls from a common nighthawk. Common nighthawks are not considered a state or federal RTE species or species of concern in Maine but is a SGCN (MDIFW 2015). The species has exhibited significant widespread declines in the northeast (Brigham et. al., 2011, Massachusetts Breeding Bird Atlas 2012), and nighthawks nesting on natural substrate, are of significance since most of the remaining populations in the region are found nesting only on gravel roof tops of man-made structures (Brigham et. al., 2011).

Notable habitat features for birds on Site include snags/cavity trees which are used for nesting, roosting and foraging, as well as downed woody debris and shallow areas along wetland habitat where birds forage; although as noted, none of these features are abundant on the site. Burned forest communities, particularly those that have been burned repeatedly or subject to intense fire, generally lack standing dead trees and downed woody material. But, the resulting dense undergrowth, nearly non-existent mid-canopy layer, and sparse over-canopy dominated

by large trees, provides a unique habitat for many bird species such as prairie warbler, rufous sided-towhee, mourning warbler, brown thrasher, white-throated sparrow, tree sparrow as well as woodpeckers and nuthatches to name a few. Several of these are Birds of Conservation Concern (USFWS 2008) or Species of Special Concern in Maine (MDIFW 2011).

5.3.3 Fish

No surveys for fish species have been conducted to date at the Hollis site however Hornpout (*Ameiurus nebulosus*) and Chain pickerel (*Esox niger*) have both been observed in the pond by MEARNG biologists. Chain pickerel were also inadvertently trapped during turtle surveys (Stantech 2018).

5.3.4 Reptiles and Amphibians

Thirty-seven native species of non-marine amphibians and reptiles occur in Maine, including nine frogs and toads, nine salamanders, eight turtles and eleven snakes; many of which are rare (Hunter et. al., 1999). Of these, 15 have been confirmed on the Hollis Site, including; nine amphibians and six reptiles (Appendix D, Table 2). Three new amphibians and two new reptiles were documented during the 2017 assessment.

None of the amphibians or reptiles documented are currently federal or state-listed TE species (MDIFW 2015, USFWS 2018). Two species, Northern Leopard Frog (*Rana pipiens*) and Ribbon Snake (*Thamnophis sauritus*), are Species of Special Concern in Maine (MDIFW 2011).

A targeted survey for Spotted turtles was conducted in 2018 (Stantech) using both Visual Rapid Assessment (VRA) and Trap-based Rapid Assessment techniques (Appendix E). This survey resulted in no spotted turtle detections but did reveal numerous painted turtles (*Chrysemys picta*) and managed to trap several Chain pickerel.

Habitat features of importance on the Hollis Site include forested areas in proximity to freshwater wetland and open water areas. Also present are open sandy areas adjacent to aquatic and semi-aquatic habitats which are key to reproduction for many turtle species. Evidence of turtle nesting was confirmed in several areas of the Site during the 2017 assessment; with 11 nests found in one 0.75-acre area alone. Activities such as off-road vehicle and ATV use, may help to keep these important turtle nesting areas open and free of vegetation, but may also contribute to direct mortality of adults, juveniles and buried eggs.

5.3.5 Invertebrates

Based on surveys and observations documented from the Hollis site since the mid 1980's, over 100 invertebrate species have been documented. These include five state species of special concern (Mariano 1996, Gawler and Jessee 1997, MDIFW 2005, 2006, MNAP 2005) and six

considered SGCN (MDIFW 2015). Appendix D, Table 2 provides a list of invertebrates that have been confirmed on the site.

Odonates and Lepidoptera

Numerous targeted surveys for invertebrates, including dragonflies, damselflies and butterflies, were conducted on the Site in the 1990's by Schweitzer 1992, Sneddon et al. 1996, and Gawler and Jessee 1997 and more recently (Tetra Tech 2016). Over 100 invertebrate species were reportedly documented during surveys in the 1990's and included several state-listed or formerly-listed species and Species of Special Concern. Fifty-eight (58) of the invertebrate species found were reportedly pine-barren dependent species. Unfortunately, the details of these studies could not be located to confirm report details or species lists.

Targeted survey efforts in 2016 (Tetra Tech 2016) documented 20 Odonates (4 damseflies and 16 dragonflies) and 126 Lepidoptera (24 butterflies and 102 moths). This included two state-listed species, five Species of Special Concern (Appendix D, Table 2) and six SGCN. No invertebrates were documented during the 2017 assessment, although numerous species were noted incidentally.

Habitats of importance to these invertebrates include waterbodies, open wetlands and other open vegetated habitats such as meadows and early successional cover types; particularly those with high nectar and pollen sources. Although flowering plants are generally uncommon on Site due to the deep sandy soils, native plants of the following genera are especially important food sources; asclepias, aster, achillea, anaphalis, scirpus, schizachyrium, lazula, leersia, juncus, eupatorium, eutrochium, helianthus, rudbeckia and symphyotrichum. Other favorable habitat characteristics include high light regimes, heterogeneity in structure and high fluctuations in microclimates. Disturbances such as fire, herbivory and logging are known to enhance the diversity of herbs and thereby can increase dragonfly, damselfly and butterfly diversity (Roberts 2004).

5.4 Threatened and Endangered Species and Habitats

Army Regulation 200-1, Chapter 4 requires protection of listed species and designated critical habitat under the Endangered Species Act (ESA) of 1997, as amended; all activities conducted by installations and Army personnel are subject to ESA requirements. AR 200-1 also encourages cooperation and informal consultation with regulatory agencies at the earliest planning stages to determine the need for formal consultation. It is an Army goal to systematically conserve biological diversity on Army lands within the context of its mission.

The ESA imposes five primary requirements upon the Army:

- conserve listed species;
- not “jeopardize” listed species;
- “consult” and “confer”;
- conduct a biological assessment; and,
- not to “take” listed fish and wildlife species or to remove or destroy listed plant species.

Endangered Species Act Section 7 consultation compliance was met in the development of this INRMP through direct written and verbal consultation with the USFWS, Maine Field Office and was held concurrent with development and public review of this plan. In addition, natural resource agencies and organizations that include the USFWS, MDIFW, TNC and MNAP, were consulted regarding the presence of any know species or habitats of special concern at the Hollis Training Site. Agency consultation letters are provided in Appendix C.

5.4.1 Federal or State-listed Species

Surveys and observations for Federal and state rare species have been conducted on Hollis during 1991, 1996, 2004, 2005, 2012, 2016, 2017 and 2018 (MNAP 1991, UMO 1991, Gawler and Jessee 1997, MEARNG 2004, 2012, 2016, 2017 MDIFW 2005, MNAP 2005, 2006b, Stantec 2016, 2018). As a result of these efforts, no Federally-listed species have been confirmed on the site. Three state-listed threatened plant species, two endangered invertebrate and two endangered mammals have been confirmed on the site and are discussed below. Responses from Federal and state agencies support these findings (MDIFW 2005, 2006, USFWS 2005) and are presented in Appendix C. Four ecological communities and ecosystems of state significance also occur on the site and are discussed in Section 5.4.3 (Appendix B, Figure 3) (MNAP 2005).

Confirmed Listed Species

Previous surveys have confirmed the presence of seven state-listed species on the Hollis site (Gawler and Jessee 1997, MDIFW 2006, MEARNG 2020). These include three threatened plants: the narrow-leaved goldenrod, northern blazing star, and four animal species: the endangered invertebrate Edwards’ hairstreak, the threatened Sleepy dusky-wing, the threatened Small-footed bat and the endangered Little brown bat. Edwards’ hairstreak has been confirmed on the Hollis Training Site during several different surveys (1996 & 2016). Two adult vouchers were deposited at the Maine Forest Service Entomology Office in Augusta and were based on collections made July 10, 1996, by Joseph Mariano and confirmed by Dr. Reginald Webster (MDIFW 2005, 2006). The exact collection location of the Edwards hairstreak captured in 1996 is unknown, but in 2016 an individual was captured at the edge of the pond in an area of their preferred scrub oak habitat (Appendix B, Figure 6). The goldenrod was found

along the three-way sedge – goldenrod outwash plain pondshore community in the west-central portion of the Hollis site (Appendix B, Figure 6). In the 2012 survey, the previous population of fall fimbry (listed as threatened until 2015 when changed to species of concern) was not relocated but an additional population was located adjacent to the Sweetgale Mixed Shrub Fen to the east of the kettlehole bog (Appendix B, Figure 6). The blazing star, a fire dependent species, was found in the pine barren habitat along an open sandy area near the center of the site, but has not been observed since 1996 (Appendix B, Figure 6). It is likely that this fire dependent species could return to the site as a result of habitat modifications from fire management activities. According to the MNAP database, the goldenrod and fimbry species have recently been identified and are still likely to be present on the site (MNAP 2005, 2006b).

Potential Listed Species

Northern Long-eared Bat (Myotis septentrionalis) may occur on site but has not been recorded during past acoustic surveys. Suitable habitat does exist on site however no roost trees or hibernacula have been identified on or near the site. MEARNG considers impacts to bats and bat habitat during project review and IAW ESA Section 7 requirements. MEARNG utilizes the USFWS Streamlined Consultation for projects potentially impacting bats or bat habitat.

Based on availability of suitable habitat, the New England cottontail (*Sylvilagus transitionalis*), a species formerly considered for Federal listing, could potentially occur on the site (Department of Interior 2004, USFWS 2005). Several winter tracking surveys have been conducted on the Hollis TS for New England cottontail (NEC). These surveys did not detect NEC but did reveal significant Snowshoe hare presence. Suitable habitat for this species does occur on the site and includes pitch pine–scrub oak forests with dense understory, particularly those areas where disturbances such as timber harvesting and fires maintain shrub-dominated and early-successional habitats on the landscape. Based on range maps for the New England cottontail, the Hollis site may be beyond the range of this species. Presently the range of the cottontail is believed to be restricted to only a few locations in New England, and includes only two southern coastal counties in Maine, including the county where Hollis is located (Department of Interior 2004). There has been at least one Eastern cottontail record for northern York County (MNAP 2006b, c).

Under suitable conditions (i.e., periodic fire events), numerous rare plants (13 potential species in Maine) and animal species (including over 28 invertebrates) may also occur on the site due to their association with the unique pitch pine–scrub oak barren habitat (Mariano 1996, Gawler and Jessee 1997, MDIFW 2005, MNAP 2005, USFWS 2005, MNAP 2021). Based on existing site conditions, upland scrub oak habitats throughout the site are believed to support the state threatened pine barrens zanclognatha.

Additional state-listed species have been documented within a 4-mile radius of the site including the state-endangered box turtle (*Terrapene carolina*), which was documented within 2 miles of the site, and the state-threatened black racer (*Coluber constrictor*) (MNAP 2005, USFWS 2005). A 2019 survey for rare turtles did not detect any on site. Box turtles prefer loose mineral soils for burrowing, which are present on the Hollis site (Natureserve 2005). Box turtles have been documented in similar barrens such as the sand-dominated scrub oak forests of the Long Island, NY, barrier island ecosystem (USACE 2004). Black racers prefer scrubby, dry woodland and shrub habitat similar to that of the general region of the Hollis Barrens (MDIFW 2006).

5.4.2 Species of Special Concern

Confirmed Species of Special Concern

MDIFW personnel observed one vertebrate, the ribbon snake, a state species of special concern, in the three-way sedge–goldenrod outwash plain pondshore community in the west-central portion of the site (MDIFW 2005) (Appendix B, Figure 6).

Five invertebrates of special concern have also been observed on the site and include the sleepy dusky-wing (*Erynnis brizo brizo*), southern pine sphinx (*Lapara coniferarum*), oblique zale (*Zale obliqua*), cobweb skipper (*Hesperia metea*), huckleberry sphinx (*Paonias astylus*) (Mariano 1996, Gawler and Jessee 1997, MNAP 2005). All were found within the pitch pine– scrub oak habitat.

Potential Species of Special Concern

The wood turtle (*Clemmys insculpta*), a state special concern species, has been documented near the site (USFWS 2005). This species typically prefers fast flowing streams, but have also been known to occur where low flow systems exist. The Hollis site may lack suitable habitat for the wood turtle due to lack of fast-flowing rivers and streams on site. Although there are no documented occurrences of the Fowler's toad (*Bufo fowleri*) within Maine, the species is thought to occur in the warm, southern ecoregions of Maine (MDIFW 2006). The breeding habitat of this toad consists of generally smaller wetlands and vernal pools, such as those in the three-way sedge – goldenrod outwash plain pondshore. Numerous other invertebrates, many of which are believed to be rare, also likely occur on the Hollis site due to the presence of rare habitat types. Currently there is insufficient information about many of these species to determine their legal status at this time (Gawler and Jessee 1997, MDIFW 2005).

5.4.3 Significant Habitats and Communities

There are four rare and unique natural communities within the boundary of Hollis (Appendix B, Figure 3). They include the kettlehole bog–pond ecosystem, unpatterned fen ecosystem, the pitch pine–scrub oak barren community, and the three-way sedge–goldenrod outwash plain pondshore community (MNAP 2005). Although identified as communities or ecosystems of significance, they are not afforded state legal status (MNAP 2004, 2005).

The three-way sedge – goldenrod outwash plain pondshore community has a state rarity rank of S1 (i.e. critically imperiled in Maine because of extreme rarity, five or fewer occurrences remaining, or because some aspect of its biology makes it especially vulnerable to extirpation), and a global rarity rank of G2G3 (i.e. globally imperiled because of its rarity, 6–20 occurrences or few remaining, or because of other factors making it vulnerable to decline). The pitch pine-scrub oak community has a state rarity rank of S2 (i.e., imperiled in Maine because of rarity, 6-20 occurrences or few remaining individuals or acres, because of other factors making it vulnerable to further decline) and a global rank of G2 (i.e., globally imperiled because of rarity, 6-20 occurrences or few remaining individuals or acres, or because of other factors making it vulnerable to further decline). The pitch pine bog community has a state rarity rank of S2 (i.e., imperiled in Maine because of rarity, 6-20 occurrences or few remaining individuals or acres, because of other factors making it vulnerable to further decline) and a global rank of G3G5 (i.e., globally rare (20-100 occurrences), demonstrably secure globally.). The kettlehole bog-pond ecosystem and the unpatterned fen ecosystem both have state rarity ranks of S4 (i.e., apparently secure in Maine).

5.5 Wetlands

The U.S. Congress enacted the Clean Water Act in 1972 to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Section 404 of the Clean Water Act delegates jurisdictional authority over wetlands to the U.S. Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA). Waters of the United States protected by the Clean Water Act include rivers, streams, estuaries, and most ponds, lakes, and wetlands. The USACE and the EPA jointly define wetlands as areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (Environmental Laboratory 1987). Wetlands generally include swamps, marshes, fens, bogs, and similar areas.

The USFWS further defines wetlands to include a variety of areas that fall into one of five categories:

- Areas with hydrophytes and hydric soils, such as those commonly known as marshes, swamps, and bogs;

- Areas without hydrophytes but with hydric soils, such as flats where drastic fluctuation in water levels, wave action, turbidity, or high concentration of salts may prevent the growth of hydrophytes;

- Areas with hydrophytes but non hydric soils, such as margins of impoundments or excavations where hydrophytes have become established but hydric soils have not yet developed;

- Areas without soils but with hydrophytes, such as the seaweed-covered portion of rocky shores; and,

- Wetlands without soils and without hydrophytes, such as gravel beaches or rocky shores without vegetation.

Wetlands on the Hollis site were mapped in September 2000 using remote sensing methods in accordance with a system developed by the USFWS, and described above (Cowardin et al. 1979). Four wetlands covering 66.8 acres were identified. Wetlands and their associated vegetative communities were also classified using the MNAP classification system (MNAP 2006a). Appendix A, Table 3 lists all wetlands on the Hollis site. A list of all plants observed on the site, including plants found in wetlands, is provided in Appendix D.

5.5.1 Unpatterned Fen Ecosystem

Fens are peat-forming wetlands that receive nutrients through drainage from surrounding mineral soils, springs, seeps, and from groundwater movement. Fens differ from bogs because they are less acidic and have higher nutrient levels.

The fen community on Hollis covers approximately 21 ac and includes the community type defined by MNAP as an unpatterned fen ecosystem (Appendix B, Figures 3 and 4). Previous to surveys performed in 2005, the fen community on Hollis was mapped as both a leatherleaf boggy fen and a mixed tall sedge fen (MNAP 2005, 2006a). Currently, this wetland community is no longer a good representation of a leatherleaf boggy fen and mixed tall sedge fen, thus these community designations have been removed and this area is currently defined as an unpatterned fen ecosystem.

The unpatterned fen ecosystem at Hollis is dominated by species that are adapted to nutrient-poor environments including lambskill (*Kalmia angustifolia*), Labrador tea (*Ledum groenlandicum*), dwarf huckleberry (*Gaylussacia dumosa*) and large cranberry (*Vaccinium macrocarpon*). Herbs include sundews (*Drosera* sp.), beakrush (*Rhynchospora alba*) and cottongrass (*Eriophorum spp*.). The extent and depth of open water in the fen is variable and fluctuates depending on surface water input throughout the year. Typically any open water is

dominated by water lilies, spadderdock, arrow arum (*Peltandra virginica*) and spike rush (*Eleocharis elliptica*). The remaining area is dominated by sphagnum moss, robust sedges including *Carex lasiocarpa* and *C. utriculata,* leatherleaf and sweetgale (*Myrica gale*).

Often the habitat types described above are found in close association with one another. This is evident in the wetlands located near the center of the western boundary of the Hollis site, as shown in Appendix B, Figure 3.

5.5.2 Kettlehole Bog–Pond Ecosystem

Kettlehole bog–pond ecosystems are flat peatlands located in glacial depressions that are formed by the melting of buried glacial ice blocks. The kettlehole bog-pond ecosystem at the Hollis site includes wetlands covering approximately 24 ac (Appendix B, Figures 3 and 4). Open water within the pond is dominated by water lilies, water shield (*Brasenia schreberi*) and pipewort surrounded by a saturated transitional zone dominated by dense *Carex lasiocarpa*, tussock sedge (*Carex stricta*) and cottongrass (*Eriophorum virginicum*). Drier areas of the bog contain sphagnum moss (*Sphagnum sp*.), leatherleaf, rhodora (*Rhododendron canadense*), sheep laurel, sweet gale and bog rosemary (*Andromeda polifilia*). Scattered black spruce (*Picea mariana*), eastern larch (*Larix laricina*) and white pine trees occur along the edge of the bog.

5.5.3 Three-way Sedge–Goldenrod Plain Pondshore Community

This is an extremely rare natural community type in Maine and is ranked S1 by MNAP (MNAP 2108). The Three-way Sedge – Goldenrod Outwash Plain Pondshore on the Hollis Site is one of the highest quality examples of this community in the state and was used to develop ecological descriptions of the type (Appendix A, Figure 3). The community covers 6 acres and a total of 49 plant species have been documented in this community (Appendix D, Table 1). The area occupied by this community has expanded substantially since 2012, although this expansion may be transient and simply due to naturally changing water levels in the pond.

This community displays strong patterns of vegetation zonation. The upper banks surrounding the pond are dominated by buttonbush, with lesser amounts of maleberry, fox grape, sweet gale, meadowsweet and silky dogwood. Invasive Japanese barberry is encroaching upon native vegetation in this zone along the western shore. It does not appear to have expanded its range significantly since 2012 but remains an urgent priority for management. Just below the buttonbush zone, around the seasonal high-water line, taller herbs are dominant. These include meadow beauty, rice cutgrass, umbrella sedge, brown-fruited rush, blunt mannagrass, blue-flag iris, northern water-horehound and the rare narrow-leaved goldenrod. The lowest zone included dwarf spikerush, blunt spikerush, water smartweed, common pipewort and floating pondweed that had been stranded by the receding water levels. Two new species were

documented in this community type in 2017; American water horehound and stalked woolgrass.

Significant changes noted in this community in 2017 included a significant expansion in the distribution of rare narrow-leaved goldenrod. In 2012, this species was documented in seven small patches, with a few hundred individuals total (NewEarth 2012). In 2017, narrow-leaved goldenrod was the dominant species around most of the lower pondshore, with hundreds of thousands, possibly millions, of individuals. This rapid expansion may be due to changes in hydrology or other unknown factors. In the lower zones of the community, this species formed a near-monoculture. Populations of three-way sedge and other indicator species of this community type were significantly lower than in 2012. Despite the fact that narrow-leaved goldenrod is threatened in Maine, these changes may represent a decrease in the health and integrity of the Three-way Sedge – Goldenrod Outwash Plain Pondshore community. Since this is considered an exemplary occurrence of the type, ongoing monitoring is recommended to determine whether these changes in community composition persist. It would also be worth considering whether any recent human activity at the site could have caused these changes, and if so, how those activities fit with broader management goals for the property.

6.0 Mission Impacts on Natural Resources

MEARNG command and staff are required to complete the military training mission successfully, and an integral part of that mission is good environmental stewardship. Overall the effect of natural resources management on the military mission of MEARNG is positive. The ITAM program in particular has a positive effect both on military training and the environment. Other programs, such as forestry, prescribed fire and fish and wildlife management have positive effects on military mission requirements. Many forestry and prescribed fire projects open up areas to military use that otherwise would be difficult to utilize, and fish and wildlife management provides resources for more realistic training while also providing another element to support soldiers' quality of life.

6.1 Land Use

Land within the Hollis site boundary is owned by the State of Maine for the use of MEARNG. Land use over the past 10 years has included limited training for the MEARNG, Maine Air National Guard (MEANG), U.S. Army Reserves (USAR) and U.S. Marine Corps Reserves (USMCR) and both authorized and limited unauthorized recreational uses by the public. Currently, the land is used by MEARNG to train, mobilize and deploy combat-ready forces to meet operational commitments, which involves light dismounted activities such as small unit operations, bivouac, land navigation, temporary fighting positions, engineer equipment training and some tactical driving. In the future, MEARNG proposes to continue to conduct training outside of significant

natural/cultural resource management zones and will limit training inside of valuable natural/cultural resource management zones in order to preserve and protect significant cultural and natural features, species, and habitats on the site.

Much of the site is bordered by lands managed by MDIFW as shown in Appendix B, Figure 3. Management goals for protecting and preserving significant species and habitat on adjacent lands are similar to the goals of the MEARNG lands and are consistent with MEARNG's use of the site for training purposes while promoting sound natural resource stewardship principles and land management practices. Unlike MEARNG management, fire management is currently not a tool being used by MDIFW to promote fire dependent habitats on these adjacent lands.

Many overlapping land uses occur on the site. Many training areas include forests that are open to outdoor recreation activities, and are part of MEARNG's fire management program. Because of overlapping uses, coordination of projects and land use between Command, Combat Readiness Training Division, Deputy Chief of Staff for Operations (DSCOPS), and the Directorate of Facilities Engineering–Environmental Section (DFE-ENV) is extremely important.

6.2 Current Major Impacts

Comprehensive studies that specifically evaluate the effects of military training and recreational uses to natural resources have not been conducted at the Hollis site. Current training activities on the site are infrequent and the nature of the activities is likely to cause minimal negative impacts to natural resources. However, observations made during previous site visits and surveys for wildlife and habitat have revealed some site disturbance and potential sources of disturbance, past and current, which include the following:

- Unimproved sand roads and trails;
- Active bivouac sites and foot-traffic in forested areas;
- Field maintenance of vehicles and weapons during tactical maneuvers;
- Trash and other debris, primarily from unauthorized public use of the property;
- Maintenance activities to create fire breaks;
- Prescribed burning; and,
- Recreational uses of the site that include horseback riding, snowmobiling and unauthorized use by ATV riders.

With the exception of unauthorized uses of the site (i.e., dumping of trash and debris, use of ATV's), the disturbances resulting from authorized uses of the site are overall very minor and

have not resulted in significant negative impacts to the natural resources of the site. Observed impacts include the following:

- Erosion primarily associated with roads, the sand habitat and waters edge;
- Disturbance to wildlife due to noise/activity associated with training and recreational activities;
- Materials and litter associated with training activities;
- Long term vegetation loss in maintained roads, trails, open areas, and pad sites; and,
- Short-term impacts to vegetation in burned areas, training areas, and along road edges.

In addition, prescribed burning has an overall positive impact on the natural communities of the site and fully supports military training activities.

6.3 Potential Future Impacts

If the basic mission, land area, and intensity of missions remain unchanged as MEARNG anticipates, mission impacts on natural resources are expected to remain similar to those today. However, current and future training activities at Hollis could change over time as necessary to support the military mission.

Future activities proposed for the Hollis site include the continuation of military training exercises (i.e., orienteering, bivouacs, convoy training, small-arms firing with blanks, aviation training, engineer equipment training, foot maneuvers), and prescribed burns. Vehicular traffic will be restricted to existing cleared areas and trails. Thus, no additional future impacts are anticipated. Foot traffic may cause some trampling of vegetation and disturbance to soils, but overall impacts to the communities will be minor. Controlled burning activities would result in temporary vegetation disturbance. However, the impacts are desirable because it promotes growth of rare fire dependent species and promotes the long-term survival of fire-dependent communities within the ecologically sensitive and rare pine barren ecosystem, reduces fuel loading and provides better maneuver space for military training.

6.4 Natural Resource Needs to Support the Military Mission

Quality training opportunities necessitate quality natural resources. The mosaic of natural communities found on Hollis provides the MEARNG with a variety of realistic training scenarios. Forested areas are used for infantry training and as bivouac sites. Forest clearings serve as small unit assembling points. Therefore, training areas are managed to support the military mission while sustaining their resource capabilities.

6.5 Natural Resource Constraints to Missions and Mission Planning

MEARNG command and staff are determined to complete the military training mission successfully, and an integral part of that mission is good environmental stewardship. However, there are some negative aspects of natural resources or their management on military training.

There may be time delays to coordinate with Natural/Cultural Resources staff or to obtain permits for proposed activities. Delays associated with these may affect military training schedules. In addition, as shown in Appendix B, Figure 6, a portion of the installation is off-limits to training, or has training restrictions, due to archeological or environmental constraints. For example, training activities of any kind are generally not permitted within the vicinity of known locations of Federal or state-listed species or archaeological sites as shown on Appendix B, Figure 7. In addition, training activities are limited to foot traffic only in wetland areas and within 100 feet of vernal pools, fens and bogs. Finally, activities are limited to foot-traffic only and prescribed burning in areas where species require fires to ensure long-term sustainability of habitats and such activities support the military mission.

7.0 Natural Resources Program Management

This section identifies management practices that directly affect soil, water, vegetation, and fauna. It includes forest management, habitat management, wetlands management, water quality programs, grounds maintenance, pest management, training land management, fire management and direct manipulation of fish and wildlife and threatened and endangered species management. This section also identifies all programs that will be used to manage installation natural resources during the next 5 years. Appendix A, Table 5, provides a summary of those management programs listed below that have specific management actions associated with them.

7.1 Natural Resources Program Management

Natural resource management can be accomplished through focused natural resource management projects, including forest management, wetlands management, fire management, and similar programs. The goals presented below ensure that MEARNG is able to continue to meet and improve military training objectives while ensuring impacts to natural resources are minimized and appropriate resources are protected. The specific objectives are identified to achieve these goals. Goals and objectives follow established Best Management Practices (BMP) where applicable.

7.1.1 Natural Resource Management Goals and Objectives

The Natural Resource Management Goals and Objectives for the Hollis Training site and the actions needed to achieve these goals and objectives are discussed in Sections 7.2 through 7.6, and are summarized in Appendix A, Table 5.

7.1.2 Natural and Cultural Resource Management Zones

In order to accomplish many of the above goals and objectives, three general natural and cultural resource management zones have been developed to consolidate activities in appropriate locations and to restrict certain activities in sensitive areas. The location and extent of these management zones are presented in Appendix B, Figure 7 and include the following:

Significant Natural/Cultural Resource Management Zone (SMZ)

All training activities are generally restricted in this zone due to the presence of significant natural and/or cultural resources. Resources protected by this zone at Hollis currently include confirmed and former locations of federally or state-listed species such as the state-listed threatened northern blazing star (former location of this species), fall fimbry and narrow-leaved goldenrod, and MNHP designated archaeological sites (7.40, 7.60, 7.61). Buffer zones around these features vary based on the characteristics of the habitat.

Valuable Natural/Cultural Resource Management Zone (VMZ)

Training activities in this zone are generally limited to foot traffic only (provided that soil disturbance and the removal of vegetation will be minimal) due to the presence of valuable natural resources. Resources protected by this zone at Hollis currently include all streams, waterbodies, and wetlands (which include the kettlehole bog-pond ecosystem, unpatterned fen ecosystem and the three-way sedge–goldenrod outwash plain pondshore community) as well as species of special concern such as the ribbon-snake. Buffer zones around these features vary based on the characteristics of the habitat.

Fire Management Zone (FMZ)

Prescribed burns are permitted in this area as the fire management activity supports the long-term survival of the habitat and associated fire-dependent species. Resources protected by this zone at Hollis currently include all vegetated upland communities. It is recognized that training may occur within these zones. However, unlike designated training zones, training activities within FMZ areas are limited to foot traffic and low-impact maneuvers.

Training Zones (TZ)

Training activities in this zone are generally not limited and vegetation disturbance is permitted in this zone for construction, training operations and prescribed burns. However, although not restricted, training activities throughout most of the designated TZ zone at Hollis activities that might impact soils are restricted to existing roads, trails and open sandy areas. Proposed construction at Hollis includes a lay down area, box culvert and roundabout for training purposes. This construction has already been through NEPA review and is permitted by the Maine Department of Environmental protection. TZ's at the site include all of the FMZ, existing sandy roads, airstrip, trails and open areas.

7.2 Geographic Information Systems (GIS)

A Geographic Information System (GIS) database facilitates MEARNG's efforts to achieve the above goals and objectives and is an important training site management tool. MEARNG actively maintains a GIS and associated spatial data for all of its training facilities.

Data used in the production of figures and acreage estimates in this INRMP are based on the most recent available GIS data (MEARNG 2020). The database associated with the location of significant natural resources at the Hollis site is continually being updated by MNAP based on survey data collected by MNAP and MDIFW staff.

7.3 Fish and Wildlife Management

The purpose of fish and wildlife management is to improve and maintain diverse vegetation/land cover types that support an array of native fauna. Fish and wildlife management can also help maintain ecologically sound population levels of game and non-game species. The diverse vegetation/land cover types on Hollis are beneficial to various wildlife populations. Broad based habitat improvement is a major focus of general wildlife management. However, more specific management programs are often necessary for individual species or a group of species.

Moreover, wildlife enhancements aimed at one or several species are often beneficial to many non-targeted species. Being a designated State Wildlife Refuge, hunting is not permitted within the training site. However, hunting is permitted on the adjacent WMA's. The wildlife habitat conservation at Hollis will include the following management prescriptions:

- Preserve sensitive communities that fish and wildlife species depend upon by placing barriers across major access points to deter disturbance to critical habitats;

- Restrict activities in critical habitats for fish and wildlife in accordance with designated management zones as shown in Appendix B, Figure 7; and,

- Preserve the habitat for sensitive species and migratory birds known to occur on the Hollis site by restricting training and public access to those areas during established breeding seasons.

As discussed in the water resource protection section, alterations of streams and open water bogs and fens will be avoided and soil disturbances and vegetation removal will be restricted within, and up to 100 feet from, a stream or floodplain wetland in order to maintain optimal water quality for fish production.

The DoD/MBTA rule (50 CFR 21) and EO 13186 authorize military Services to take migratory birds during military readiness activities (MRAs). Conditions are that if any MRA would cause a significant impact to a population of migratory bird species, then the military Service would have to confer with USFWS and establish measures to minimize such impacts.

The EO also discusses requirements for conservation of migratory birds. The MOU guides management and conservation of migratory birds for military non-readiness activities such as land management, MILCON, maintenance, etc. It addresses means to avoid or minimize impacts on migratory birds, when practicable and reasonable.

Impacts to migratory birds will be considered during the NEPA process for all non-readiness activities IAW EO 13186 and the associated MOU between DoD and USFWS.

7.4 Management of Threatened and Endangered Species and Habitats

It is ESA and Army policy to protect federally and state-listed species, and to afford protection to special concern (not legally-protected) species and habitats whenever possible. To accomplish this, MEARNG training activities are conducted within appropriate resource zones (as shown in Appendix B, Figure 7 and described in Section 7.1) and every effort is made to follow specific guidelines in areas where there are populations of RTE species. These include:

- Ensure the long-term success of rare fire-dependent communities, and the species that utilize these communities, using prescribed burning as a management tool to promote these species;

- Conduct surveys as necessary to confirm presence of potential RTE species (i.e., New England cottontail, box turtle, black racer, Myotis bat species, pollinator species, pitch pine-oak barren dependent butterfly and moth species);

- Avoid direct impacts to rare plants, such as the narrow-leaved goldenrod and fall fimbry, and avoid impacts to former locations of the northern blazing star;

- Avoid direct impacts to rare species, pollinators and nest sites;
- Reduce indirect impacts to rare species by minimizing traffic and activities in areas where birds or other rare animals are nesting or breeding;
- Maintain water levels surrounding rare aquatic plants and prevent alteration to water levels by avoiding watershed disturbances; and,
- Avoid low-level flying in areas where rare birds may nest in tree tops.

All natural and cultural resources management activities and military training will be conducted in a manner to minimize negative impacts to habitats and species. MEARNG Environmental management practices avoid creating favorable conditions for exotic plant species, as any exotic species may impose threats to native flora, thereby affecting rare species and natural communities. Should planting be required on site, only native species will be planted in open areas to prevent soil erosion by wind or trampling. Any future activities will not begin until an examination of rare species habitats has been completed and recommendations on land use have been made (Table 5). Recreational activities on land or water have been, and will continue to be, managed so that species of concern and significant habitats and features are not disturbed.

7.5 Water Resource Protection

There are two surface waterbodies within the installation boundary (Appendix B, Figure 3). Surface waters at the Hollis site include the kettlehole bog and pond and an unnamed tributary on the southwestern corner of the site (MEARNG 2004). Local, state, and Federal laws restrict certain activities within and adjacent to these surface waters. In order to maintain the integrity of these resources, no training activities will occur within a 100-foot buffer (i.e., VMZ area) between normal high water mark and the aforementioned waterbodies. These buffer zones also help to maintain water quality by filtering potential nutrients and sediments from water that drains into these waterbodies from surrounding areas. The MEARNG Environmental Office must approve any activities inconsistent with these guidelines.

In addition, MEARNG conducts annual erosion surveys throughout the site to document erosion issues that may impact water resources at Hollis and will implement measures to address issues as needed.

7.6 Wetlands Protection

Wetlands protection is required by Executive Order 11990, Protection of Wetlands. Protection and maintenance of habitat are the primary thrust of wetlands management on Hollis. There are four wetlands located within the installation boundary and include wetlands associated with the kettlehole bog ecosystem, the unpatterned fen ecosystem, and three-way sedge–goldenrod outwash plain pondshore community (Appendix B, Figure 3). All of these have been identified as habitats of special significance (MNAP 2010). As such, in order to maintain the integrity of these resources, training restrictions have been established for each wetland and within a 100¬foot buffer surrounding each wetland (i.e., VMZ area), as shown in Appendix B, Figure 7. These buffer zones also help to maintain water quality by filtering potential nutrients and sediments from water that drains into these wetlands from surrounding areas.

Environmental review is the primary means of detecting threats to wetlands at Hollis. DFE-ENV reviews actions that may affect wetlands. Reviews come from several sources: work orders, contracts, training site requests, military mission plans, NEPA documentation, major construction plans, etc. If necessary, projects with potential impacts are referred to the USACE (New England District) to determine if jurisdictional wetlands are implicated, establish mitigation procedures, and/or obtain permits. Projects that affect wetlands also require NRPA documentation.

In addition, MEARNG conducts annual erosion surveys throughout the site to document erosion issues that may impact wetland resources at Hollis and will implement measures to address issues as needed (Table 5).

Efforts in the past by MEARNG to reduce human impacts to wetland areas have had positive effects. Based on surveys in 2004, wetlands are currently in good health. Signs and barriers placed at wetland access points have essentially eliminated use of wetland shorelines by ATV's and cobble placed on trails leading to wetlands has significantly reduced erosion from upslope areas into wetlands. The following recommendations will help to ensure that wetlands persist and are functionally valuable:

- Continue restricted use (VMZ designation) of all areas within a minimum of 100 feet of all wetlands and waterbodies;
- Create and distribute information and maps that identify restricted areas;
- Monitor wetland health and document negative impacts; and,
- Use signs and barriers to further restrict access where needed.

7.7 Grounds Maintenance

Site structures and grounds maintenance has the potential to affect training and natural resource management goals. There is minimal core infrastructure remaining at the Hollis site and therefore grounds maintenance is limited to the following activities:

- Prescribed burns to control the shrub layer that promotes habitats and species of importance, reduces fuel load, and improves line of sight and maneuverability of troops on foot in the forest understory;

- Brush-hogging to maintain fire breaks, improve line of sight and maneuverability of troops on foot, and to minimize encroachment of vegetation onto existing roadways and training areas; and,

- Minor grading of existing unimproved roadways.

7.8 Terrestrial Vegetation Management

The general vegetation and forest management goal for the Hollis site is to use the forestlands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and potential to fulfill, now and in the future, relevant ecological, economic, and social functions at local, state, and national levels, and that does not cause damage to the ecosystems within limits of overruling MEARNG military mission in accordance with the following objectives:

- Enhance military training facilities by providing accessible forestland cover (through proper silvicultural practices) that support year-round, intermittent and relatively low-impact military training;

- Maintain and optimize existing quality of wildlife habitat for overall species diversity, particularly in regard to deer winter cover, hard mast production, wetland protection and riparian corridors for stream and lake shoreline areas;

- Maintain critical habitat conditions for rare species;

- Maintain, and where possible enhance, the visual quality of areas surrounding recreational sites, trails, and travel corridors;

- Periodically evaluate the site for opportunities to remove damaged vegetation (i.e., trees damaged by ice, storms or infestations) in order to improve overall site conditions; and,

- Inspect and mark property boundaries every 10 years to protect against trespassing and unauthorized uses of the forest.

Currently, MEARNG conducts very limited timber harvesting on this site. However, should MEARNG decide to harvest timber, it would be in accordance with the forest management plan, which supports the following objectives:

- Periodically update stand inventory data and stand maps;
- Regulate timber yield consistent with the site productivity and stand-specific objectives;
- Harvest marketable timber products and contribute forest products to the local and state economy;
- Manage the forest ecosystem to support the military mission, maintain ecosystem integrity, and produce forest products on a sustainable basis;
- Clearly mark all boundary lines within 200 feet of cutting operation harvest areas greater than 10 ac; and,
- Maintain a suitable number of wildlife trees (4 to 5 ac on average) and forest floor debris within harvested areas in order to maintain complex habitats for species that prefer such habitat (e.g., cavities, snags, and perches).

In addition, should timber management take place in the future on Hollis, all activities will be planned and conducted in accordance with Army Regulations 200-1. The State of Maine will administer any logging contracts. In addition, decisions regarding future timber harvests (e.g., stumpage sales) will be under the guidance of a licensed professional forester.

7.9 Fire Management

Many of the plant communities at Hollis include fire dependent species. Fire is an integral part of this local ecosystem and supports the training mission at Hollis. As such, MEARNG has developed an Integrated Wildland Fire Management Plan for the site and actively manages portions of the site in accordance with this plan as shown in Appendix B, Figure 5 and within the FMZ designated area as shown in Appendix B, Figure 7 (Patterson 1997, Patterson and Duveneck 2004).

Specifically, the goals of MEARNG's Fire Management Plan are to:

1) Reduce the cover of tall shrubs in order to increase mobility during training operations;

2) Reduce hazardous fuel loads;

3) Attempt restoration and encourage the expansion of the pitch pine-scrub oak habitat through fire and vegetation management activities (including the application of prescribed fire);

4) Create or improve potential habitat on the site for unusual or rare insect and plant species that are associated with pine barren ecosystems; and,

5) Encourage more widespread conservation of pine barrens ecosystems in Maine by educating local citizens about this ecosystem and by demonstrating that, when used in a controlled manner, fire is a useful conservation tool.

In accordance with this plan, MEARNG has a goal of conducting fire management activities on approximately 100 acres of the site per year on a rotating basis throughout all but approximately 50 acres of the site. These 50 acres include wetlands and bare areas. Due to weather, regional priorities and preparation conditions the 100-acre target can be difficult to reach. Prescribed burns generally are very intense to mimic natural wildfire conditions in order to achieve the goals of significantly reducing the understory vegetation, duff layer and promoting regeneration of pitch pine and oak.

MEARNG will continue to use prescribed burns to promote and maintain a healthy, diverse environment at the Hollis site that is optimal for both training and the ecosystem in accordance with MEARNG's 2018 Integrated Fire Management Plan. Fire Management activities through 2025 include at least one prescribed burn per forest stand and the creation of additional fire breaks to permit burning in the southwestern and western portions of the site (Appendix B, Figure 5). Research is continuing to determine the extent that prescribed burning should be used at Hollis to ensure that military missions can continue while maintaining native plant communities and ecosystem functionality. Full vegetation surveys to evaluate the impacts on the FMP are proposed every five years with the last complete in 2017.

7.10 Agricultural Outleasing

No agricultural activities have been permitted on Hollis. Grazing of domestic animals is not allowed due to the determination that it is not in accordance with natural resource management for the installation. There are no plans to institute either agricultural or grazing leases since they are not compatible with the military mission or ecosystem management strategies.

7.11 Integrated Pest Management Program

The Integrated Pest Management (IPM) program goal is to control those plant and animal species that affect natural resources management (e.g., reduce ecosystem functionality, displace native species) or directly affect the military mission on Hollis.

Non-native and/or noxious weeds pose threats to native habitats, endangered species, and plant community composition and diversity. More specifically, they threaten wetland

ecosystems, complicate land restoration projects, add to the cost of pest management, and in general, threaten ecosystem functionality. MEARNG is committed to the prevention of introduction of invasive species as well as their control, per Executive Order 13112, Invasive Species.

In accordance with MEARNG's 2019 Integrated Pest Management Plan (IPMP), surveillance will be used to identify pests and invasive species at Hollis and to monitor their status and the success of control measures. Typically a combination of techniques may be required to resolve a problem on a sustained basis. Integrated Pest Management may include optimum sanitation measures, good structural design and maintenance of facilities, mechanical control, cultural control, biological control and regulatory control.

Several invasive plant species were identified on the site during 2004, 2012 and 2017 survey efforts (MEARNG 2004, 2012, 2017). All species are herbaceous and most were found in disturbed areas along trails and roads and within the graminoid and sand communities. Invasive species included hop clover (*Trifolium dubium*), red clover (*Trifolium pratense*), rabbit's foot clover (*Trifolium arvense*), white clover (*Trifolium repens*), mullein (*Verbascum thapsus*), hawkweed (*Hieracium pratense*), orchard grass (*Dactylis glomerata L.*), redtop (*Agrostis gigantean*), yarrow (*Achillea millefolium*), field sorrel (*Rumex acetosella*), Morrow's honeysuckle (*Lonicera morrow*) and Japanese Barberry (*Berberis thunbergii*). No invasive species were documented on the site during 1993 and 1996 survey activities (Gawler and Jessee 1997). Efforts were made in 2020 to control the Japanese barberry and Morrow's honeysuckle populations. These efforts will continue annually.

Insect and animal pests thought to occur, or that may potentially occur, at Hollis include ticks, mosquito, black flies, gypsy moths, raccoon, porcupines and skunks. The comprehensive approach identified in MEARNG's PMP and used to control or prevent these pests ensures methods of pest control are used in a compatible manner and avoids/minimizes adverse side effects to non-target organisms and the environment (MEARNG 2019). The MEARNG IPMP discusses many aspects of pest management that are not directly within the scope of this INRMP, such as control of disease vectors and protection of facilities.

7.12 Outdoor Recreation

The most common authorized public activities at the site are recreational activities such as snowmobile, horseback riding and walking/jogging. In the past, a significant portion of public use is unauthorized activities such as ATV use and discharging of firearms by private citizens both hunting and target practice. These uses have been significantly reduced by the introduction of a new ATV trail around the training site, enhanced law enforcement presence and additional signage. Historically, public uses (both authorized and unauthorized) have

resulted in negative impacts to the natural communities, including soil erosion, rutting, direct destruction of wetland and upland vegetation and dumping of household trash, appliances and other debris. Negative impacts documented in the past include fragmentation of natural communities from new trails, loss of communities from widening of existing trails, direct impacts to wetlands (specifically the shoreline of the globally rare three-way sedge–goldenrod outwash plains pondshore), and extensive dumping of trash, appliances, cars and tires throughout the site (Gawler and Jessee 1997, MEARNG 2004).

In accordance with recommendations presented in the Conservation Plan of 1997 and 2004, MEARNG has significantly increased efforts to reduce unauthorized use of the site by placing gates, barriers and signage along access points to the site, and by maintaining close communication with local officials, residents, snowmobile clubs and ATV associations. In addition, MEARNG has removed most of the trash and debris from the site (MEARNG 2020). MEARNG will perform periodic surveys and proactively address any unauthorized uses of the site by means of environmental awareness (e.g., public outreach, signs, and barriers) and law enforcement if necessary. The MEARNG has deployed surveillance measures and will pursue legal action to curtail unauthorized use, destruction of property and dumping.

7.13 Coastal Zone Management

The site is not located near coastal areas. Therefore, this section is not applicable.

7.14 Cultural Resources Protection

The MEARNG maintains a current Integrated Cultural Resource Management Plan which covers all MEARNG facilities and training sites including Hollis.

Management of Hollis cultural resources is a mission of the DFE-ENV. A Cultural Resources Manager handles all aspects of cultural resource management including coordination with the Federally-recognized Native American tribal organizations, which include the Penobscot, Passamaquoddy, Maliceet and Micmac tribes, and the public, as appropriate. The ICRMP is the guiding document for all cultural resources issues and should be referred to for specific resource management.

7.15 Enforcement

Many aspects of the MEARNG natural resources management require effective environmental law enforcement (e.g., protection of rare or unique species, protection of sensitive areas, enforcement of bans on hunting and trapping, fishing, recreation and protection of cultural resources). Several local, state and Federal agencies are responsible for the enforcement of regulations protecting the natural resources at Hollis. Enforcement agencies and their areas of

focus include the following: the Maine Warden Service, which regulates and enforces Maine's hunting and fishing regulations and snowmobile and ATV rules; Maine Forest Service, which enforces Maine's forestry laws and ATV rules; USFWS, which regulates and enforces Federal wildlife laws; MDEP, which regulates and enforces NRPA and the Shoreline Zoning Act; and USACOE, which regulates and enforces Federal laws associated with wetlands and streams. Local and state police departments also provide surveillance and enforcement at the site.

7.16 Public Outreach

Public awareness of conservation is instrumental in creating conditions needed to manage natural resources. The MEARNG approach to awareness stresses education via flyers and partnering with MIF&W, MNAP and The Nature Conservancy who maintain web and outreach activities. Our internal outreach includes Unit Environmental Officer training and occasional newsletter articles. It provides military personnel and the public with insights into installation natural environments and conservation challenges. The more people know about the installation's unique and valuable natural resources, the more responsibly they act toward them. Education also promotes awareness of critical environmental projects and the rationale behind them. Activities, land rehabilitation, wildfire suppression and other management activities can be accomplished with little conservation awareness effort because installation personnel, recreationists and the general public naturally support these easily understood efforts. However, issues such as protection of sensitive areas for little known plant and wildlife species, prescribed burning, permit fees and their uses, etc., require effective conservation communication to get positive support and, perhaps more importantly, to avoid adverse reactions from various users. A conservation awareness program must be directed to both installation and external interests to maximize effectiveness.

8.0 Training Area Management

The Training Area Management Goals and Objectives for the Hollis Training site and the actions needed to achieve these goals and objectives are summarized in Appendix A, Table 5.

9.0 Implementation

The success of this INRMP depends upon MEARNGs' capability to implement it at Hollis. Table 5, in Appendix A, presents the actions proposed to support this INRMP. Although this INRMP was prepared with a goal of 100% implementation, all activities, construction, design aspects, and other components of this INRMP are subject to the availability of annual funding, availability of manpower, environmental factors, the realization that some efforts will be ongoing and subject to mission requirements. MEARNG will make best efforts to request and procure funding through appropriate channels. Where projects identified in the plan are not implemented due to lack of funding, availability of manpower, mission requirements or other

compelling circumstances, MEARNG will review the plan's goals and objectives annually to determine whether adjustments are necessary. Below are described the organization, personnel, and funding needed to implement INRMP programs.

9.1 Work Plans

The military must maintain the capability, through a total force effort, to put overwhelming combat power on the battlefield to defeat any potential enemies. Decisive victory depends on the ability to deploy rapidly, to fight, to self-sustain and to win quickly with minimum casualties. Force readiness depends on high-quality realistic training. Such training, in turn, relies on the availability of training land on Army installations. The MEARNG will utilize the ITAM Program to integrate the military mission with the sustainable ecological management at Hollis. According to Army Regulation 350-4, Integrated Training Area Management, "The U.S. Army recognizes that executing training to doctrinal standards to maintain the readiness of its units will impact the environment". The intent of ITAM is to support sound natural resources management practices to provide stewardship of land assets while sustaining those assets to support training and other installation missions.

ITAM establishes a systematic framework for decision-making regarding use of military training lands at or controlled by military installations. It integrates elements of operational, environmental, master planning and other programs to identify and assess land use alternatives. The ITAM Program is built around four components. Range and Training Land Assessment (RTLA) is a management procedure that provides for collecting, inventorying, monitoring, managing and analyzing tabular and spatial data concerning land conditions on an installation. Training Requirements Integration (TRI) is a decision support procedure that integrates training requirements with land management, training management and natural and cultural resources management processes and data derived from RTLA and Army Conservation Program components. Land Rehabilitation and Maintenance (LRAM) is a preventive and corrective land rehabilitation and maintenance procedure that reduces the long-term impacts of training and testing on an installation. Environmental awareness is a means to develop and distribute educational materials to land users. Materials relate procedures for sound environmental stewardship of natural and cultural resources and reduce the potential for inflicting avoidable impacts.

ITAM projects that would support this INRMP are presented in Appendix A, Table 5. Projects will be completed based on availability of funds.

The DFE-ENV Section at MEARNG can implement most of this INRMP, fulfill general goals and policies established in Chapter 1 and more specific goals and objectives within Table 5. Other MEARNG organizations identified in Section 2.2 are also capable of implementing their portions

of this INRMP with no organizational changes, although they may elect to make changes during the next INRMP update for improved operations efficiency.

9.2 Natural Resources Management Staffing

Professionally trained natural resources management personnel are required to implement this INRMP. This will likely require the following personnel within the Environmental Division and ITAM program; Environmental Branch Chief, Natural Resource Manager, Seasonal Field Crews, GIS Operator, Environmental Specialists, ITAM Coordinator as well as outside contractors (part-time).

9.3 Annual Coordination Requirements

Although not required by the Sikes Act, an annual review will be initiated by the MEARNG and conducted by the USFWS at the Field Office level. Based on the findings of the INRMP annual review, there may be no changes, there may be minor editorial changes or significant resource management changes required. Minor editorial changes requiring an update will not require concurrence from USFWS, MDIFW and MNAP, but a revision requiring significant resource management changes will require the concurrence. The annual review will consist of a scheduled correspondence with at least representatives from the USFWS, MDIFW and MNAP. The outcome of the review meeting should be documented in a memo to all parties involved in the development of the INRMP for the site.

9.4 Monitoring INRMP Implementation

The natural resource management goals and objectives identified in Appendix A, Table 5, will be used to monitor the effectiveness of natural resources management at Hollis. INRMP implementation will be evaluated by the NRM's periodic evaluation of the progress of management activities associated with the objectives and projects, management review, and periodic assessment to ensure those activities are in support of military training and natural resource management.

10.0 Summary of Hollis Training Site

- Location: Hollis, York County
- Terrain and elevation: Ranges from flat lying to gently rolling with elevations from 260 to 300 feet (approximately 85 to 91.5m).
- Acreage: 412 ac (167 hectares).
- Soil: Include upland Adams loamy sand soils with varying slopes from 0 to 40% and Vassalboro peat that is frequently flooded.

- Habitats: Eight upland habitats: pitch pine–scrub oak–gray birch (33.1%), scrub oak–gray birch (32%), sand (9.2%), pitch pine–white pine–scrub oak–gray birch (5.4%), gray birch (2.4%), mixed conifer-hardwood (1.3%), heath (1.3%), graminoid (1.2%), and wetlands associated with the kettlehole bog and pond ecosystem (5.8%), three-way sedge–goldenrod outwash plain pondshore community (3.3%) and unpatterned fens (5.0%).

- Access: Hard Scrabble Road via Maine State Road Route 117. Roads are unimproved/sand-based. Hiking and ATV trails exist through the site.

- Military facilities: Concrete tent pads, sand road.

- Land use: Activities include light dismounted activities such as small unit operations, bivouac, land navigation, engineer equipment training and some tactical driving on existing road network. Recreational uses include fishing, hiking, cross-country skiing and bird watching.

- Hunting or fishing: The site is designated as a state wildlife refuge, thus hunting is not permitted within the site. Two ponds exist on site and fishing is allowed in these areas with appropriate state fishing licenses. Hunting and fishing are permitted on the adjacent MDIFW wildlife management areas, which surround much of the Hollis site.

- Confirmed Federal or State-listed Species or Habitats: No Federally-listed species. Three state-listed plant species (the narrow-leaved goldenrod, the fall fimbry and northern blazing star), two state-listed invertebrates(Edwards hairstreak and Sleepy duskywing) and two state-listed mammals (Eastern small-footed bat and Little brown bat). The blazing star has not been documented on the site since 1996.

- Confirmed Sensitive Species or Habitats: One vertebrate of state special concern (ribbon snake), five invertebrates of state special concern (cobweb skipper, southern pine sphinx, Huckleberry sphinx, oblique zale and red-winged sallow), one amphibian of special concern (Northern leopard frog), twenty birds of special concern and three mammals of special concern (Eastern red bat, hoary bat and Silver-haired bat). All were found within the pitch pine–scrub oak habitat. Four significant habitats that include the pitch pine-oak barren community and the three-way sedge– goldenrod outwash plain pondshore communities (S1 communities), as well as the kettlehole bog and pond ecosystem and the unpatterned fen ecosystem (S4 community).

- Cultural Resources of Concern: Three sensitive archaeological sites have been identified on the site and are designated as sites ME-7.40, ME-7.60 and ME-7.61 by the Maine Historic Preservation Office.

- Other Special Concerns: There is potential for other state-listed species and species of concern on site (i.e., New England cottontail, box turtle, black racer, as well as two moth

species that are dependent upon the pitch pine-scrub oak habitat type). If the pitch pine-scrub oak barren ecosystem is maintained for the long-term as a fire-dependent habitat through prescribed burns, it is likely that fire-dependent species (many of which are rare) would re-colonize the site.

- Fire History and Management: Active fire management has been implemented at Hollis from 1995 to present. A total of 65 prescribed fires have been conducted through 2020 and approximately 878 ac have been burned. Prescribed burns support military mission and promote critical habitat at the site.

- Natural Resource Management Strategies: Adherences to Resource Protection Zones and conduct monitoring, maintenance, and surveys as recommended in Appendix A, Table 5, as funding becomes available.

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12.0 List of Acronyms

Aa – Adams soil series

Ac – Acre(s)

ATV – All Terrain Vehicles

BMPs – Best Management Practices

C – Celsius

CA – Cantonment Area

CERCLA – Comprehensive Environmental response, Compensation and Liability Act

DFE – Directorate of Facilities Engineering

DFE-ENV –Directorate of Facilities Engineering-Environmental Programs

DOD – Department of Defense

EA – Environmental Assessment

EIS – Environmental Impact Statement

EPA – Environmental Protection Agency

ESA – Endangered Species Act

F – Fahrenheit

FMO – Facilities Management Officer

FMZ – Fire Management Zone

FNSI – Finding of No Significant Impact

Ft – Foot or feet

GIS – Geographic Information System

HQDA – Headquarters Department of the Army

ICRMP – Integrated Cultural Resources Management Plan

INRMP – Integrated Natural Resources Management Plan

IPM – Integrated Pest Management

ITAM – - Integrated Training Area Management

LRAM – Land Rehabilitation and Maintenance

MACOM – Major Army Command

MDEP – Maine Department of Environmental Protection

MDIFW – Maine Department of Inland Fisheries and Wildlife

MEARNG – Maine Army National Guard

MGS – Maine Geological Survey

MHPC – Maine Historic Preservation Commission

MNAP – Maine Natural Areas Program

MPH – Miles Per Hour

MSL – Mean Sea Level

NEHSTC – New England Hydric Soils Technical Committee

NEPA – National Environmental Policy Act

NGB – National Guard Bureau

NRCS – Natural Resources Conservation Service

NRPA – Natural Resources Protection Act

OCONUS – Continental United States

PLS - Planning Level Surveys

PO – Plans Operations

PMP – Pest Management Plan

RTE – Rare, Threatened, and Endangered

RTLA – Range and Training Land Assessment

SEC – Sedimentation and Erosion Control

SMZ – Significant Natural Resource Management Zone

SWH – Significant Wildlife Habitat

TNC – The Nature Conservancy

TO – Training Officer

TRI – Training Requirements Integration

TZ – Training Zones

UMO – University of Maine, Orono

USACE – U.S. Army Corps of Engineers

USDA – U.S. Department of Agriculture

USFWS – U.S. Fish and Wildlife Service

USGS – U.S. Geological Survey

Va – Vassalboro peat series

VMZ – Valuable Natural Resource Management Zone

% – Percent

Appendix A

Tables

Table 1. Natural Community Types on the Hollis Training Site

Community Type	Forest Stand Classification[1]	Number of Areas	Acres
Fen	N/A	1	6.7
Dwarf Shrub Bog	N/A	1	13.8
Gramminoid	N/A	8	4.7
Grey Birch	H1A	3	9.9
Heath	N/A	11	5.5
Kettlehole Bog and Pond Community	N/A	2	23.8
Mixed Conifer-Hardwood	M2A	2	5.6
Three-way Sedge–Goldenrod Outwash Plain Pondshore	N/A	1	13.8
Pitch Pine-Scrub Oak-Grey Birch	M3C	33	136.3
Pitch Pine-White Pine-Scrub Oak-Gray Birch	M2B	4	22.6
Sand	N/A	2	37.9
Scrub Oak-Gray Birch	H2C	21	131.8
Total		89	412.4

[1] First character in the alphanumeric system corresponds to the forest type (S = softwood, M = mixed wood, and H = hardwood). Second character corresponds to the height class (either 1 = 0 to 35 ft, 2 =36 - 64 ft, and over 64 ft). Third character corresponds to the crown density (A= 71% +, B= 41-70 %, C = 11- 40 %). Source: Galwer and Jessee 1997, MEARNG 2004, MEARNG 2005, Vitale 2012.

Table 2. Summary of Soil Types on the Hollis Training Site

Location	Map Unit	Soil Series with Description	Drainage Class	Acres
Hollis Training Site	AdB AdC AdD	Adams loamy sand 0 – 8% Adams loamy sand 8 – 15% Adams loamy sand 15 – 40%	Excessively drained Excessively drained Excessively drained	274 52 38
	VA	Vassalboro peat	Poorly drained	31
	W	Waterbodies		16
			Total	**411**

Source: NRCS 2016

Table 3. Description of Wetland Community Types at the Hollis Training Site

Wetland Type	Description	Acres
Spruce-Larch Wooded Bog	This forested peatland community occurs to the west of the kettlehole bog in the southern portion of the Hollis Training Site and covers approximately 4 acres. This is a relatively common type statewide, and is ranked S4, or apparently secure, by MNAP. In the Spruce – Larch Wooded Bog, there are many large dead trees that may be the result of an increase in water level. Most of the core of the community appears to be relatively intact. A total of 36 plant species have been documented in this community type. The canopy is dominated by tamarack and black spruce. White pine is also present, particularly along upland edges and in transition zones. Red maple is more significant part of the canopy to the west and approaches co-dominance in some areas. Heath shrubs are strongly dominant in the understory. Common species include rhodora, sheep laurel, huckleberry and velvet-leaved blueberry. Common herbs include three-seeded sedge, white beak-rush, tawny cottongrass, crested woodfern, two-seeded sedge and dewdrop, all growing on a lush and continuous carpet of Sphagnum mosses. Two new species (bog laurel and star sedge) were observed in this community in 2017.	4
Pitch Pine Bog	The Pitch Pine Bog community covers approximately 15 acres within the facility boundary but extends offsite as a part of a larger 37 acre feature also described in Leatherleaf Boggy Fen). This community is located along the western boundary of the training site near the north extent of the property. MNAP ranks this community type as an S2 or imperiled due to rarity. Pitch pine is the dominant tree species within this community type though quite sparse. Shrub presence includes leatherleaf, bog rosemary, black chokeberry, rhodora, sheep laurel and dwarf huckleberry. Large and small cranberry are typical dwarf shrub species occurring within the community. Herbs include tawny cottongrass, three-way sedge, swollen-beaked sedge, white beak rush, pod-grass, round-leaved sundew, pitcher plant and spatulate-leaved sundew.	[15]
Leatherleaf Boggy Fen	This peatland community is ranked S4, or apparently secure, by MNAP. It collectively covers 29 acres on the Site and occurs in four locations: along the northwestern boundary, to the south of the pond, around the shoreline of the kettlehole bog, and along the southwestern boundary. These occurrences vary somewhat in terms of hydrology and species composition, but overall display high levels of ecological integrity. The first occurrence along the northwestern boundary is in a shallow, poorly drained basin, and is the driest of the four also described as Pitch Pine Bog). The second occurrence is a lakeshore fen and occupies the large drainage basin to the south of the pond. It has experienced some floristic changes since 2012, including an expansion of narrow-leaved goldenrod into the fen along drainage channels. The third occurrence is another shoreline fen around the perimeter of the kettlehole bog. The fourth occurrence is in a poorly drained basin along the southwestern boundary of the property. Overall, this community type has changed little in distribution or spatial extent since 2012. This is a shrubby peatland type, with occasional trees and dense coverage of heath shrubs. Trees are either absent or extremely sparse, with pitch pine, tamarack, and black spruce occurring at very low density. Shrub species include leatherleaf, bog rosemary, black chokeberry, rhodora, sheep laurel and dwarf huckleberry. The southern occurrences also include some sweetgale. Dwarf shrubs are present in many areas, with both large cranberry and small cranberry the typical species. Herbs include tawny cottongrass, three-way sedge, swollen-beaked sedge, white beak rush, podgrass, round-leaved sundew, pitcher plant and spatulate-leaved sundew. Sphagnum coverage is typically dense throughout the entire site. A dense thicket of maleberry surrounds most of these wetlands.	29

Table 3. Description of Wetland Community Types at the Hollis Training Facility (cont)

Sweetgale Mixed Shrub Fen	This common open wetland type is ranked S4, or apparently secure, by MNAP. A total of 45 plant species were documented in this community type. This wetland is dominated by shrubs and tall graminoids, with most vegetation around a meter in height. Common shrubs include sweet gale, meadowsweet, leatherleaf, steeplebush and rhodora. The herb layer in this wetland is extremely diverse. In the eastern portion of the wetland, common herbs include rattlesnake mannagrass, reed mannagrass, common woolgrass, sharp-fruited rush, grass-leaved goldenrod, rice cutgrass, swamp candles and short-tailed rush. Other species include boneset, white beak-rush, marsh fern, hairy-rosette panic grass, spatulate-leaved sundew, autumn bentgrass and northern water-horehound.	3
Three-way Sedge – Goldenrod Outwash Plain Pondshore	Outwash plain pondshore community on the facility is globally rare, and listed as a critically imperiled habitat in Maine. Open water areas are dominated by yellow and white pond lilies, and, spadderdock and pipewort. Three-way sedge, meadow beauty, golden hedge hyssop, umbrella sedge, panic grass, bluejoint grass, and a wide diversity of other less common herbaceous plants and sedges dominate the transition area, which extends from open water to the shrub shoreline. Two state-listed species, dwarf bulrush and narrow-leaved goldenrod, occur here. The wetland shrub shoreline is dominated by buttonbush, meadowsweet, and maleberry.	6
Water Lily - Macrophyte Aquatic Bed	This is very common statewide and is ranked S5, or demonstrably secure, by MNAP. Vegetation is restricted to aquatic herbs, and typically includes both floating and emergent species. Dominant species include white pond lily, floating pondweed, water shield, common pipewort as well as a wide variety of algae. Tall emergents such as broad-leaved cattail and common wool-sedge are occasionally present in shallow water or mud along the periphery.	10
	Total	**52**

Source: MNAP, NewEarth 2017

Table 4. Description of Upland Communities on the Hollis Training Site

Community Type	Forest Stand Type	Description	Acres
Graminoid		Found in previously disturbed areas, along road and trail edges, and in frost pockets. The community is low growing and dominated by Pennsylvania sedge, poverty grass, lowbush blueberry, woodland sedge, hairgrass, ricegrass and moss.	4.7
Grey Birch	H1A	Three small stands were identified, two are adjacent to the wetland complex located near the center of the facility and another is located within the former airstrip. 70% cover of grey birch and, aside from a few scattered white pine and pitch pines, there is a lack of overstory trees.	9.9
Heath		Found in openings, most often within tree/shrub communities. Dominated by lowbush blueberry (80%), sweetfern, bracken fern, woodland sedge, black chokeberry, sheep laurel and meadowsweet.	5.5
Mixed Conifer-Hardwood	M2A	Found only along the northern shoreline of one wetland complex on the facility. Dominated by white oak and red oak. Black oak, white pine and red maple also exist but in smaller numbers.	5.6
Pitch Pine-Scrub Oak-Gray Birch	M3C	The most common community type dominated by pitch pine. Other common species include grey birch and white pine.	136.3
Pitch Pine-White Pine-Scrub Oak-Grey Birch	M2B	Characterized by a moderately dense (50% cover) tree layer that is dominated by white pine and pitch pine. Distribution of pine is variable within stands and occurs in relatively dense clusters as well as widely spaced individual trees.	22.6
Sand		Found throughout the facility in cleared areas and trails. Dominant species include little bluestem, crabgrass, pineweed and grasses and sedges.	37.9
Scrub Oak-Grey Birch	H2C	The second most common community type on the facility; tree layer of scattered scrub oak and a dense understory that is dominated by > 60% scrub oak characterizes the community. Grey birch, pitch pine and white pine are also found in the tree layer but are relatively uncommon.	131.8
		Total	354.4

Source: Gawler and Jessee 1997, MEARNG 2004, MEARNG 2005, Vitale 2012, NewEarth 2017.

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
INTEGRATED TRAINING AREA MANAGEMENT (ITAM)	Ensure sustained use of lands for military training and align land management priorities with training and readiness priorities	1	Document and monitor training impacts on natural resources.	1	Define training area uses and frequency and intensity of use.	Information has been collected and combined in Integrated Training Area (ITAM) Map. New information is added as need is identified.	Ongoing (2021-2026)	ITAM, GIS
				2	Document existing natural resources, current impacts and identify areas of heavy use.	Information has been collected. New information is added as required.	Ongoing (2021-2026)	ITAM, NRM
				3	Incorporate pertinent data in the MEARNG GIS using GPS and digital aerial photography.	Information has been collected. New information is added as required.	Ongoing (2021-2026)	GIS
		2	Maintain Training Requirements Integration (TRI) program to ensure integration of training requirements and training land management.	1	Identify existing and projected training land resources and prioritized land use requirements.	Information has been collected and combined in ITAM Map.	Ongoing (2021-2026)	ITAM
				2	Integrate training requirements with training land management into prioritized work plan, and execute requirements subject to availability of resources.	Project planning process has served to prioritize and fund projects.	Ongoing (2021-2026)	ITAM
				3	Coordinate mission requirements and land maintenance activity with training land carrying capacity.	Cooperative partnering between MEARNG groups - environmental, facilities, installation trainers is having positive impact on decision quality.	Ongoing (2021-2026)	ITAM
				4	Generate prioritized requirements for land rehabilitation, repair, and/or reconfiguration.	Project planning process has served to prioritize and fund projects.	Ongoing (2021-2026)	ITAM
				5	Conduct fire management (IAW Fire Management Plan) and manual removal of understory vegetation as necessary and in significant natural resource management zones (SMZ's) to improve line of sight and maneuverability for training purposes.	Ongoing and conducted annually in accordance with the Integrated Wildland Fire Management Plan and as funding permits.	Annually (2021-2026)	ITAM, NRM
		3	Maintain LRAM program to reduce long-term training impacts by using preventive and corrective land rehabilitation and maintenance procedures.	1	Identify and prioritize potential LRAM sites based on information acquired through ITAM Objectives 1 and 2.	Ongoing implementation. Restoration projects performed as needed based on inspection and training records. LRAM are prioritized through ITAM process and through on-site coordinators (TRI process).	Ongoing (2021-2026)	ITAM
				2	Apply best management practices (BMPs) for design and execution of LRAM to ensure that the rehabilitation, repair and maintenance results are commensurate with the applied resources.	Implemented and ongoing.	Ongoing (2021-2026)	ITAM
				3	Identify significant natural resource management zones (SMZ's) and ensure activity restrictions are adhered to.	Implemented and ongoing.	Ongoing (2021-2026)	NRM, ITAM
				4	Remove abandoned and unused infrastructure as warranted.	Abandoned buildings and the range have been removed, wells have been capped. Filled old latrine site in 2006. Efforts ongoing as need is identified.	Ongoing (2021-2026)	ITAM
				5	Coordinate long-term land maintenance plans with other real property management programs on the installation.	Project planning process has served to prioritize and fund projects.	Ongoing (2021-2026)	ITAM, PLN
		4	Maintain the ITAM-EA program to educate users to ensure concurrent protection for both users and the training environment.	1	Inform MEARNG personnel that INRMP is approved and provide document access.	Notification dependent upon plan approval.	2021	NRM
				2	Create and distribute training maps illustrating environmentally sensitive and off-limits areas (SMZ's).	Information has been collected and combined in ITAM Map.	Ongoing (2021-2026)	GIS, ITAM
				3	Provide information on potential environmental dangers, such as Lyme disease and poisonous plants or animals that may occur at the installation and review prior to training activities.	Implemented and ongoing.	Ongoing (2021-2026)	NRM, ITAM

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
INTEGRATED TRAINING AREA MANAGEMENT (continued)	Ensure sustained use of lands for military training and align land management priorities with training and readiness priorities (continued)	5	Provide quality natural resources as a critical training asset upon which to accomplish the military mission of Hollis. Improve the training conditions through natural resources management.	1	Document habitat conditions.	Conditions are documented in the Conservation Management Plan and INRMP, are updated periodically as needed. Habitat surveys were completed in 2012 and will be re-visited in 2017.	Ongoing (2021-2026)	NRM
				2	Document training needs and habitat conditions that may impede training efforts.	Implemented and updated periodically as needed.	Ongoing (2021-2026)	NRM, ITAM
				3	Identify opportunities for combined habitat management activities that also improve training conditions.	Implemented and updated periodically as needed. Current strategies include fire management activities to promote pitch pine-scrub oak barren communities and species and improve line of sight and troop maneuverability during training.	Ongoing (2021-2026)	NRM, ITAM
		6	Comply with local, state, federal and Army policies, laws and regulations and manage natural resources within the spirit and letter of environmental laws.	1	Review of relevant Army documents.	Implemented and ongoing.	Ongoing (2021-2026)	ITAM, NRM
				2	Review of relevant local and state documents.	Implemented and ongoing.	Ongoing (2021-2026)	ITAM, NRM
				3	Review of relevant federal documents.	Implemented and ongoing.	Ongoing (2021-2026)	ITAM, NRM

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
NATURAL RESOURCE MANAGEMENT (Terrestrial Communities)	Manage and maintain diverse natural terrestrial habitats to promote native flora and fauna, ensure long-term training uses of these habitats and provide recreational opportunities.	1	Maintain and protect upland forest habitats to maintain the natural diversity of the upland forest and to ensure the long-term training use of this habitat.	1	Identify SMZ's and ensure activity restrictions are adhered to.	Implemented and updated periodically as needed. Monitoring conducted as part of annual erosion surveys.	Annually (2021-2026)	NRM, ITAM
				2	Conduct bivouacking operation in approved sites. Minimize off-road vehicle use to avoid damaging trees and understory species and to avoid soil compaction. Use portable toilets, remove garbage and debris, and avoid spills of gasoline, diesel fuel, and other vehicle-related lubricants.	Successfully implemented with training, SOP's and REC's.	Ongoing (2021-2026)	ITAM
				3	Minimize vegetative disturbance in upland forests except in areas targeted for fire management.	Successfully implemented with training and SOPs.	Ongoing (2021-2026)	NRM, ITAM
				4a	Minimize use of heavy equipment and vehicles during wet weather, confine vehicle use to designated roads and trails to the extent possible, and park vehicles and equipment in old fields and existing openings when practicable to protect trees.	Implemented on a case-by-case basis through RECs.	Ongoing (2021-2026)	ITAM, NRM
				4b	Continue to prohibit or restrict public access to designated existing roads and restrict off-road vehicle usage in upland forest, wetlands and streams.	Continuing restrictions.	Ongoing (2021-2026)	ITAM, NRM
				5	Suppress fires in upland forests from training activities, and take reasonable precautions when using pyrotechnics and other training devices to prevent forest fires. Use live ammunition and other explosive and pyrotechnic devices in designated areas. Hollis staff will contact the USFS to determine if weather conditions and the dangers of forest fires will limit or restrict training activities.	Successfully implemented through training and SOPs. Maintain diligence.	Ongoing (2021-2026)	NRM, ITAM
				6	Concentrate any new developments around the existing road infrastructure and other suitable areas to avoid further habitat fragmentation and forest loss.	Continuing Implementation.	Ongoing (2021-2026)	NRM, ENG, PLN
		2	Monitor upland habitats and mitigate for adverse affects to these habitats that threaten natural diversity and the long-term training use of these habitats.	1	Implement terrestrial habitat restoration measures as necessary. These measures include seeding, reseeding and mulching areas disturbed by training; installation of silt fences before training (if possible) and after training; reshaping eroded gullies giving the drainage way a broad flat or slightly concave bottom.	Implementation as needed. No specific areas have been identified at this time.	Ongoing (2021-2026)	NRM
				2	Maintain existing unimproved sand roadways, road shoulders and road ditches to minimize indirect affects to adjacent terrestrial communities. Provide v-shaped side ditches along roads. Routinely inspect roadways, road ditches, intermittent drainage ways and permanent stream banks to document signs of erosion.	Surveys of road conditions will be completed as part of annual erosion surveys. Improvement activities will be conducted as needed.	Annually (2021-2026)	ITAM
				3	Conduct brush removal as needed along existing roadways in the fall to control woody succession along the road shoulders and create small amount of herbaceous habitat, to add habitat diversity.	Continuing annual implementation	Annually (2021-2026)	ITAM
				4	Conduct surveys to document existing natural communities and evaluate potential impacts to communities.	Vegetation/terrestrial habitat surveys completed in 2017. Additional surveys to update vegetation descriptions and GIS database are proposed for the 2021-2026 period.	Ongoing (2021-2026)	NRM
		3	Provide recreational use of upland habitats.	1	Continue to allow access to the facility for authorized uses such as hiking, birding, fishing, etc.	Continuing Implementation.	Ongoing (2021-2026)	ITAM, NRM
				2	Work with local law enforcement to educate the public on acceptable and responsible uses of the facility.	Continuing Implementation.	Ongoing (2021-2026)	ITAM, PLN

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
NATURAL RESOURCE MANAGEMENT(Fish and Wildlife)	Manage and maintain year-round fish and wildlife habitat to ensure the long term sustainability of populations of resident species and provide seasonal habitats for migratory species, ensure the long term training uses of habitat, provide recreational uses of fish and wildlife to the public.	1	Maintain, protect, and enhance fish and wildlife habitat to promote regional biodiversity, provide a sustained yield for fish and game species, and ensure the long-term training use of these habitats.	1	Identify SMZ's and ensure activity restrictions are adhered to.	SMZ's have been identified. Continuing implementation to enforce, assess during training activities and during annual site erosion surveys.	Annually (2021-2026)	NRM, ITAM
				2	Utilize fire management practices (in accordance with the Fire Management Plan) to maintain and enhance fire-dependant pitch pine/scrub-oak forests and to promote fire dependent plant and animal species.	Continuing implementation in accordance with 2018 Fire Management Plan. Prescribed burns proposed 2021 through 2026.	Annually (2021-2026)	NRM
		2	Monitor wildlife populations and mitigate for adverse affects to fish and wildlife species and their associated habitats and that threaten the long term training use of these areas.	1	Conduct baseline surveys as needed to document fish and wildlife communities.	Baseline surveys have been conducted for some species as described in the Hollis INRMP. No new surveys for non-listed species are proposed for the 2021-2026 period.	Ongoing (2021-2026)	NRM
				2	Conduct monitoring as needed to evaluate potential affects to existing fish and wildlife communities.	Species specific surveys are proposed for 2021 - 2026. General observations for potential impacts are conducted during annual erosion surveys.	Annually (2021-2026)	NRM
		3	Provide for the consumptive and non-consumptive uses of fish and wildlife in accordance with federal and state laws and regulations.	1	Continue to allow fishing within facility for persons with appropriate state licenses.	Continuing implementation	Ongoing (2021-2026)	ITAM
				2	Use signage to deter hunting on the facility in accordance with restrictions associated with designation of a State Game Preserve.	Signs have been posted. Ongoing implementation as needed.	Ongoing (2021-2026)	ITAM
				3	Continue to allow access to the facility for authorized uses such as hiking, birding, wildlife viewing, etc.	Continuing implementation	Ongoing (2021-2026)	ITAM, NRM
NATURAL RESOURCE MANAGEMENT (Threatened and Endangered Species and Habitats)	Maintain and enhance existing habitats to support known populations of rare, threatened, and endangered species in compliance with the Endangered Species Act (ESA) and applicable state laws and regulations.	1	Maintain and protect rare species habitat to promote regional biodiversity, protect and monitor listed species, and ensure long-term training use.	1	Identify SMZ's and ensure activity restrictions are adhered to.	SMZ's have been identified. Continuing implementation to enforce, assess during training activities and during annual site erosion surveys.	Annually (2021-2026)	NRM, ITAM
				2	Continue fire management practices to promote rare pitch pine/scrub oak forests and fire dependent species.	Continuing implementation in accordance with 2018 Fire Management Plan. Prescribed burns proposed 2021 through 2026.	Annually (2021-2026)	NRM
				3	Actively protect significant habitats and features by restricting access to these designated areas.	Concrete barriers have been placed at key access points to restrict access to critical habitats. Ongoing Implementation as needed.	Ongoing (2021-2026)	ITAM, NRM
		2	Monitor rare species and critical habitats to insure compliance with state and federal laws and regulations.	1	Conduct baseline surveys as needed to document rare species and habitats.	Baseline surveys have been conducted for species and habitats as described in the Hollis INRMP. Surveys for rare bat and reptiles are proposed for the 2021 through 2026 period. Future surveys for rare turtles, pollinators and pitch pine oak dependent moth species will be considered as funding becomes available.	Ongoing (2021-2026)	NRM
				2	Conduct monitoring as needed to evaluate potential affects to rare species and habitats.	Species specific surveys are proposed for 2021 - 2026 period. General observations for potential impacts are conducted during annual erosion surveys. Continuing implementation to educate users of the facility of SMZ's and to enforce SMZ restrictions.	Annually (2021-2026)	NRM
				3	Maintain ongoing coordination with the USFWS, MDIFW and MNAP. Use GIS to monitor and assess species populations and their habitats.	Ongoing implementation. GIS and database updates are conducted as new information becomes available.	Ongoing (2021-2026)	NRM, GIS

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
NATURAL RESOURCE MANAGEMENT (Surface Water, Water bodies and Wetlands)	Manage and maintain diverse natural aquatic communities to protect associated watersheds and to promote native flora and fauna, and provide recreational opportunities in compliance with laws and regulations.	1	Maintain and protect wetlands and surface waters to promote regional biodiversity, protect water quality and aquatic species, and ensure long-term training use.	1	Identify SMZ's and ensure activity restrictions are adhered to.	SMZ's have been identified. Continuing implementation to enforce and modify as necessary.	Ongoing (2021-2026)	NRM
				2	Continue to restrict or prohibit vehicle traffic in streams, water bodies and wetlands.	Ongoing implementation. Training activities reviewed on a case by case basis by MEARNG personnel.	Ongoing (2021-2026)	ITAM, NRM
				3	Actively protect wetlands and water bodies by restricting access and restricting mowing/brush-hogging within 30 feet of the shoreline.	Barriers have been placed to restrict access to wetlands and water bodies on the facility. Ongoing implementation as needed.	Ongoing (2021-2026)	ITAM
		2	Monitor wetland and aquatic habitats and mitigate for adverse affects to these habitats that threaten natural diversity and the long term training use of the facility.	1	Conduct surveys to document existing wetland and aquatic communities.	Wetland and aquatic habitat surveys were completed in 2003 and are presented in the Hollis INRMP. Vernal pool surveys were conducted in 2017. Communities will be assessed and descriptions may be revised if needed based on vegetation sampling efforts proposed for 2021-2026 period.	Ongoing (2021-2026)	NRM
				2	Conduct monitoring as needed to evaluate potential affects to wetland and aquatic habitats.	Species specific surveys are proposed for 2021-2026 period. General observations for potential impacts are conducted during annual erosion surveys. Continuing implementation to educate users of the facility of SMZ's and to enforce SMZ restrictions.	Annually (2021-2026)	NRM
		3	Continue to allow recreational use of surface waters (i.e., fishing) in compliance with state regulations to provide recreational opportunities for the public.	1	Continue to allow fishing and access to surface waters for approved recreational uses. Continue to restrict access for unauthorized uses of water bodies and wetlands.	Ongoing implementation.	Ongoing (2021-2026)	ITAM, NRM
NATURAL RESOURCE MANAGEMENT (Pests and Invasive Species Management)	Minimize pesticide use in controlling pest and invasive species. Suppress or prevent pests from exceeding acceptable populations or damage thresholds with judicious use of mechanical, physical, cultural, and chemical controls.	1	Maintain and protect native wildlife and vegetation communities to promote regional biodiversity, protect native species and ecosystems, and ensure long-term training use.	1	Prohibit use of invasive plants for landscaping or other purposes. Implement BMP's to minimize land disturbances that promote invasion and re-vegetate disturbed areas with native species. Keep avoidance as the preferred control measure.	Ongoing implementation.	Ongoing (2021-2026)	NRM, ENG, ITAM
				2	Monitor site once per 5 year period for presence of invasive species.	Invasive species control is an ongoing effort.	Ongoing (2021-2026)	NRM
		2	Monitor the site for invasive species and mitigate for adverse affects from these species that threaten natural diversity and the long term training use of the facility.	1	Use GIS to manage spatially referenced data related to the physical infrastructure and natural features of the installation. Use GIS as a tool for managing natural resources. Attach data to the mapped features and store in a database within the program.	Ongoing implementation, species mapped as they are found.	Ongoing (2021-2026)	NRM, GIS
				2	Conduct monitoring as needed to evaluate potential affects to wetland and aquatic habitats.	Invasive species monitoring is proposed for the 2021-2026 period.	Annually (2021-2026)	NRM
				3	Conduct targeted invasive species control/removal actions as needed and as funding and staffing allows.	Invasive Species control efforts are proposed for the 2021-2026 period.	Annually (2021-2026)	NRM
		3	Train MEARNG personnel to recognize and avoid disease vectors and poisonous plants while participating in training Activities.	1	Train personnel and troops to minimize tick exposure by wearing appropriate clothing, applying tick repellent, performing personal hygiene inspections daily and avoiding tick habitat. Coordinate tick-borne disease awareness training.	Ongoing implementation.	Ongoing (2021-2026)	NRM, ITAM

Table 5. Hollis Training Facility INRMP Implementation Plan 2021 - 2026

Management Plan	Goal		Objective		Recommended Management Action	Implementation		
						Task(s)	Date	Lead
CULTURAL RESOURCE MANAGEMENT	Maintain integrity of known locations of features of cultural significance in compliance with state laws and regulations.	1	Maintain and protect integrity of known locations of cultural resources and ensure the long term training use of the facility.	1	Identify SMZ's and ensure activity restrictions are adhered to.	SMZ's have been identified. Continuing implementation to enforce.	Ongoing (2021-2026)	NRM, CRM
		2	Monitor the site for cultural resources and mitigate for adverse affects to cultural resources that threaten the long term use of the facility for training purposes.	1	Conduct surveys to document existing locations of cultural resources of significance.	Surveys for cultural resources have been conducted as presented in the INRMP. No additional surveys are proposed.	Ongoing (2021-2026)	CRM
				2	Conduct monitoring as needed to evaluate potential affects to known locations of cultural resources of significance.	No monitoring is proposed for the 2021 - 2026 period. General observations for potential impacts are conducted during annual erosion surveys. Continuing implementation to educate users of the facility of SMZ's and to enforce SMZ restrictions.	Annually (2021-2026)	CRM
TRAINING SITE RESOURCE INFORMATION MANAGEMENT	Manage training site data to facilitate decision-making that integrates military training requirements with natural resources information.	1	Maintain natural resources information and GIS data to facilitate resource protection, protect resident and migratory species, identify rare ecosystems, and ensure the long-term use of the area for training purposes.	1	Use GIS to manage spatially referenced data related to the physical infrastructure and natural features of the installation. Use GIS as a tool for managing natural resources. Attach data to the mapped features and store in a database within the program.	Ongoing implementation. GIS database created and ITAM map produced in 2004. Revisions will likely be necessary following vegetation surveys and rare species surveys.	Ongoing (2021-2026)	GIS
				2	Train GIS Analyst and other Environmental Management Office staff members through NGB-sponsored classes, specialized training and in-house training.	Ongoing implementation.	Ongoing (2021-2026)	GIS
		2	Disseminate natural resources information to the Hollis community, military personnel, and to other interested parties to educate users about natural resources at Hollis.	1	Facilitate access to current resource information, including GIS maps to groups using Hollis for training or other activities that may potentially affect the resource found there.	Ongoing implementation. ITAM maps created in 2004. Site manager briefings cover these topics as well. Provide maps of area showing locations of SMZ's.	Ongoing (2021-2026)	GIS
				3	Provide complete and reliable sources of data for each natural resources topic discussed in this INRMP to facilitate sound management, training, planning, and construction.	Ongoing implementation. Databases are revised within 30-days of receipt of updates or new information from surveys.	Ongoing (2021-2026)	NRM, GIS
				4	Promote data sharing with partnering agencies, such as the USFS, and other MEARNG offices and installations.	Ongoing implementation.	Ongoing (2021-2026)	NRM
					Conduct resource awareness training for site personnel and training units. Brief advance parties on wetland locations; rare, threatened, and endangered species locations; cultural resources; restricted areas; pest management; information on dangerous or toxic plants and animals and other information that helps reduce the risk of negative impacts to resources on the site and dangers to personnel.	Ongoing implementation. ITAM maps created in 2006. Site manager briefings cover these topics as well. Provide maps of area showing locations of SMZ's.	Ongoing (2021-2026)	ITAM, NRM

Legend:

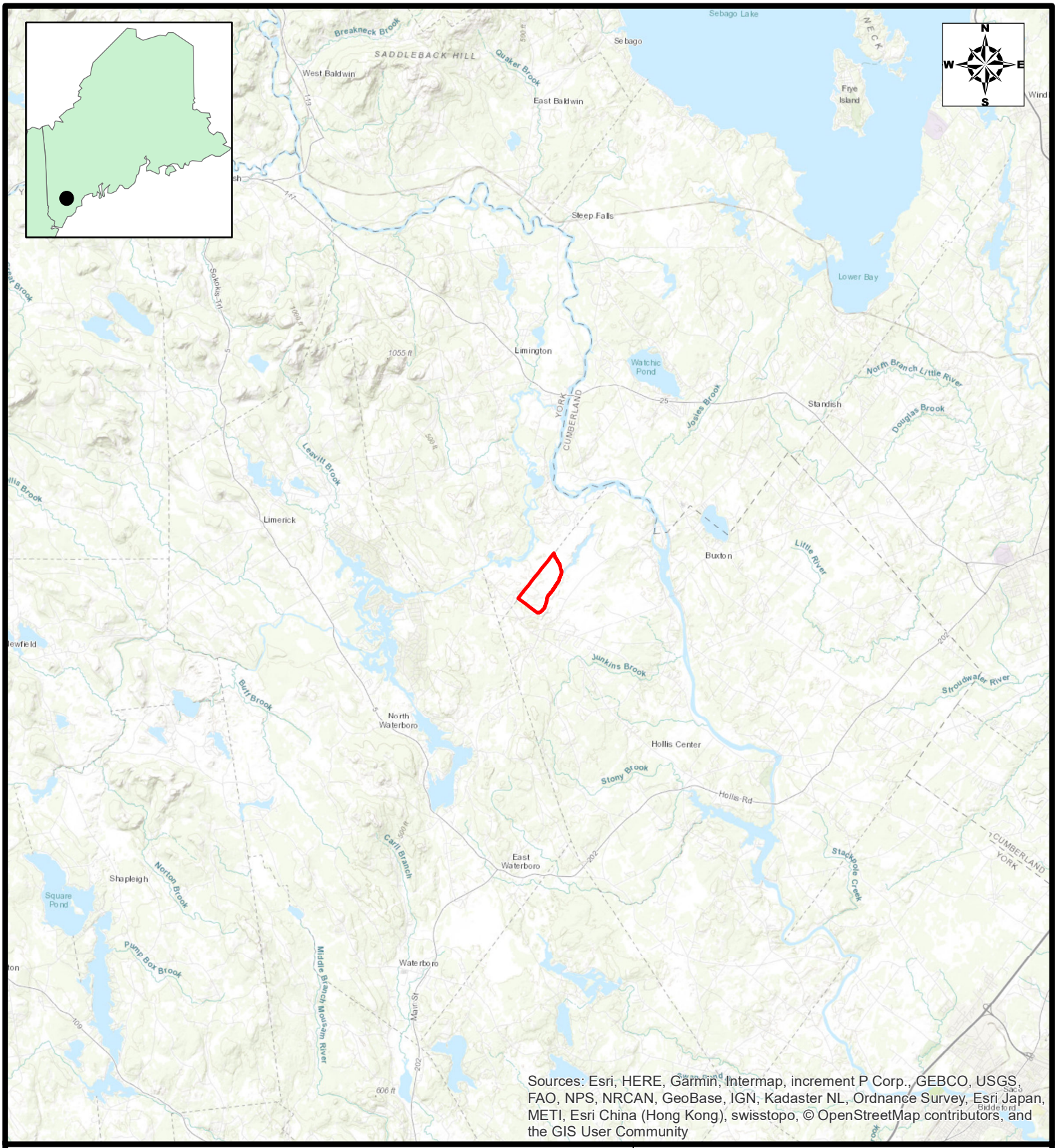
NRM = Natural Resource Manager
ITAM = Integrated Training Area Management Coordinator
ENG = Engineering office
PLN = Planning Office
CRM = Cultural Resource Manager
GIS = GIS Manager

Implementation status

- Fully Implemented
- Implemented but not complete or needs additional effort
- Not implemented

Appendix B

Figures



Property Boundary

Figure 1. Location of Hollis Training Site

Project Name:
Integrated Natural Resource Management Plan

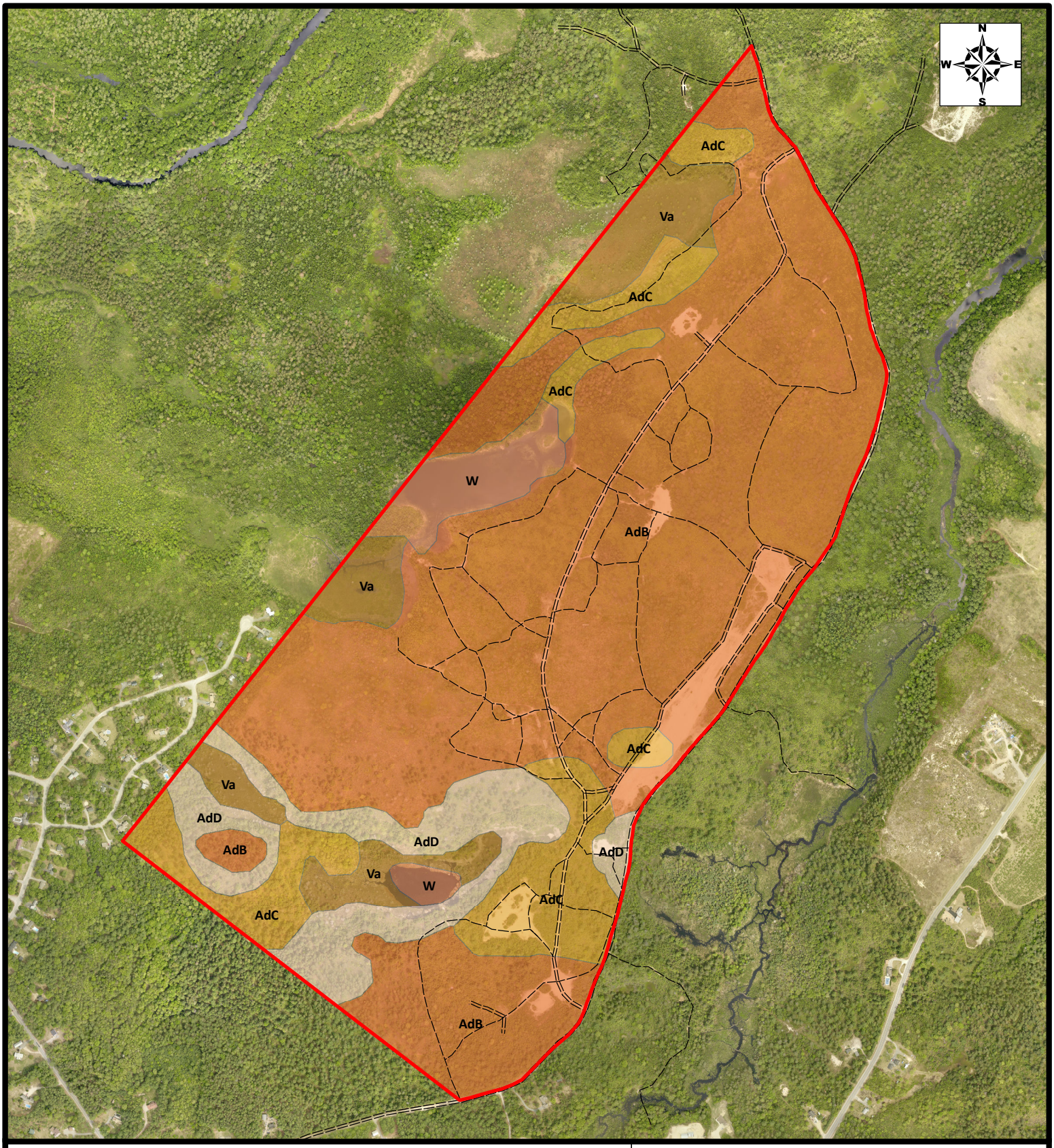
Project Location:
Hollis, Maine

0 0.75 1.5 3 4.5 6
Miles

Source: ESRI, MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 1.mxd

Date: 7 Oct 2020



Property Boundary
Road
Trail

0 70 140 280 420 560

Meters

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 2 2021.mxd

Date: 8 Oct 2020

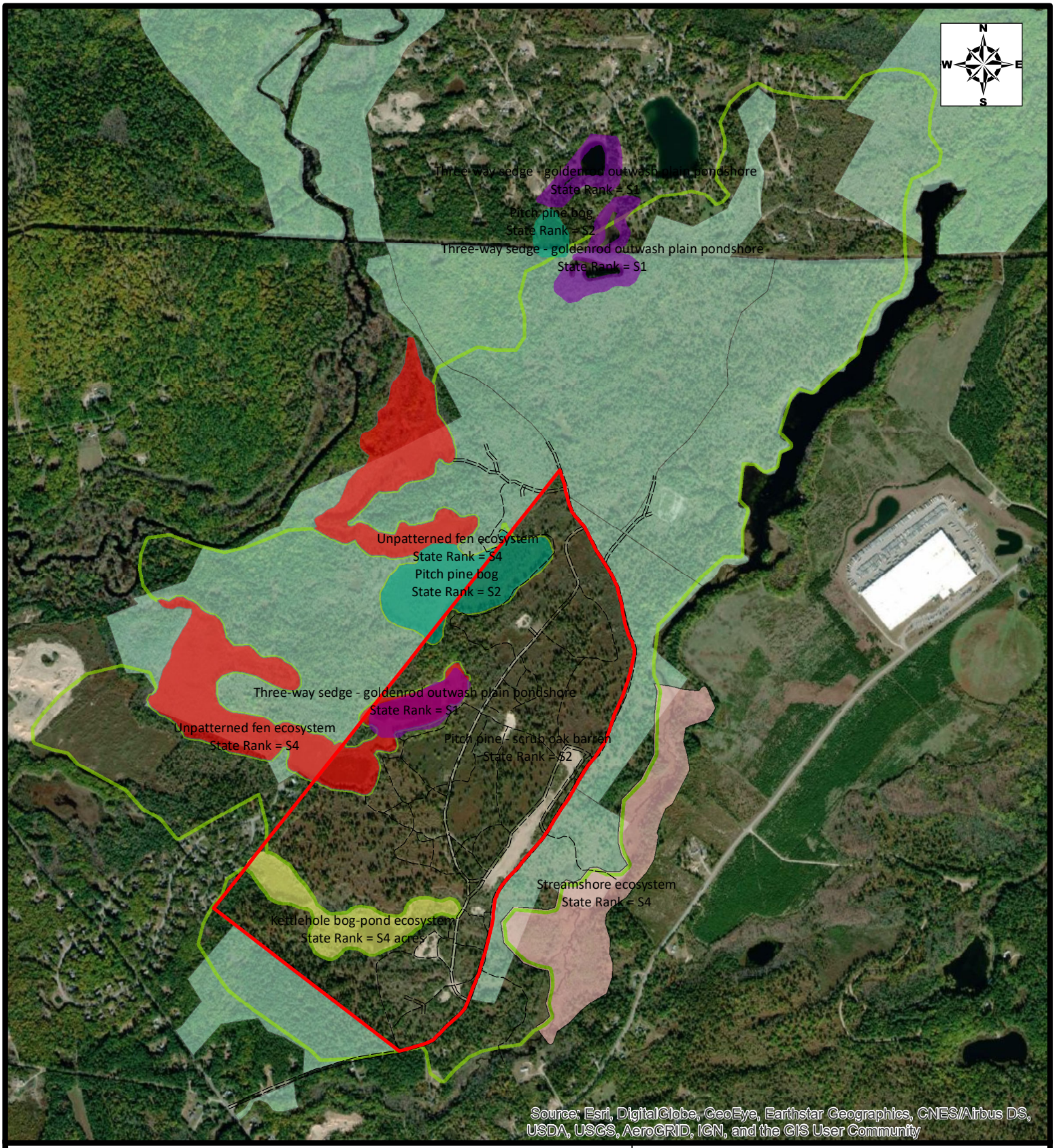
Figure 2. Location of NRCS Soils Series

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine



Property Boundary
Road
Trail

Kettlehole bog-pond ecosystem
Pitch pine - scrub oak barren
Pitch pine bog
Streamshore ecosystem
Three-way sedge - goldenrod outwash plain pondshore
Unpatterned fen ecosystem

IF&W Wildlife Management Areas

0 120 240 480 720 960

Meters

Source: MEARNG; MNAP
Author: Tim Bickford

Filename: Hollis INRMP Figure 3 2021.mxd

Date: 8 Oct 2020

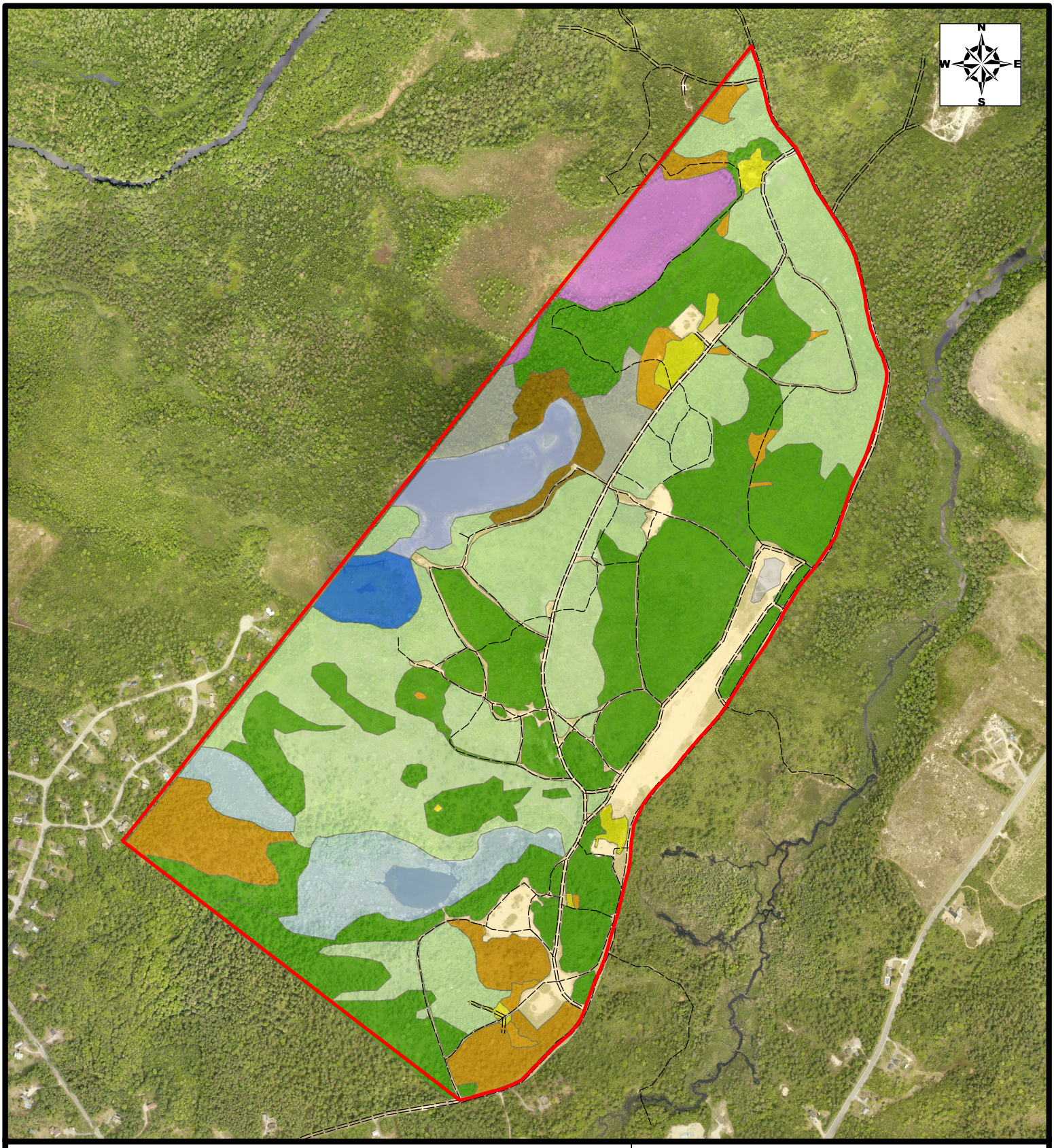
Figure 3. Location of Ecosystems And Communities Of Statewide Importance

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine



Property Boundary
Road
Trail

Habitat Type

- Acidic Fen
- Dwarf Shrub Bog
- Gramminoid
- Gray Birch
- Heath
- Kettlehole Bog and Pond Community
- Mixed Conifer-Hardwood
- Outwash Plain Pondshore
- Pitch Pine-Scrub Oak-Gray Birch
- Pitch Pine-White Pine-Scrub Oak-Gray Bir
- Sand
- Scrub Oak-Gray Birch

0 70 140 280 420 560

Meters

Figure 4. Location of Habitat Types

Project Name:

Integrated Natural Resource Management Plan

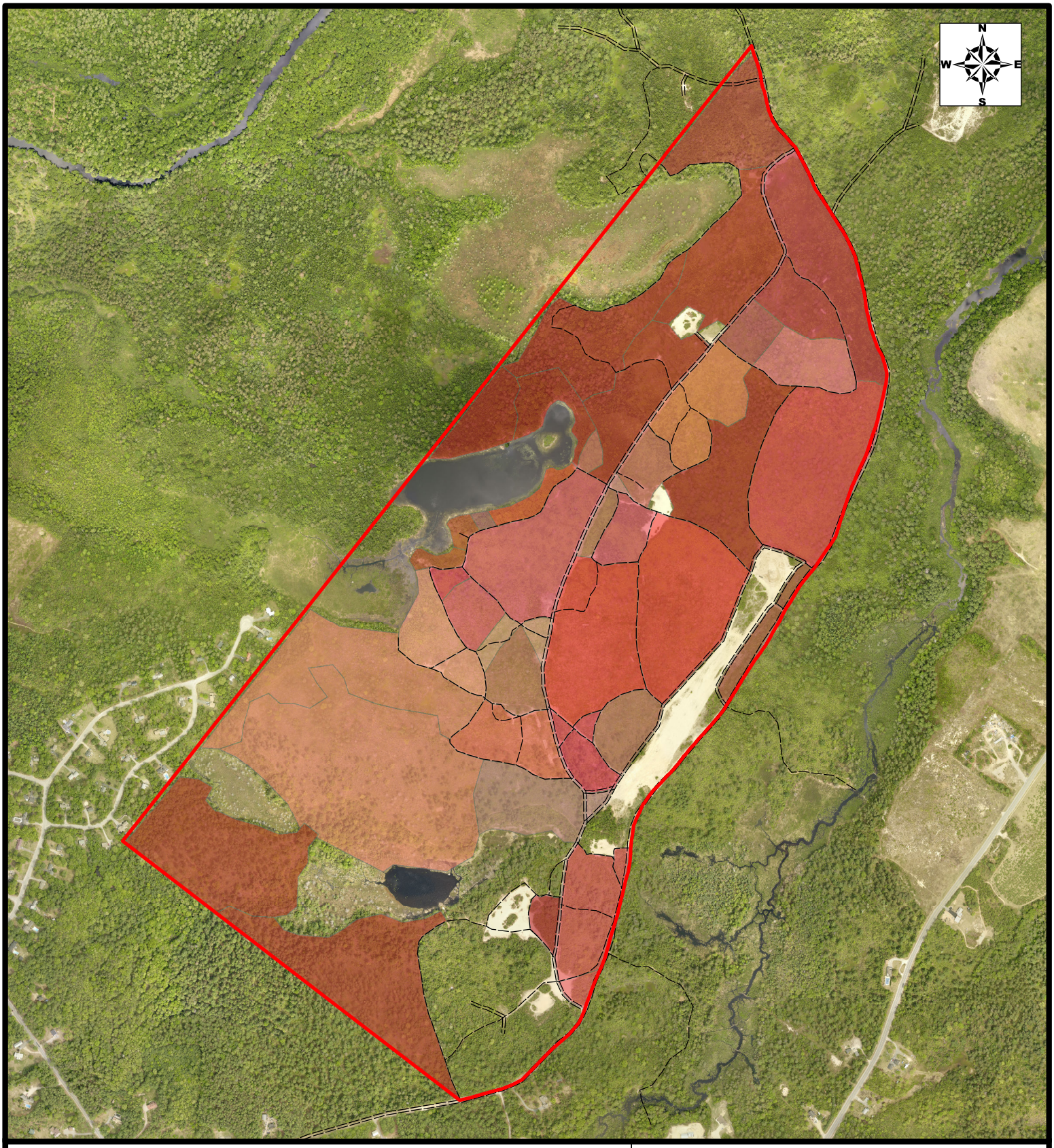
Project Location:

Hollis, Maine

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 4 2021.mxd

Date: 8 Oct 2020



Property Boundary
Road
Trail

Fire Management Units/Year(s) Burned

1995 1997 2006
1995 1997 2007
1995 1997 2009
1995 1998 2007
1995 2006 2009
1996
1996 2005
1996 2005 2008
1996 2006 2009
1996 2007 2009
1996 2010 2016
1996 2015
1997 2005 2008
1997 2006 2009
1997 2007 2009
1997 2010 2016
1998 2005 2008
1998 2006 2009
1998 2012
1999 2005 2010
2007 2009
2010 2016
2010 2016
2012
2013
2017

0 70 140 280 420 560

Meters

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 5 2021.mxd

Date: 8 Oct 2020

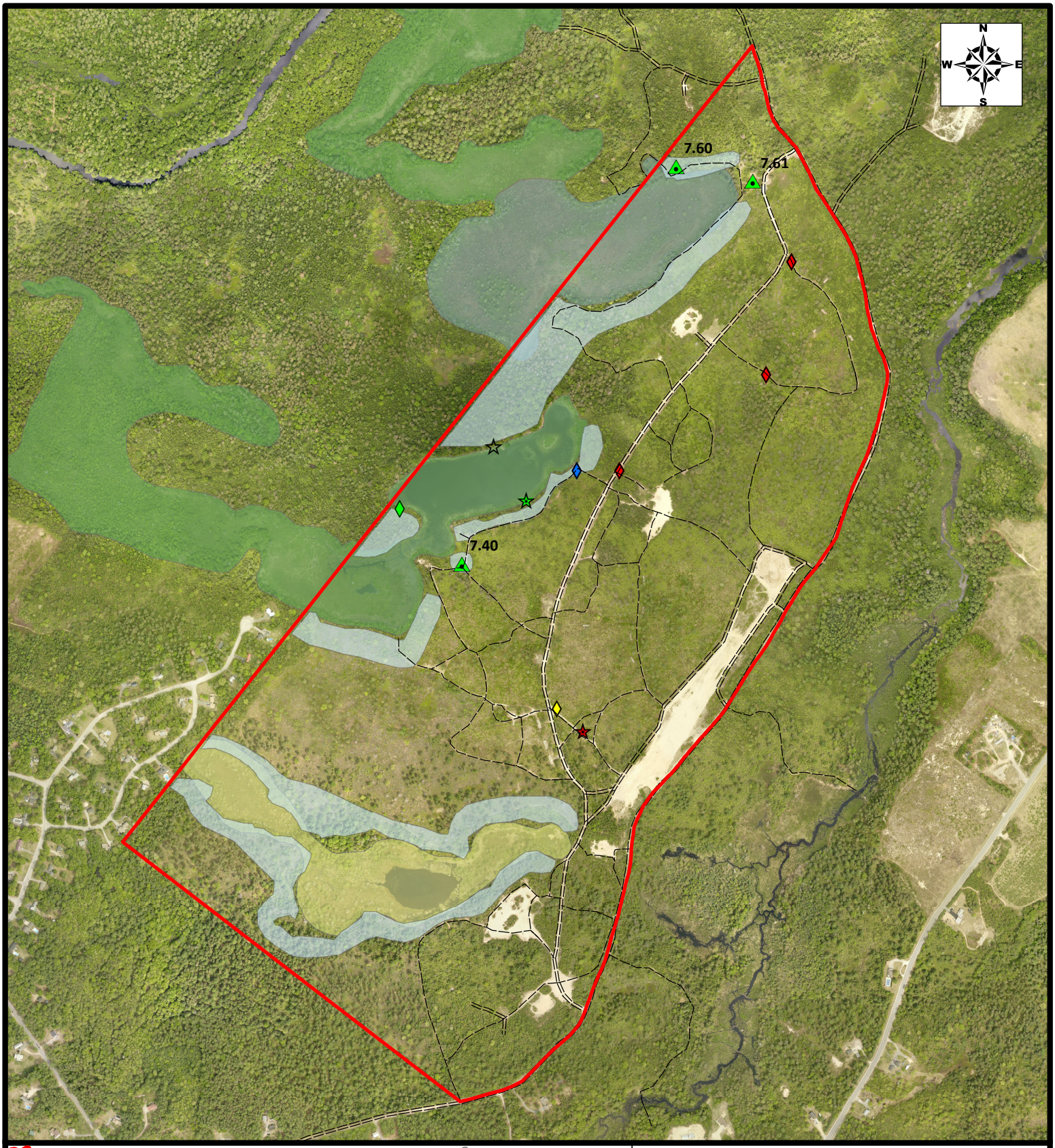
Figure 5. Location and History of Fire Management Units

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine



Property Boundary
Road
Trail
Archaeological Site

Rare Plants
- Fall fimbry
- Narrow-leaved goldenrod
- Northern blazing star

Rare Wildlife
- Ribbon Snake
- Cobweb skipper
- Edward's hairstreak
- Sleepy duskywing

- Sensitive Archaeological Area
- Kettlehole bog-pond ecosystem
- Pitch pine bog
- Unpatterned fen ecosystem

0 70 140 280 420 560

Meters

Figure 6. Location of RTE, Valuable Wildlife Habitat & Archaeological Sites

Project Name:

Integrated Natural Resource Management Plan

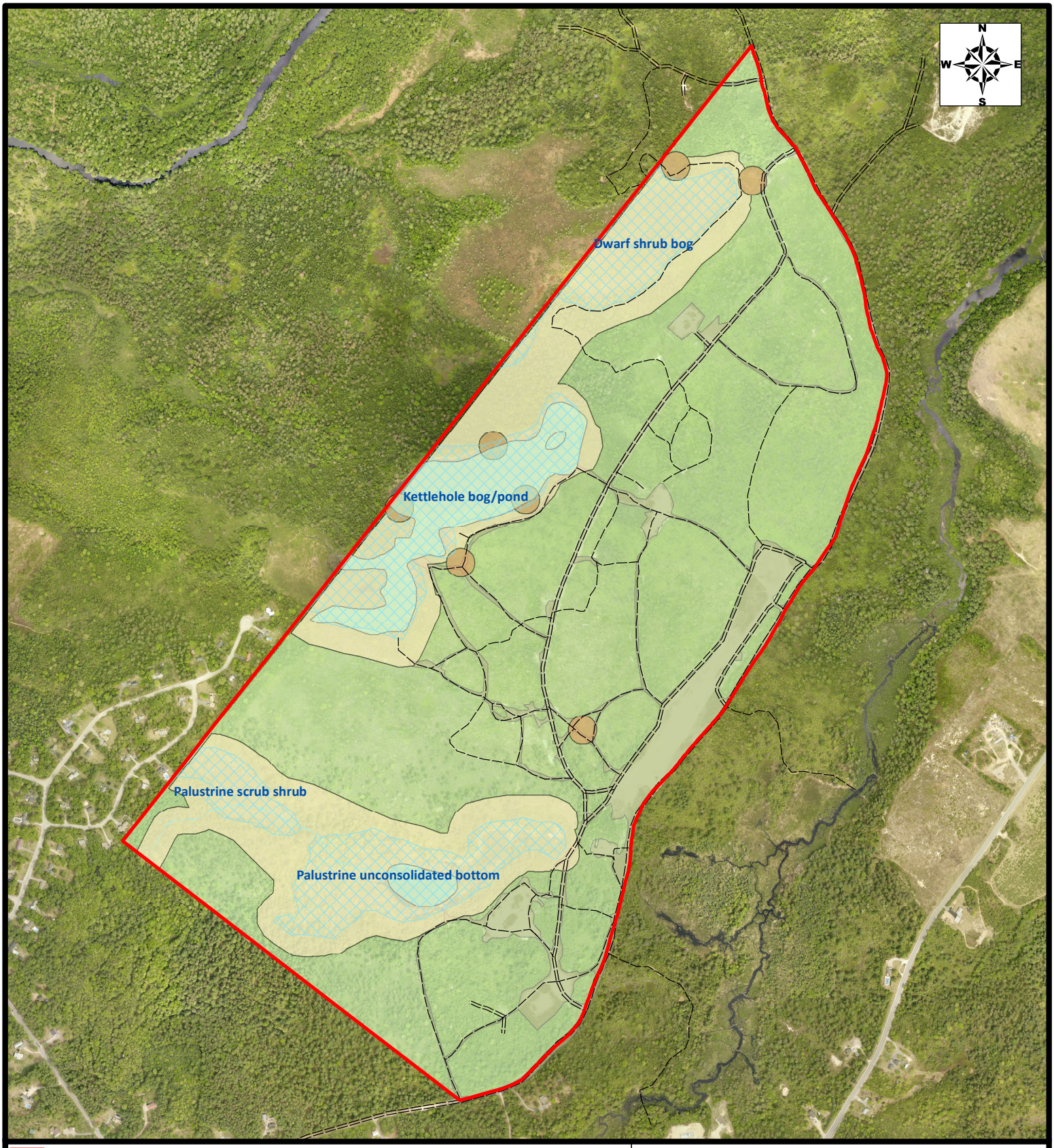
Project Location:

Hollis, Maine

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 6 2021.mxd

Date: 9 Oct 2020



Property Boundary
Road
Trail
Wetlands
Water Bodies
Intermittent Stream

Management Zones

Significant Natural Resource Management Zone
Valuable Natural Resource Management Zone
Training Zone
Fire Management Zone

0 70 140 280 420 560

Meters

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 7 2021.mxd

Date:17 Dec 2020

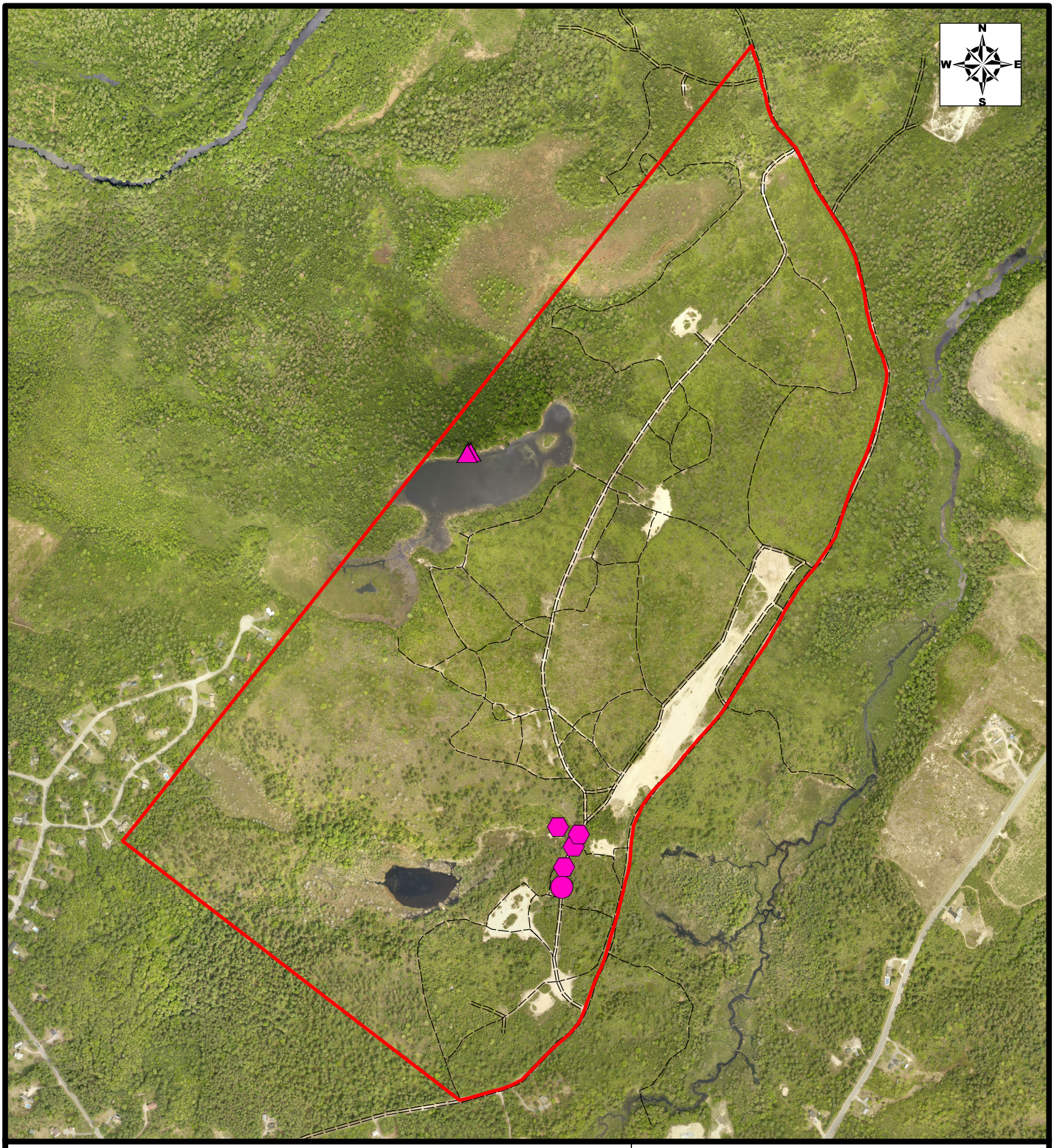
Figure 7. Location of Training and Natural/Cultural Resource Management Zones

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine



Property Boundary
Road
Trail

Invasive Species

Field sorrel
Japanese barberry
Morrow's honeysuckle

0 70 140 280 420 560

Meters

Figure 8. Location of Invasive Species

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 8 2021.mxd

Date: 9 Oct 2020

Property Boundary
Road
Trail
Countours (5')

0 70 140 280 420 560

Meters

Figure 9. Contour Map

Project Name:

Integrated Natural Resource Management Plan

Project Location:

Hollis, Maine

Source: MEARNG
Author: Tim Bickford

Filename: Hollis INRMP Figure 9 2021.mxd

Date: 24 Nov 2020

Appendix C

Correspondence with Agencies and Interested Parties

DEPARTMENT OF
DEFENSE, VETERANS AND EMERGENCY MANAGEMENT
Directorate of Facilities Engineering
Headquarters, Maine Army National Guard
Camp Keyes, Augusta, Maine 04333-0033

4 January 2021

MEMORANDUM FOR RECORD

SUBJECT: ESA Section 7 Consultation for Hollis Integrated Natural Resource Management Plan (INRMP)

1. A Record of Environmental Consideration (REC) has been prepared by the MEARNG for the implementation of the Hollis INRMP, Hollis, Maine.

2. The proposed action consists of the implementation of the Hollis INRMP as described within the plan.

3. The proposed action requires an internal Section 7 review and effects determination for the presence or potential habitat of federally listed species as required by the ESA of 1973, as amended.

4. The U.S. Fish & Wildlife Service (USFWS) Maine Field Office in East Orland, Maine, has approved the following list of federally listed species and critical habitat for the project site under Consultation Code: 05E1ME00-2021-SLI-0312.

Common Name	Scientific Name	Habitat Present w/in Project Area	Determination
Northern long-eared Bat	*Myotis septentrionalis*	Yes	May Affect
Small-whorled pogonia	*Isotria medeleoides*	No	No Affect

5. Northern Long-eared Bat habitat does exist in the area, and since trees may be cut and prescribed fire is expected, MEARNG has determined **"may affect"** will occur as a result of the project.

6. Small-whorled pogonia habitat is not known to exist on Hollis TS and therefore MEARNG has determined "**no affect**" will occur as a result of this project.

7. The POC for this action is Mr. Timothy Bickford, Natural Resources Manager, MEARNG at (207) 430-5923 or timothy.a.bickford2.nfg@mail.mil.

TIMOTHY BICKFORD
EN, MEARNG
Natural Resource Manager

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Maine Ecological Services Field Office
P. O. Box A
East Orland, ME 04431
Phone: (207) 469-7300 Fax: (207) 902-1588
http://www.fws.gov/mainefieldoffice/index.html

In Reply Refer To: January 14, 2021
Consultation code: 05E1ME00-2021-TA-0312
Event Code: 05E1ME00-2021-E-01372
Project Name: Hollis TS INRMP

Subject: Verification letter for the 'Hollis TS INRMP' project under the January 5, 2016, Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-eared Bat and Activities Excepted from Take Prohibitions.

Dear Timothy Bickford:

The U.S. Fish and Wildlife Service (Service) received on January 14, 2021 your effects determination for the 'Hollis TS INRMP' (the Action) using the northern long-eared bat (*Myotis septentrionalis*) key within the Information for Planning and Consultation (IPaC) system. This IPaC key assists users in determining whether a Federal action is consistent with the activities analyzed in the Service's January 5, 2016, Programmatic Biological Opinion (PBO). The PBO addresses activities excepted from "take"[1] prohibitions applicable to the northern long-eared bat under the Endangered Species Act of 1973 (ESA) (87 Stat.884, as amended; 16 U.S.C. 1531 et seq.).

Based upon your IPaC submission, the Action is consistent with activities analyzed in the PBO. The Action may affect the northern long-eared bat; however, any take that may occur as a result of the Action is not prohibited under the ESA Section 4(d) rule adopted for this species at 50 CFR §17.40(o). Unless the Service advises you within 30 days of the date of this letter that your IPaC-assisted determination was incorrect, this letter verifies that the PBO satisfies and concludes your responsibilities for this Action under ESA Section 7(a)(2) with respect to the northern long-eared bat.

Please report to our office any changes to the information about the Action that you submitted in IPaC, the results of any bat surveys conducted in the Action area, and any dead, injured, or sick northern long-eared bats that are found during Action implementation. If the Action is not completed within one year of the date of this letter, you must update and resubmit the information required in the IPaC key.

This IPaC-assisted determination allows you to rely on the PBO for compliance with ESA Section 7(a)(2) only for the northern long-eared bat. It **does not** apply to the following ESA-protected species that also may occur in the Action area:

- Small Whorled Pogonia Isotria medeoloides Threatened

If the Action may affect other federally listed species besides the northern long-eared bat, a proposed species, and/or designated critical habitat, additional consultation between you and this Service office is required. If the Action may disturb bald or golden eagles, additional coordination with the Service under the Bald and Golden Eagle Protection Act is recommended.

---

[1]Take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct [ESA Section 3(19)].

Action Description
You provided to IPaC the following name and description for the subject Action.

1. Name

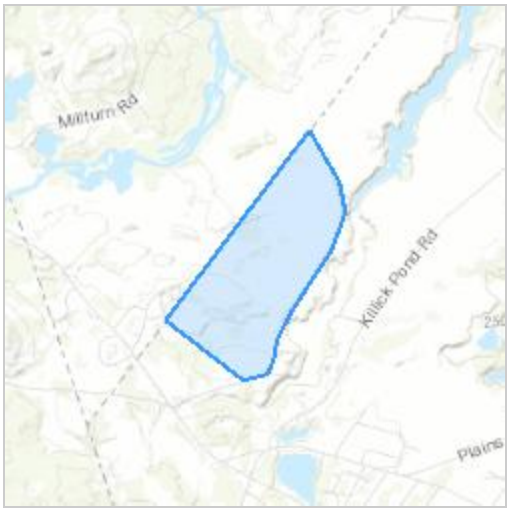
Hollis TS INRMP

2. Description

The following description was provided for the project 'Hollis TS INRMP':

> This project is for the 5 year update and implementation of the Hollis Training Site Integrated Natural Resource Management Plan.

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@43.66971777950161,-70.66284482474367,14z



Determination Key Result

This Federal Action may affect the northern long-eared bat in a manner consistent with the description of activities addressed by the Service's PBO dated January 5, 2016. Any taking that may occur incidental to this Action is not prohibited under the final 4(d) rule at 50 CFR §17.40(o). Therefore, the PBO satisfies your responsibilities for this Action under ESA Section 7(a)(2) relative to the northern long-eared bat.

Determination Key Description: Northern Long-eared Bat 4(d) Rule

This key was last updated in IPaC on May 15, 2017. Keys are subject to periodic revision.

This key is intended for actions that may affect the threatened northern long-eared bat.

The purpose of the key for Federal actions is to assist determinations as to whether proposed actions are consistent with those analyzed in the Service's PBO dated January 5, 2016.

Federal actions that may cause prohibited take of northern long-eared bats, affect ESA-listed species other than the northern long-eared bat, or affect any designated critical habitat, require ESA Section 7(a)(2) consultation in addition to the use of this key. Federal actions that may

affect species proposed for listing or critical habitat proposed for designation may require a conference under ESA Section 7(a)(4).

Determination Key Result

This project may affect the threatened Northern long-eared bat; therefore, consultation with the Service pursuant to Section 7(a)(2) of the Endangered Species Act of 1973 (87 Stat.884, as amended; 16 U.S.C. 1531 et seq.) is required. However, based on the information you provided, this project may rely on the Service's January 5, 2016, *Programmatic Biological Opinion on Final 4(d) Rule for the Northern Long-Eared Bat and Activities Excepted from Take Prohibitions* to fulfill its Section 7(a)(2) consultation obligation.

Qualification Interview

1. Is the action authorized, funded, or being carried out by a Federal agency?

   Yes

2. Have you determined that the proposed action will have "no effect" on the northern long-eared bat? (If you are unsure select "No")

   No

3. Will your activity purposefully **Take** northern long-eared bats?

   No

4. [Semantic] Is the project action area located wholly outside the White-nose Syndrome Zone?

   Automatically answered
   No

5. [Semantic] Is the project action area located within 0.25 miles of a known northern long-eared bat hibernaculum?

   Note: The map queried for this question contains proprietary information and cannot be displayed. If you need additional information, please contact your State wildlife agency

   Automatically answered
   No

6. [Semantic] Is the project action area located within 150 feet of a known occupied northern long-eared bat maternity roost tree?

   Note: The map queried for this question contains proprietary information and cannot be displayed. If you need additional information, please contact your State wildlife agency

   Automatically answered
   No

Project Questionnaire

If the project includes forest conversion, report the appropriate acreages below. Otherwise, type '0' in questions 1-3.

1. Estimated total acres of forest conversion:

0

2. If known, estimated acres of forest conversion from April 1 to October 31

0

3. If known, estimated acres of forest conversion from June 1 to July 31

0

If the project includes timber harvest, report the appropriate acreages below. Otherwise, type '0' in questions 4-6.

4. Estimated total acres of timber harvest

0

5. If known, estimated acres of timber harvest from April 1 to October 31

0

6. If known, estimated acres of timber harvest from June 1 to July 31

0

If the project includes prescribed fire, report the appropriate acreages below. Otherwise, type '0' in questions 7-9.

7. Estimated total acres of prescribed fire

120

8. If known, estimated acres of prescribed fire from April 1 to October 31

120

9. If known, estimated acres of prescribed fire from June 1 to July 31

0

If the project includes new wind turbines, report the megawatts of wind capacity below. Otherwise, type '0' in question 10.

10. What is the estimated wind capacity (in megawatts) of the new turbine(s)?

0

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Maine Ecological Services Field Office
P. O. Box A
East Orland, ME 04431
Phone: (207) 469-7300 Fax: (207) 902-1588
http://www.fws.gov/mainefieldoffice/index.html

In Reply Refer To:
Consultation Code: 05E1ME00-2021-SLI-0312
Event Code: 05E1ME00-2021-E-00922
Project Name: Hollis TS INRMP

December 10, 2020

Subject: List of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies the threatened, endangered, candidate, and proposed species and designated or proposed critical habitat that may occur within the boundary of your proposed project or may be affected by your proposed project. This species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC Web site at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 et seq.), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the Endangered Species Consultation Handbook at: http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

This species list also identifies candidate species under review for listing and those species that the Service considers species of concern. Candidate species have no protection under the Act but are included for consideration because they could be listed prior to completion of your project. Species of concern are those taxa whose conservation status is of concern to the Service (i.e., species previously known as Category 2 candidates), but for which further information is needed.

If a proposed project may affect only candidate species or species of concern, you are not required to prepare a Biological Assessment or biological evaluation or to consult with the Service. However, the Service recommends minimizing effects to these species to prevent future conflicts. Therefore, if early evaluation indicates that a project will affect a candidate species or species of concern, you may wish to request technical assistance from this office to identify appropriate minimization measures.

Please be aware that bald and golden eagles are not protected under the Endangered Species Act but are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.). Projects affecting these species may require development of an eagle conservation plan: http://www.fws.gov/windenergy/eagle_guidance.html Information on the location of bald eagle nests in Maine can be found on the Maine Field Office Web site: http://www.fws.gov/mainefieldoffice/Project%20review4.html

Additionally, wind energy projects should follow the wind energy guidelines: http://www.fws.gov/windenergy/ for minimizing impacts to migratory birds and bats. Projects may require development of an avian and bat protection plan.

Migratory birds are also a Service trust resource. Under the Migratory Bird Treaty Act, construction activities in grassland, wetland, stream, woodland, and other habitats that would result in the take of migratory birds, eggs, young, or active nests should be avoided. Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g.,

cellular, digital television, radio, and emergency broadcast) can be found at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm and at: http://www.towerkill.com; and at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Tracking Number in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Maine Ecological Services Field Office
P. O. Box A
East Orland, ME 04431
(207) 469-7300

Project Summary

Consultation Code: 05E1ME00-2021-SLI-0312

Event Code: 05E1ME00-2021-E-00922

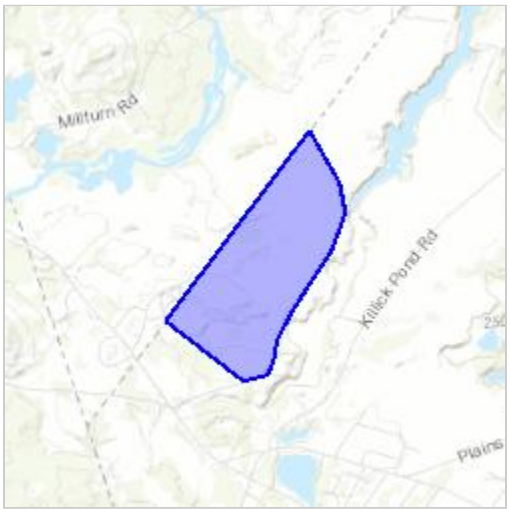
Project Name: Hollis TS INRMP

Project Type: LAND - MANAGEMENT PLANS

Project Description: This project is for the 5 year update and implementation of the Hollis Training Site Integrated Natural Resource Management Plan.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/43.66971777950161N70.66284482474367W



Counties: York, ME

Endangered Species Act Species

There is a total of 2 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Flowering Plants

NAME	STATUS
Small Whorled Pogonia *Isotria medeoloides* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1890	Threatened

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

Appendix D

Lists of Plants and Wildlife

Table 1. Flora Species List for Hollis Training Site

Scientific Name	Common Name	Total Species to Date	Invasive Species	State or Federally-Listed Species	Pitch Pine - Scrub Oak	Leatherleaf Boggy Fen	Spruce-Larch Wooded Bog	Outwash Plain Pondshore	Sweetgale Mixed Shrub Fen	White Oak Red Oak Forest
Acer rubrum	Red maple	1			1	1	1		1	
Achillea millefolium	Yarrow	1			1				1	
Agrostis canina	Velvet bentgrass	1			1					
Agrostis perennans	Autumn bentgrass	1			1					
Agrostis scabra	Ticklegrass	1			1					
Alnus viridis	Green alder	1				1				
Ambrosia artemesiifolia	Common ragweed	1			1					
Anaphalis margaritacea	Pearly everlasting	1			1					
Andromeda polifolia	Bog rosemary	1				1			1	
Anthoxanthum odoratum	Sweet vernal grass	1			1					
Apocynum androsaemifolium	Spreading dogbane	1			1			1		
Aquilegia sp.	Columbine sp.	1			1					
Aralia nudicaulis	Wild sarsaparilla	1								1
Aronia melanocarpa	Black chokeberry	1			1	1	1		1	
Asclepias incarnata	Swamp milkweed	1							1	
Asclepias syriaca	Common milkweed	1							1	
Berberis thunbergii	Japanese barberry	1	1					1		
Betula populifolia	Gray birch	1			1			1		1
Bidens frondosa	Devil's beggar ticks	1						1		
Brasenia schreberi	Water shield	1						1		
Bulbostylis capillaris	Tufted hair sedge	1			1					
Calamagrostis canadensis	Bluejoint	1					1		1	
Calla palustris	Wild calla	1				1				
Capnoides sempervirens	Pale corydalis	1			1					
Carex disperma	Two-seeded sedge	1					1			
Carex echinata	Star sedge	1							1	
Carex foenea	Straw sedge	1			1					

Table 1. Flora Species List for Hollis Training Site (cont)

Carex houghtoniana	Houghton's sedge	1			1					
Carex scoparia	Pointed broom sedge	1			1					
Carex sp.	Sedge	1								1
Carex stricta	Tussock sedge	1				1				
Carex trisperma	Three-seeded sedge	1					1			
Carex utriculata	Swollen-beaked sedge	1				1				
Cephalanthus occidentalis	Buttonbush	1						1		
Chamaedaphne calyculata	Leatherleaf	1				1	1	1	1	
Chamaepericlymenum canadense	Bunchberry	1					1			
Cladonia cristatella	British soldiers lichen	1								
Comptonia peregrina	Sweetfern	1			1		1			1
Cuscuta gronovii	Common dodder	1						1		
Cyperus dentatus	Umbrella sedge	1			1			1		
Cyperus lupulinus	Great plains flatsedge	1			1					
Dactylis glomerata	Orchard grass	1			1					
Danthonia spicata	Poverty oatgrass	1			1					
Dennstaedia punctobula	Hay-scented fern	1			1					1
Deschampia flexuosa	Hairgrass	1			1					
Diabeis baeomyces	Pink earth lichen	1								
Dichanthelium acuminatum	Hairy rosette-panicgrass	1			1					
Dichanthelium clandestinum	panicgrass	1								1
Digitaria ischaemum	Smooth crabgrass	1			1					
Ditrichum lineare	A moss	1								
Drosera intermedia	Spatulate-leaved sundew	1				1			1	
Drosera rotundifolia	Round-leaved sundew	1				1				
Dryopteris cristata	Crested woodfern	1					1			
Dulichium arundinaceaum	Three-way sedge	1				1	1	1	1	
Eleocharis acicularis	Needle spikerush	1						1	1	
Eleocharis obtusa	Blunt spikerush	1				1		1		
Eleocharis parvula	Dwarf spikerush	1						1		

Table 1. Flora Species List for Hollis Training Site (cont)

Erechtites hieraciifolius	Pilewort	1			1			1	1	1
Erigeron annuus	Annual fleabane	1			1					
Eriocaulon aquaticum	Common pipewort	1						1	1	
Eriophoron virginicum	Tawny cottongrass	1				1				
Eupatorium perfoliatum	Boneset	1							1	
Eurybia macrophylla	Large-leaved aster	1			1					
Euthamia caroliniana	Narrow-leaved goldenrod	1		1		1		1		
Euthamia graminifolia	Common grass-leaved goldenrod	1						1	1	
Fagus grandifolia	American beech	1			1					
Fallopia cilinodis	Fringed bindweed	1			1					
Fimbristylis autumnalis	Fall fimbry	1		1						
Galium trifidum	Three-petaled bedstraw	1							1	
Gaultheria procumbens	Wintergreen	1			1		1			
Gaylussacia baccata	Black huckleberry	1			1		1			1
Gaylussacia bigeloviana	Dwarf huckleberry	1					1		1	
Glyceria canadensis	Rattlesnake mannagrass	1					1		1	
Glyceria grandis	Reed mannagrass	1							1	
Glyceria obtusa	Atlantic mannagrass	1						1		
Gratiola aurea	Golden hedge-hyssop	1						1		
Hieracium paniculatum	Panicled hawkweed	1			1					
Hieracium pilosella	Mouse-ear hawkweed	1			1			1		
Hypericum gentianoides	Pineweed	1			1					
Hypericum perforatum	Common St. Johnswort	1			1			1		
Ilex verticillata	Winterberry	1					1		1	
Ionactis linariifolia	Stiff aster	1			1					
Iris versicolor	Blue flag iris	1				1	1	1	1	
Isopaches bicrematus	A liverwort	1								
Juncus acuminatus	Sharp-fruited rush	1							1	
Juncus brevicaudatus	Short-tailed rush	1			1					
Juncus canadensis	Canada rush	1								

Table 1. Flora Species List for Hollis Training Site (cont)

Juncus dichotomus	Forked rush	1								
Juncus effusus	Common rush	1								
Juncus pelocarpus	Brown-fruited rush	1						1		
Juncus tenuis	Path rush	1			1					
Kalmia angustifolia	Sheep laurel	1								
Kalmia polifolia	Bog laurel	1					1			
Larix laricina	Tamarack	1					1		1	
Leersia oryzoides	Rice cutgrass	1						1		
Lespedeza capitata	Round-headed bush clover	1			1					
Liatris novae-angliae	Northern blazing star	1		1	1					
Lilium philadelphicum	Wood lily	1			1					
Linaria vulgaris	Butter and eggs	1			1					
Lonicera morrowi	Morrow's honeysuckle	1	1		1					
Lycopus americanus	American water-horehound	1						1		
Lycopus uniflorus	Northern water-horehound	1						1		
Lyonia ligustrina	Maleberry	1				1	1	1		
Lysimachia quadrifolia	Whorled loosestrife	1			1					
Lysimachia terrestris	Swamp candles	1				1		1	1	
Maianthemum canadense	Canada mayflower	1			1					
Maianthemum trifolium	Three-leaved false solomon's seal	1				1				
Melampyrum lineare	Cow wheat	1			1					1
Menyanthes trifoliata	Bogbean	1					1			
Monotropa uniflora	Indian pipe	1								1
Myrica gale	Sweet gale	1					1	1	1	
Nabalus trifoliolatus	Three-leaved rattlesnake root	1			1					
Nuphar variegata	Yellow pond lily	1				1			1	
Nuttallanthus canadensis	Blue toadflax	1			1					
Nymphaea odoroata	White water lily	1						1		
Oclemena acuminata	Whorled aster	1					1			
Oclemena nemoralis	Bog aster	1				1				

Table 1. Flora Species List for Hollis Training Site (cont)

Oryzopsis asperifolia	White-grained ricegrass	1			1					
Osmunda claytoniana	Interrupted fern	1			1					
Osmunda regalis	Royal fern	1				1	1			
Osmundastrum cinnamomeum	Cinnamon fern	1				1	1			
Peltandra virginica	Arrow arum	1								
Persicaria amphibia	Water smartweed	1						1		
Picea glauca	White spruce	1				1				
Picea mariana	Black spruce	1					1			
Pinus rigida	Pitch pine	1			1	1				1
Pinus strobus	White pine	1			1	1	1			1
Plantago major	Common plantain	1						1		1
Polytrichum commune	Common haircap moss	1								
Polytrichum piliferum	A haircap moss	1								
Pontederia cordata	Pickerelweed	1							1	
Populus tremuloides	Quaking aspen	1			1					
Potamogeton natans	Floating pondweed	1						1		
Potentilla norvegica	Rough cinquefoil	1			1					
Potentilla simplex	Old field cinquefoil	1			1					
Prunus pensylvanica	Pin cherry	1			1					
Prunus serotina	Black cherry	1			1					
Prunus virginiana	Chokecherry	1			1					
Pseudognaphalium obtusifolium	Sweet everlasting	1						1		
Pteridium aquilinum	Bracken fern	1			1			1		1
Quercus alba	White oak	1								1
Quercus ilicifolia	Scrub oak	1			1			1		1
Quercus rubra	Red oak	1			1					1
Quercus velutina	Black oak	1								1
Rhexia virginica	Meadow beauty	1						1		
Rhododendron canadense	Rhodora	1				1	1		1	
Rhynchospora alba	White beak rush	1				1			1	

Table 1. Flora Species List for Hollis Training Site (cont)

Rhynchospora fusca	Brown beak-rush	1				1	1		1	
Rosa carolina	Carolina rose	1			1					
Rubus canadensis	Smooth blackberry	1			1					
Rubus dalibara	Dewdrop	1			1					
Rubus flagellaris	Northern dewberry	1			1					
Rubus hispidus	Swamp dewberry	1					1		1	
Rubus ideaus	Red raspberry	1			1					
Rumex acetosella	Field sorrel	1			1					
Sagittata latifolia	Common arrowhead	1				1		1		
Sarracenia purpurea	Pitcher plant	1				1			1	
Scheuchzeria palustris	Podgrass	1				1				
Schizachyrium scoparium	Little bluestem	1			1					
Schoenoplectus actutus	Hard-stemmed bulrush	1						1		
Scirpus cyperinus	Common woolgrass	1					1		1	
Scirpus pedicellatus	Stalked woolgrass	1						1		
Scutellaria galericulata	Marsh skullcap	1							1	
Silene latifolia	White campion	1			1					
Solidago bicolor	Silverrod	1			1					
Solidago canadensis	Canada goldenrod	1							1	
Solidago gigantea	Late goldenrod	1			1				1	
Solidago nemoralis	Gray goldenrod	1			1					
Solidago rugosa	Rough-stemmed goldenrod	1			1				1	
Sparganium emersum	Green-fruited bur reed	1							1	
Spirea alba	Meadowsweet	1			1			1	1	
Spirea tomentosa	Steeplebush	1			1			1	1	
Swida amomum	Silky dogwood	1			1					
Swida sericea	Red osier dogwood	1					1			
Symphyotrichum cordifolium	Heart-leaved aster	1								1
Symphyotrichum lateriflorum	Calico aster	1						1		
Symphyotrichum novi-belgii	New York aster	1			1					

Table 1. Flora Species List for Hollis Training Site (cont)

Thelypteris palustris	Marsh fern	1					1	1	1	
Toxicodendron radicans	Poison ivy	1								1
Tragopogon pratensis	Yellow goatsbeard	1			1					
Triadenum virginicum	Marsh St. Johnswort	1				1			1	
Trichostema dichotomum	Forked blue curls	1			1					
Trientalis borealis	Starflower	1			1		1			
Trifolium arvense	Rabbit foot clover	1			1					
Trifolium campestre	Yellow hop clover	1			1					
Trifolium hybridum	Alsike clover	1			1					
Trifolium repens	White clover	1			1					
Typha latifolia	Broad-leaved cattail	1					1		1	
Utricularia minor	Lesser bladderwort	1						1		
Uvularia sessifolia	Wild oats	1								1
Vaccinium angustifolium	Early low blueberry	1			1					1
Vaccinium corymbosum	Highbush blueberry	1				1	1	1		
Vaccinium macrocarpon	Large cranberry	1				1			1	
Vaccinium myrtilloides	Velvet-leaved blueberry	1			1					1
Vaccinium oxycoccos	Small cranberry	1				1				
Vaccinium pallidum	Hillside blueberry	1			1					
Verbascum thapsis	Common mullein	1			1			1		
Viburnum nudum	Wild raisin	1				1	1			
Vicia cracca	Cow vetch	1			1					
Viola sagittata	Arrowhead violet	1			1					
Viola sp.	Violet	1						1		
Vitis labrusca	Fox grape	1						1		
Summary		**202**	**2**	**3**	**92**	**36**	**36**	**49**	**45**	**23**

Table 2. Fauna Species List for Hollis Training Site

Invertebrates

Common Name	Scientific Name	Total Species	State or Federally-Listed Species	Species of Special Concern	SGCN
ODONATES (Dragonflies & Damselflies)					
Zygoptera (Damselflies)					
Hagen's bluet	*Enallagma hageni*	1			
Bluet	*Enallagma spp.*	1			
Eastern forktail	*Ischnura verticalis*	1			
Spreadwing damselfly	*Lestes spp.*	1			
	Summary	**4**	**0**	**0**	**0**
Anisoptera (Dragonflies)					
Common green darner	*Anax junius*	1			
Pond clubtail	*Arigomphus-sp.*	1			
Calico pennant	*Celithemis elisa*	1			
Halloween pennant	*Celithemis eponina*	1			
Twin-spotted spiketail	*Cordulegaster maculata*	1			
Beaverpond baskettail	*Epitheca canis*	1			
Common baskettail	*Epitheca cynosura*	1			
Baskettail	*Epitheca sp.*	1			
Uhler's sundragon	*Helocordulia uhleri*	1			
Chalk-fronted corporal	*Ladona julia*	1			
Frosted whiteface	*Leucorrhinia frigida*	1			
Dot-tailed whiteface	*Leucorrhinia intacta*	1			
Spanked skimmer	*Libellula cynosura*	1			
Twelve-spotted skimmer	*Libellula pulchella*	1			
Swift river cruiser	*Macromia illinoiensis*	1			
Common whitetail	*Plathemis lydial*	1			
	Summary	**16**	**0**	**0**	**0**
LEPIDOPTERA (Butterflies & Moths)					
Papilionidae (Swallow Tail Butterflies)					
Tiger swallowtail	*Papilio spp.*	1			
Pieridae (Whites and Sulphurs)					
Sulphur	*Colias spp.*	1			
Cabbage white	*Pieris rapae*	1			
Lycaenidae (Gossamer-winged Butterflies)					
Brown elfin	*Callophrys augustinus*	1			

Table 2. Fauna Species List for Hollis Training Site (cont)

Pine elfin	*Callophrys niphonn*	1			
Azure	*Celestrina spp.*	1			
Banded hairstreak	*Satyrium calanus*	1			
Edwards hairstreak	*Satyrium edwardsii*	1	1		1
Nymphalidae (Brush-footed Butterflies)					
Least skipper	*Ancyloxypha numitor*	1			
Silver-bordered fritillary	*Boloria selene*	1			
Common ringlet	*Coenonympha tulia*	1			
Sleepy duskywing	*Erynnis brizo*	1	1		
Juvenal's duskywing	*Erynnis juvenalis*	1			
Duskywing	*Erynnis sp.*	1			
Dun skipper	*Euphyes vestris*	1			
Cobweb skipper	*Hesperia metea*	1		1	1
White admiral	*Limenitis arthemis arthemis*	1			
Red-spotted purple	*Limenitis arthemis asyntax*	1			
Little wood satyr	*Megisto cymela*	1			
Aphrodite fritillary	*Speyeria aphrodite*	1			
Atlantis fritillary	*Speyeria atlantis*	1			
Great spangled fritillary	*Speyeria cybele*	1			
American lady	*Vanessa virginiensis*	1			
Northern broken dash	*Wallengrenia egeremet*	1			
	Summary	**24**	**2**	**1**	**2**
Moths					
A snout moth	*Acrobasis amplexella*	1			
Raspberry bud moth	*Acronicta increta*	1			
Streaked dagger moth	*Acronicta lithospila*	1			
Long-winged dagger moth	*Acronicta longa*	1			
Ovate dagger moth	*Acronicta ovata*	1			
Triton dagger moth	*Acronicta tritona*	1			
Smokey carpet moth	*Aethalura intertexta*	1			
Yellow-spotted webworm	*Anageshna primordialis*	1			
Little cloud ancylis moth	*Ancylis nubeculana*	1			
	Ancylis semiovana	1			
	Ancylis sp.	1			
	Ancylis subaequana	1			
	Anicla forbesii	1			
White-spotted leafroller	*Argyrotaenia alisellana*	1			
Io moth	*Automeris io*	1			

Table 2. Fauna Species List for Hollis Training Site (cont)

Elm sphinx	*Ceratomia amyntor*	1			
Morbid owlet moth	*Chytolita morbidalis*	1			
Cloaked marvel moth	*Chytonix palliatricula*	1			
Garden tortrix	*Clepsis peritana*	1			
Closebanded yellowhorn	*Colocasia propinquilinea*	1			
Pasture grass-veneer	*Crambus saltuellus*	1			
Virginia ctenucha	*Ctenucha virginica*	1			
Sweetfern geometer moth	*Cyclophora pendulinaria*	1			
Dogbane tiger moth	*Cycnia tenera*	1			
Yellownecked caterpillar	*Datana ministra*	1			
	Datana sp.	1			
Pawpaw sphinx	*Dolba hyloeus*	1			
	Donacaula aquilellus	1			
Rosy maple moth	*Dryocampa rubicunda*	1			
Pale-winged midget	*Elaphria alapallida*	1			
Pondside pyralid moth	*Elophila icciusalis*	1			
Milkweed tiger moth	*Euchaetes egle*	1			
Least-marked euchlaena	*Euchlaena irraria*	1			
Muzaria euchlaena moth	*Euchlaena muzaria*	1			
Spiny oak slug	*Euclea delphinii*	1			
	Eucosma sp.	1			
Sharp-lined powder moth	*Eufidonia discospilata*	1			
	Eupithecia sp.	1			
Blueberry gray moth	*Glena cognataria*	1			
	Gypsonoma fasciolana	1			
Sundew dart	*Hemipachnobia monochromatea*	1			
Saddled prominent moth	*Heterocampa guttivitta*	1			
White-blotched heterocampa	*Heterocampa umbrata*	1			
	Hydriomena sp.	1			
One-spotted variant moth	*Hypagyrtis unipunctata*	1			
Broken-line hypenodes	*Hypenodes fractilinea*	1			
Georgian prominent	*Hyperaeschra georgica*	1			
Giant leopard moth	*Hypercompe scribonia*	1			
White-lined graylet moth	*Hyperstrotia villificans*	1			
Fall webworm	*Hyphantria cunea*	1			
	Hypsopygia n. sp.	1			
Large purplish gray	*Iridopsis vellivolata*	1			
Grand arches moth	*Lacanobia grandis*	1			

Table 2. Fauna Species List for Hollis Training Site (cont)

Kidney-spotted minor	*Lacinipolia renigera*	1			
Southern pine sphinx	*Lapara coniferarum*	1		1	1
Unarmed wainscot	*Leucania inermis*	1			
Lycophotia moth	*Lycophotia phyllophora*	1			
Mousy angle moth	*Macaria agillacearia*	1			
Rannoch looper	*Macaria brunneata*	1			
Granite moth	*Macaria granitata*	1			
Peacock moth	*Macaria notata*	1			
Mottled prominent	*Macrurocampa marthesia*	1			
Eastern tent caterpillar	*Malacosoma americana*	1			
Black arches	*Melanchra assimilis*	1			
Common metarranthis moth	*Metarranthis hypochraria*	1			
Pale metarranthi	*Metarranthis indeclinata*	1			
Refracted metarranthis	*Metarranthis refractaria*	1			
Rough prominent	*Nadata gibbosa*	1			
Red-fronted emerald	*Nemoria rubrifrontaria*	1			
Sharp-blotched nola	*Nola pustulata*	1			
	Olethreutes glaciana	1			
	Olethreutes sp.	1			
Cynical quaker	*Orthodes cynica*	1			
Disparaged arches	*Orthodes detracta*	1			
	Packardia geminata	1			
Tufted white pine caterpillar	*Panthea furcilla*	1			
Huckleberry sphinx	*Paonias astylus*	1		1	1
Blinded sphinx	*Paonias excaecatus*	1			
Small-eyed sphinx	*Paonias myops*	1			
Angulos prominent	*Peridea angulosa*	1			
Olive angle shades	*Phlogophora iris*	1			
Ruddy quaker moth	*Protorthodes oviduca*	1			
Glistening rustic	*Proxenus miranda*	1			
Dotted leaftier moth	*Psilocorsis reflexella*	1			
Isabella tiger moth	*Pyrrharctia isabella*	1			
Pitch twig moth	*Retinia comstockiana*	1			
	Retinia gemistrigulana	1			
Maroonwing moth	*Sideridis maryx*	1			
Hebrew moth	*Sonia paraplesiana*	1			
Apple sphinx	*Sphinx gordius*	1			
Poecila sphinx	*Sphinx poecila*	1			

Table 2. Fauna Species List for Hollis Training Site (cont)

Agreeable tiger moth	*Spilosoma congrua*	1			
Otter spiramater	*Spiramater lutra*	1			
Red-humped oakworm moth	*Symmerista canicosta*	1			
	Symmerista sp.	1			
	Tacparia atropunctata	1			
Pale alder moth	*Tacparia detersata*	1			
Sheathed quaker	*Ulolonche culea*	1			
Rusty holomelina	*Virbia ferruginosa*	1			
Tawny holomelina	*Virbia opella*	1			
Red-winged sallow	*Xystopeplus rufago*	1		1	1
Oblique zale	*Zale obliqua*	1		1	1
Summary		**102**	**0**	**4**	**4**
Total Invertebrates		**146**	**2**	**5**	**6**

Fish

Common Name	Scientific Name	Total Species to Date	Invasive or Noxious Species	State or Federally-Listed Species	Species of Special Concern	SGCN
Hornpout	*Ameiurus nebulosus*	1				
Chain Pickerel	*Esox niger*	1				
Summary		**2**	**0**	**0**	**0**	**0**

Reptiles

Common Name	Scientific Name	Total Species to Date	Invasive or Noxious Species	State or Federally-Listed Species	Species of Special Concern	SGCN
Common snapping turtle	*Chelydra serpentina*	1				
Eastern garter snake	*Thamnophis sirtalis sirtalis*	1				
Eastern painted turtle	*Chrysemys picta*	1				
Northern water snake	*Nerodia sipedon*	1				
Red-bellied Snake	*Storeriaoccipito-maculata*	1				
Ribbon snake	*Thamnophis sauritus*	1			1	1
Summary		**6**	**0**	**0**	**1**	**1**

Table 2. Fauna Species List for Hollis Training Site (cont)

Amphibians

Common Name	Scientific Name	Total Species to Date	Invasive or Noxious Species	State or Federally-Listed Species	Species of Special Concern	SGCN
American bullfrog	*Rana catesbeiana*	1				
American toad	*Anaxyrus americanus*	1				
Gray treefrog	*Hyla versicolor*	1				
Green frog	*Rana clamitans*	1				
Northern leopard frog	*Rana pipiens*	1			1	1
Pickerel frog	*Rana palustris*	1				
Spring peeper	*Hyla crucifer*	1				
Spotted salamander	*Ambystoma maculatum*	1				
Wood frog	*Rana sylvatica*	1				
	Summary	**9**	**0**	**0**	**1**	**1**

Birds

Common Name	Scientific Name	Total Species to Date	Invasive or Noxious Species	State or Federally-Listed Species	Species of Special Concern	USFWS Birds of Conservation Concern	SGCN
Alder flycatcher	*Empidonax alnorum*	1					
American black duck	*Anas rubripes*	1					
American crow	*Corvus brachyrhynchos*	1					
American goldfinch	*Carduelis tristis*	1					
American redstart	*Setophaga ruticilla*	1			1		1
American robin	*Turdus migratorius*	1					
Baltimore oriole	*Icterus galbula*	1					1
Belted kingfisher	*Megaceryle alcyon*	1					1
Black-and-white warbler	*Mniotilta varia*	1			1		1
Black-billed cuckoo	*Coccyzus erythropthalmus*	1					1
Blackburnian warbler	*Setophaga fusca*	1					1
Black-capped chickadee	*Poecile atricapillus*	1					
Black-throated blue warbler	*Setophaga caerulescens*	1					1
Black-throated green warbler	*Setophaga virens*	1					1
Blue-headed vireo	*Vireo solitarius*	1					

Table 2. Fauna Species List for Hollis Training Site (cont)

Blue jay	*Cyanocitta cristata*	1					
Broad-winged hawk	*Buteo platypterus*	1					1
Brown creeper	*Certhia americana*	1					
Brown thrasher	*Toxostoma rufum*	1			1		1
Brown-headed cowbird	*Melothrus ater*	1	1				
Canada goose	*Branta canadensis*	1					
Canada warbler	*Cardellina canadensis*	1			1	1	1
Cedar waxwing	*Bombycilla cedrorum*	1					
Chestnut-sided warbler	*Setophaga pensylvanica*	1			1		1
Chimney swift	*Chaetura pelagica*	1			1		1
Chipping sparrow	*Spizella passerina*	1					
Common grackle	*Quiscalus quiscula*	1					
Common nighthawk	*Chordeiles minor*	1					1
Common raven	*Corvus Corax*	1					
Common yellow-throat	*Geothlypus trichas*	1					
Dark-eyed junco	*Junco hyemalis*	1					
Downy woodpecker	*Picoides pubescens*	1					
Eastern kingbird	*Tyrannus tyrannus*	1			1		1
Eastern phoebe	*Sayornis phoebe*	1					
Eastern towhee	*Pipilo erythrophthalmus*	1			1		1
Eastern whip-poor-will	*Caprimulgus vociferus*	1			1		1
Eastern wood-peewee	*Contopus virens*	1			1		1
European starling	*Sturnus vulgaris*	1	1				
Field sparrow	*Spizella pusilla*	1					1
Gray catbird	*Dumetella carolinensis*	1					
Great blue heron	*Ardea herodias*	1			1		1
Great-crested flycatcher	*Myiarchus crinitus*	1					
Hairy woodpecker	*Picoides villosus*	1					
Hermit thrush	*Catharus guttatus*	1					
Hooded merganser	*Lophodytes cucullatus*	1					
House wren	*Troglodytes aedon*	1					
Indigo bunting	*Passerina cyanea*	1					
Killdeer	*Charadrius vociferus*	1					
Least flycatcher	*Emoidonax minimus*	1			1		1
Lincoln's sparrow	*Melospiza lincolnii*	1					1
Magnolia warbler	*Setophagus magnolia*	1					
Mallard	*Anas platyrhynchos*	1					
Marsh wren	*Cistothorus palustris*	1					

Table 2. Fauna Species List for Hollis Training Site (cont)

Mourning dove	*Zenaida macroura*	1					
Magnolia warbler	*Setophaga magnolia*	1					
Nashville warbler	*Oreothlypis ruficapilla*	1					
Northern cardinal	*Cardinalis cardinalis*	1					
Northern flicker	*Colaptes auratus*	1					1
Northern mockingbird	*Mimus polyglottos*	1					
Northern parula	*Setophaga americana*	1					1
Olive-sided flycatcher	*Contopus cooperi*	1			1	1	1
Ovenbird	*Seiurus aurocapilla*	1					
Pileated woodpecker	*Dryocopus pileatus*	1					
Pine siskin	*Spinus pinus*	1					
Pine warbler	*Setophaga pinus*	1					
Prairie warbler	*Setophaga discolor*	1			1		1
Purple finch	*Carpodacus purpureus*	1					1
Red-breasted nuthatch	*Sitta canadensis*	1					
Red-eyed vireo	*Vireo olivaeus*	1					
Red-tailed hawk	*Buteo jamaicensis*	1					
Red-winged blackbird	*Agelaius phoenceus*	1					
Rose-breasted grosbeak	*Pheucticus ludovicianus*	1					1
Ruffed grouse	*Bonasa umbellus*	1					
Scarlet tanager	*Piranga olivacea*	1					1
Song sparrow	*Melospiza melodia*	1					
Spotted sandpiper	*Actitis macularia*	1					
Swamp sparrow	*Melospiza georgiana*	1					
Tennessee warbler	*Oreothlypis peregrina*	1			1		1
Tree swallow	*Tachycineta bicolor*	1			1		1
Tufted titmouse	*Baeolophus bicolor*	1					
Turkey vulture	*Cathartes aura*	1					
Veery	*Catharus fuscescens*	1			1		1
Vesper sparrow	*Pooecetes gramineus*	1					
White-breasted nuthatch	*Sitta carolinensis*	1					
White-throated sparrow	*Zonotrichia albicollis*	1			1		1
Wild turkey	*Meleagris gallopavo*	1					
Wilson's warbler	*Cardellina pusilla*	1					
Wood thrush	*Hylocichla mustelina*	1			1	1	1
Worm-eating warbler	*Helmitheros vermivorum*	1					
Yellow warbler	*Setophaga petechia*	1			1		1
Yellow-bellied sapsucker	*Sphyrapicus varius*	1					

Table 2. Fauna Species List for Hollis Training Site (cont)

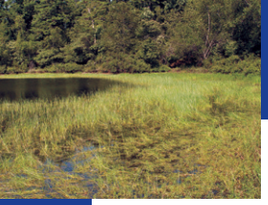
Yellow-rumped warbler	*Setophaga coronata*	1					
	Summary	**92**	**2**	**0**	**20**	**3**	**35**

Mammals

Common Name	Scientific Name	Total Species to Date	Invasive or Noxious Species	State or Federally-Listed Species	Species of Special Concern	SGCN
Beaver	*Castor Canadensis*	1				
Big brown bat	*Eptesicus fuscus*	1				1
Coyote	*Canis latrans*	1				
Eastern chipmunk	*Tamias striatus*	1				
Eastern gray squirrel	*Sciurus carolinensis*	1				
Eastern red bat	*Lasiurus borealis*	1			1	1
Eastern small-footed bat	*Myotis leibii*	1		1		1
Hoary bat	*Lasiurus cinereus*	1			1	1
Little brown bat	*Myotis lucifugus*	1		1		1
Moose	*Alces alces*	1				1
Muskrat	*Ondatra zibethica*	1				1
North American porcupine	*Erethizon dorsatum*	1				
Red fox	*Vulpes vulpes*	1				
Red squirrel	*Tamiasciurus hudsonicus*	1				
Silver-haired bat	*Lasionycteris noctivagans*	1			1	1
Snowshoe hare	*Lepus americanus*	1				
Star-nosed mole	*Condylura cristata*	1				
Whitetail deer	*Odocoileus virginianus*	1				
	Summary	**18**	**0**	**2**	**3**	**8**

Appendix E

Rare, Threatened and Endangered Species and Significant Habitat Information



Outwash Plain Pondshore

State Rank S1

Community Description

This community consists of concentric zones of different herbs around a central pond. A band of shrubs (highbush blueberry, maleberry, buttonbush, leatherleaf) is typical at the upland/ pondshore edge. Moving pondward, the next zone is dominated by narrow-leaved goldenrod and three-way sedge, with patches of flat-sedge and brown-fruited rush. In a narrow band at the top of this zone, golden pert and meadow beauty are characteristic and may form dense patches. The next zone, exposed less frequently and for a shorter time, is dominated by pipewort and spikerushes. There is no well developed bryoid layer.

Soil and Site Characteristics

This community forms a band around the perimeter of shallow, sandy bottomed ponds in glacial outwash plains. It occurs on shores that are inundated for the early part of the growing season and exposed later in the growing season, although actual exposure varies from year to year. The substrate is sandy, occasionally mucky, and usually saturated to the surface or nearly so.

Ribbon Snake

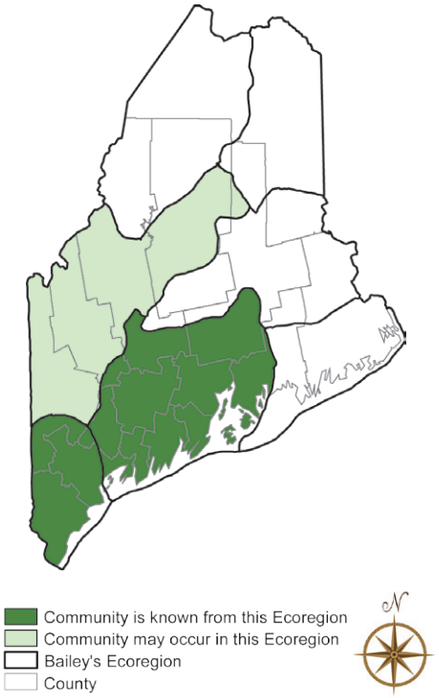
Diagnostics

Three-way sedge and usually narrow-leaved goldenrod are dominant in a sandy pondshore setting, with evidence of water level changes through the season. Golden pert and meadow beauty are indicator species.

Similar Types

Mixed Graminoid - Shrub Marshes can also occur on temporarily flooded mineral soils and can share some dominants such as three-way sedge, but they lack the concentric zonation of outwash plain pondshores and typically intermingle shrubs and herbs rather than segregating them into zones. The more variable and widespread Lakeshore Beaches lack three-way sedge, golden pert, and meadow beauty.

Location Map



Three-way Sedge

Conservation, Wildlife, and Management Considerations

This extremely rare natural community is under pressure from adjacent land uses and recreational impacts. The periphery of several sites has been developed or converted to other uses. At the few known sites on conservation lands, the major recreational impact is off-road vehicle use. At low water, ATV use has significantly altered the vegetation at some sites. Hydrologic integrity is also a concern, as water use increases from neighboring homes and businesses and aquifer drawdowns could impair these water dependent systems and lead to vegetational changes.

These outwash plain pondshores provide excellent foraging habitat for the ribbon snake. The pondshores also provide habitat for the big bluet, a rare damselfly. Other more wide-ranging rare insects are likely to be found in this community. This community may also provide feeding habitat for wading birds.

Characteristic Plants

These plants are frequently found in this community type. Those with an asterisk are often diagnostic of this community.

Herb

Bluejoint*
Brown-fruited rush*
Bur-reed*
Canada rush
Fly-away grass
Golden pert*
Narrow-leaved goldenrod*
Pipewort*
Robbin's spikerush*
Three-way sedge
Toothed flat-sedge*
Yellow loosestrife

Associated Rare Plants

Dwarf bulrush
Englemann's spikerush
Fall fimbry
Huron tansy
Long-tubercled spike-rush
Narrow-leaved goldenrod

Associated Rare Animals

Big bluet
Ribbon snake

Distribution

Extreme southwestern Maine (Eastern Broadleaf Forest Province), extending southward along the coast to Massachusetts; disjunct in Nova Scotia and Ontario.

Landscape Pattern: Small Patch

Examples on Conservation Lands You Can Visit

- Killick Pond Wildlife Management Area – York Co.
- Waterboro Barrens Preserve – Oxford Co.

Maine Natural Areas Program

Pitch Pine Bog

State Rank S2

Community Description

Pitch pine is the dominant tree in these sparsely forested peatlands. The shrub layer likewise indicates the more southerly affinities of this type, with maleberry and highbush blueberry common along with the standard bog shrubs of huckleberry and mountain holly. The herb layer may be dense evergreen heath shrubs, especially leatherleaf, or it may be more sparse peat mosses covering the ground.

Soil and Site Characteristics

Sites occur in shallow basins on the coastal plain; typical acidic bog conditions predominate. Peat may be shallow, over sandy mineral soil, or deep (>50 cm) as is typical of peatlands. In some, but not all, cases these types are adjacent to pitch pine uplands.

Diagnostics

This is an organic soil wetland with abundant peat and low heath shrubs, sparsely forested by pitch pine.

Sheep Laurel

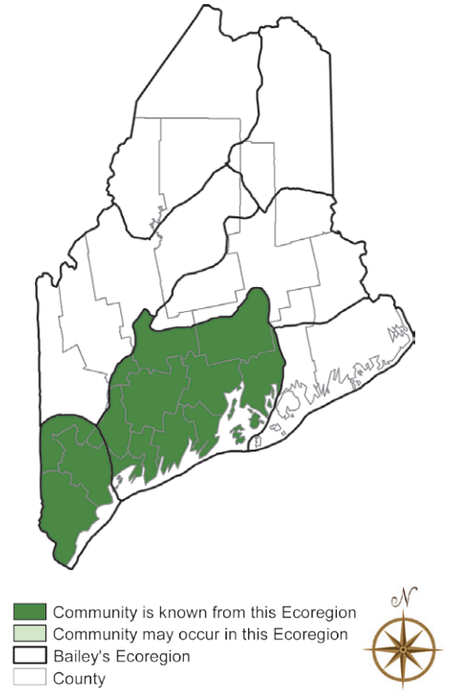
Similar Types

Several other peatland community types have very similar dwarf shrub, herb, and bryophyte composition, especially Spruce - Larch Wooded Bog, Sheep Laurel Dwarf Shrub Bog, and Leatherleaf Boggy Fen. The predominance of pitch pine in the tree layer makes this type unique in Maine.

Conservation, Wildlife, and Management Considerations

Strong development pressures in southern Maine may threaten unprotected sites and degrade their landscape surroundings. Four sites in southern Maine are in public or private conservation ownership.

Location Map



Pitch Pine Bog

Birds associated with this community include wetland species such as the common yellowthroat and northern waterthrush.

Distribution

Along the north Atlantic coastal plain (Eastern Broadleaf Forest Province) to southern and midcoast Maine.

Landscape Pattern: Small Patch, mostly 5-40 acres.

Large Cranberry

Characteristic Plants

These plants are frequently found in this community type. Those with an asterisk are often diagnostic of this community.

Canopy

Pitch pine

Sapling/shrub

Black chokeberry
Black huckleberry*
Highbush blueberry*
Maleberry
Mountain holly
Speckled alder

Dwarf Shrub

Large cranberry
Leatherleaf*
Sheep laurel

Herb

Bracken fern
Cinnamon fern
Three-seeded sedge
Wild sarsaparilla

Bryoid

*Sphagnum girgensohnii**

Associated Rare Plants

Smooth winterberry holly

Examples on Conservation Lands You Can Visit

- Brownfield Bog Wildlife Management Area – Oxford Co.
- East of Little River, Rachel Carson National Wildlife – York Co.
- Saco Heath Preserve – York Co.
- Scarborough Marsh Wildlife Management Area – Cumberland Co.

Pitch Pine - Scrub Oak Barren

State Rank S2

Community Description

This woodland type ranges from very open to nearly closed canopy (25-75% closure) in which pitch pine is dominant (up to 50% cover). Red maple is frequent but rarely abundant in the canopy. In openings among the trees, a dense shrub/sapling layer of scrub oak is typical. Gray birch may be a prominent feature of the shrub layer, and shrubs are locally dense. A low layer of heath shrubs dominated by lowbush or velvet-leaf blueberry is usually present. Bracken fern and woodland sedge are characteristic herbs. Bryoids are virtually absent. Vegetation is typically very patchy, with some areas clearly pitch pine dominated and others areas extensive thickets of scrub oak. Nonforested openings with blueberry and lichens may occur within the barrens.

Soil and Site Characteristics

Sites occur on nutrient poor soils of glacial outwash plains or moraines south of 44 degrees latitude. Topography is flat to undulating. The xeric to dry-mesic, sandy soils are acidic (pH usually <5.0) and have little organic matter. Fire is an important factor in maintaining this community.

Northern Blazing Star

Diagnostics

These are pitch pine dominated partially forested areas which develop on sands or glacial outwash deposits, not on stabilized coastal dunes. Scrub oak is common and locally dominant in the shrub layer.

Similar Types

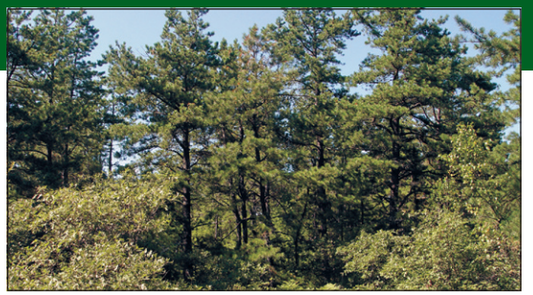
Pitch Pine Woodlands can be floristically similar but occur on bedrock, not on deep sandy soils. Pitch Pine Dune Woodlands occur on stabilized sand dunes along the coast. They also lack a well developed heath shrub layer. Pitch Pine - Heath Barrens share many species but lack the scrub oak layer (scrub oak may be present but only at low cover). Pitch Pine Bogs are wetlands, with at least a shallow peat substrate.

Conservation, Wildlife, and Management Considerations

This community type is dependent upon periodic fires to eliminate competing tree species and prevent succession to an Oak - Pine Forest. Because of fire suppression in the last century, this community type has become very rare. Relatively large areas are required to maintain this dynamic community and its associated rare animal species. Most of the large sites in the state have been fragmented by permanent conversion to residential areas or to sand and gravel pits.

Birds such as the whip-poor-will, eastern towhee, pine warbler, and prairie warbler may prefer this open habitat. This community type includes a rich array of rare butterflies and moths that use pitch pine or scrub oak as their larval host plant, including the southern pine sphinx, pine pinion, oblique zale, the buckmoth, Edward's hairstreak, pine barrens zale, pine barrens itame, and sleepy dusky wing.

Location Map



Pitch Pine – Scrub Oak Barren

Distribution

Primarily southern Maine (Eastern Broadleaf Forest Province). Extends southward and southwestward from the state along the Atlantic coastal plain.

Landscape Pattern: Large Patch

Examples on Conservation Lands You Can Visit

- Brownfield Bog Wildlife Management Area – Oxford Co.
- Kennebunk Plains Preserve – York Co.
- Killick Pond Wildlife Management Area – York Co.
- Waterboro Barrens Preserve – York Co.

Characteristic Plants

These plants are frequently found in this community type. Those with an asterisk are often diagnostic of this community.

Canopy
Gray birch
Pitch pine*
Red maple

Sapling/shrub
Gray birch
Pitch pine
Scrub oak*
Shadbush
Sweetfern
Wild-raisin

Dwarf Shrub
Lowbush blueberry*
Sheep laurel
Velvet-leaf blueberry

Herb
Bracken fern*
Canada mayflower
Mayflower
Sharp-pointed ricegrass
Wintergreen*
Woodland sedge

Bryoid
Large hair-cap moss

Associated Rare Plants

Butterfly weed
Fern-leaved false foxglove
Northern blazing star
Wild chess
Wild indigo
Wild lupine

Associated Rare Animals

Edward's hairstreak
Oblique zale
Pine barrens itame
Pine barrens zale
Pine barrens zanclognatha
Pine pinion
Pine-devil moth
Pink sallow
Similar underwing
Sleepy duskywing
Southern pine sphinx
The buckmoth
Twilight moth
Whip-poor-will

Pitch Pine - Scrub Oak Barren

Sweetgale Fen

Sweetgale Mixed Shrub Fen

State Rank S4

Community Description

A mixture of shrubs, typically about 1 m high (generally taller than bog shrubs, but shorter than most alder thickets), is dominated by sweetgale, leatherleaf, and hardhack or meadowsweet. Alder is usually present but not dominant. Graminoids, typically slender sedge, tussock sedge, and/or bluejoint grass, are usually mixed with the shrubs but are less abundant (averaging around 20% cover). Where shrubs are dense, herb cover is very limited. The bryoid layer is usually very minor; when present it is dominated by peat mosses.

Soil and Site Characteristics

These basin wetlands occur either as part of larger peatlands bordering open water or in impounded areas with peat or muck soils (e.g. beaver flowages). Slow moving open water usually borders this vegetation. The substrate is seasonally to semi-permanently flooded organic material.

Diagnostics

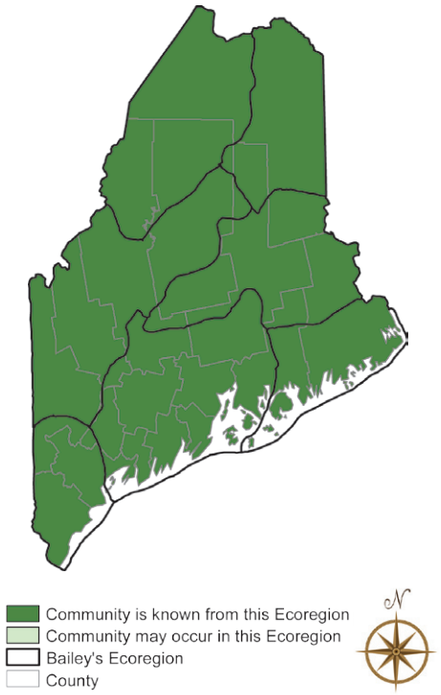
This type has a dominance of medium-height shrubs of sweetgale, meadowsweet, and leatherleaf. Graminoids are present but subordinate to shrubs. Sites occur on saturated or flooded organic soils.

Sweetgale

Similar Types

Sweetgale Mixed Shrub Fens are usually embedded within a mosaic of other peatland types. Mixed Tall Sedge Fens occur in similar settings but have graminoids far more dominant than shrubs. Mountain Holly - Alder Woodland Fens have more alder or mountain holly and usually occur at the peatland/upland interface. Mixed Graminoid - Shrub Marshes have graminoids equaling or exceeding shrub cover and occur on mineral soils or with only a thin organic layer over saturated mineral soil. Alder Shrub Thickets also usually occur on mineral soils rather than peat or muck and have a stronger dominance of alder.

Location Map



Sweetgale Mixed Shrub Fen

Conservation, Wildlife, and Management Considerations

This wetland type is well distributed throughout the state and receives little direct use. Maintaining appropriate wetland buffers and water quality are appropriate conservation measures. Public lands and private conservation lands contain many examples of this community.

These shrublands, especially in close proximity to open water, may provide habitat for bird species such as common yellowthroat, alder flycatcher, Wilson's warbler, Lincoln's sparrow, and the rare rusty blackbird. Thaxter's pinion moth uses sweetgale as one of its larval host plants and may be found in this community. The black meadowhawk, a dragonfly of open fens and marshes, may occur here as well. Sites of this community type in northern Maine may be inhabited by the subarctic bluet.

Distribution

Statewide; extends westward and probably eastward and northward as well.

Landscape Pattern: Small Patch

Characteristic Plants

These plants are frequently found in this community type. Those with an asterisk are often diagnostic of this community.

Sapling/shrub
Alder*
Black spruce*
Larch*
Leatherleaf*
Meadowsweet*
Mountain holly*
Red maple*
Sweetgale*
Winterberry holly*

Dwarf Shrub
Leatherleaf*
Rhodora*
Sheep laurel*
Sweetgale*

Herb
Bluejoint
Bog aster*
Few-seeded sedge*
Royal fern*
Slender sedge
Tussock sedge*
White beak-rush*

Bryoid
Sphagnum mosses*

Associated Rare Plants

Long's bulrush

Associated Rare Animals

Rusty blackbird

Examples on Conservation Lands You Can Visit

- Mattagodus Wildlife Management Area – Penobscot Co.
- Middle Pond State Park – Oxford Co.
- Moose River – Somerset Co.
- Nahmakanta Public Lands – Piscataquis Co.
- Wiggins Brook, Squaw Mountain Public Lands – Piscataquis Co.

Maine Natural Areas Program

White Oak - Red Oak Forest

State Rank S3

Community Description

This deciduous forest type is dominated by red oak with white oak as a canopy associate. White pine is occasionally present, but conifers comprise only a small proportion (<20%) of the canopy. Sugar maple and beech may be present in minor amounts. Shrubs occur as well spaced patches; typical species include striped maple and ironwood. The forest floor is characterized by low heath shrubs such as lowbush blueberry. Common herbs include woodland sedge, bracken fern, whorled loosestrife, and Canada mayflower. Bryoids are very sparse.

Soil and Site Characteristics

Sites of this type are on well drained gentle slopes (up to 20%) below 600' elevation. The soil is generally well drained, stony, sandy loam, fairly acidic (pH 4.8-5.0), and 20-50 cm deep. These forests are usually on somewhat sheltered sites.

Diagnostics

Forests dominated by a mixture of red oak and white oak, without a strong white pine or hickory component. White oak forms at least 25% of the canopy.

White Oak –Red Oak Forest

Similar Types

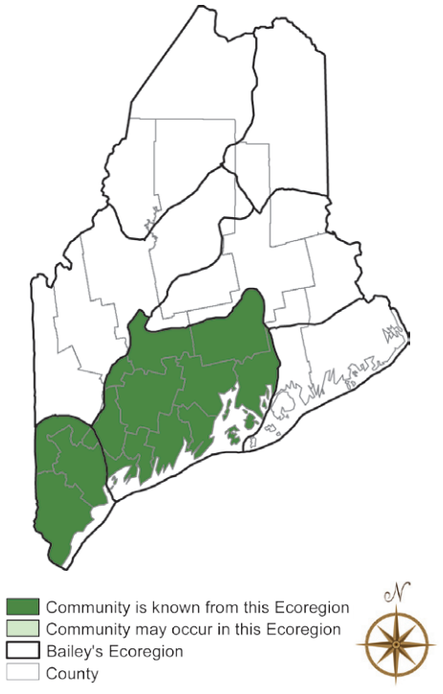
Oak - Pine Forests lack white oak and may have white pine co-dominant with red oak. Red Oak - Northern Hardwoods - White Pine Forests lack white oak and have a larger component of beech or sugar maple. Shagbark hickory is dominant in Oak - Hickory forests.

Conservation, Wildlife, and Management Considerations

The few mature sites of White Oak - Red Oak Forest known to remain in Maine are all on land that was once cleared. The known sites are subject to fragmentation by timber harvesting, clearing for agriculture, and residential development, uses that have reduced this naturally rare type even further. Community dynamics are not well known, but there are some indications that red oak regenerates more strongly than white oak at some sites and may replace it over time. Fire may also play a role in natural regeneration. Most occurrences of this type are on private lands.

This type offers habitat for a variety of birds, including scarlet tanager and ovenbird. Mature occurrences of this community type offer excellent potential sites for cavity dwellers such as the southern flying squirrel. The rare red-winged sallow moth uses red oak as one of its host plants and may be found in this community.

Location Map



Scarlet Oak Leaf held against Oak Bark

White Oak Leaf

Characteristic Plants

These plants are frequently found in this community type. Those with an asterisk are often diagnostic of this community.

Canopy

Red oak*
Sugar maple
White oak*

Herb

Rough-leaved ricegrass
Wild sarsaparilla
Wild-oats
Wintergreen
Woodland sedge*

Associated Rare Plants

Bitternut hickory
Chestnut oak
Flowering dogwood
Scarlet oak

Associated Rare Animals

Early hairstreak
Red-winged sallow
Whip-poor-will

Distribution

Restricted primarily to southern Maine, characteristic of the Eastern Broadleaf Forest Province.

Landscape Pattern: Small to Large Patch, generally 100 acres or less.

Examples on Conservation Lands You Can Visit

- Mt. Agamenticus – York Co.
- Sebago Lake State Park – Cumberland Co.

Maine Natural Areas Program

Appendix F

Climate Change

The following climate change information is taken from the Department of Defense's Climate Assessment Tool Regional Overview. The Regional Overview and Background and Context sections contain information consolidated from the 3rd and 4th National Climate Assessments (NCA3 and NCA4) produced by the U.S. Global Change Research Program (USGCRP) for Continental U.S., Alaska and Hawaii (CONUS/AK/HI) regions. Section 18 is included here which specifically addresses the Northeastern United States. Installation specific climate change assessments are not yet available for Maine locations. This section will be updated as further information becomes available.

18 Northeast

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On the Web: https://nca2018.globalchange.gov/chapter/northeast

18 Northeast

Bartram Bridge in Pennsylvania

Key Message 1

Changing Seasons Affect Rural Ecosystems, Environments, and Economies

The seasonality of the Northeast is central to the region's sense of place and is an important driver of rural economies. Less distinct seasons with milder winter and earlier spring conditions are already altering ecosystems and environments in ways that adversely impact tourism, farming, and forestry. The region's rural industries and livelihoods are at risk from further changes to forests, wildlife, snowpack, and streamflow.

Key Message 2

Changing Coastal and Ocean Habitats, Ecosystems Services, and Livelihoods

The Northeast's coast and ocean support commerce, tourism, and recreation that are important to the region's economy and way of life. Warmer ocean temperatures, sea level rise, and ocean acidification threaten these services. The adaptive capacity of marine ecosystems and coastal communities will influence ecological and socioeconomic outcomes as climate risks increase.

Key Message 3

Maintaining Urban Areas and Communities and Their Interconnectedness

The Northeast's urban centers and their interconnections are regional and national hubs for cultural and economic activity. Major negative impacts on critical infrastructure, urban economies, and nationally significant historic sites are already occurring and will become more common with a changing climate.

Key Message 4

Threats to Human Health

Changing climate threatens the health and well-being of people in the Northeast through more extreme weather, warmer temperatures, degradation of air and water quality, and sea level rise. These environmental changes are expected to lead to health-related impacts and costs, including additional deaths, emergency room visits and hospitalizations, and a lower quality of life. Health impacts are expected to vary by location, age, current health, and other characteristics of individuals and communities.

Key Message 5

Adaptation to Climate Change Is Underway

Communities in the Northeast are proactively planning and implementing actions to reduce risks posed by climate change. Using decision support tools to develop and apply adaptation strategies informs both the value of adopting solutions and the remaining challenges. Experience since the last assessment provides a foundation to advance future adaptation efforts.

Executive Summary

The distinct seasonality of the Northeast's climate supports a diverse natural landscape adapted to the extremes of cold, snowy winters and warm to hot, humid summers. This natural landscape provides the economic and cultural foundation for many rural communities, which are largely supported by a diverse range of agricultural, tourism, and natural resource-dependent industries (see Ch. 10: Ag & Rural, Key Message 4).[1] The recent dominant trend in precipitation throughout the Northeast has been towards increases in rainfall intensity,[2] with increases in intensity exceeding those in other regions of the contiguous United States. Further increases in rainfall intensity are expected,[3] with increases in total precipitation expected during the winter and spring but with little change in the summer.[4] Monthly precipitation in the Northeast is projected to be about 1 inch greater for December through April by end of century (2070–2100) under the higher scenario (RCP8.5).[4]

Ocean and coastal ecosystems are being affected by large changes in a variety of climate-related environmental conditions. These ecosystems support fishing and aquaculture,[5] tourism and recreation, and coastal communities.[6] Observed and projected increases in temperature, acidification, storm frequency and intensity, and sea levels are of particular concern for coastal and ocean ecosystems, as well as local communities and their interconnected social and economic systems. Increasing temperatures and changing seasonality on the Northeast Continental Shelf have affected marine organisms and the ecosystem in various ways. The warming trend experienced in the Northeast Continental Shelf has been associated with many fish and invertebrate species moving northward and to greater depths.[7,8,9,10,11] Because of the diversity of the Northeast's coastal landscape, the impacts

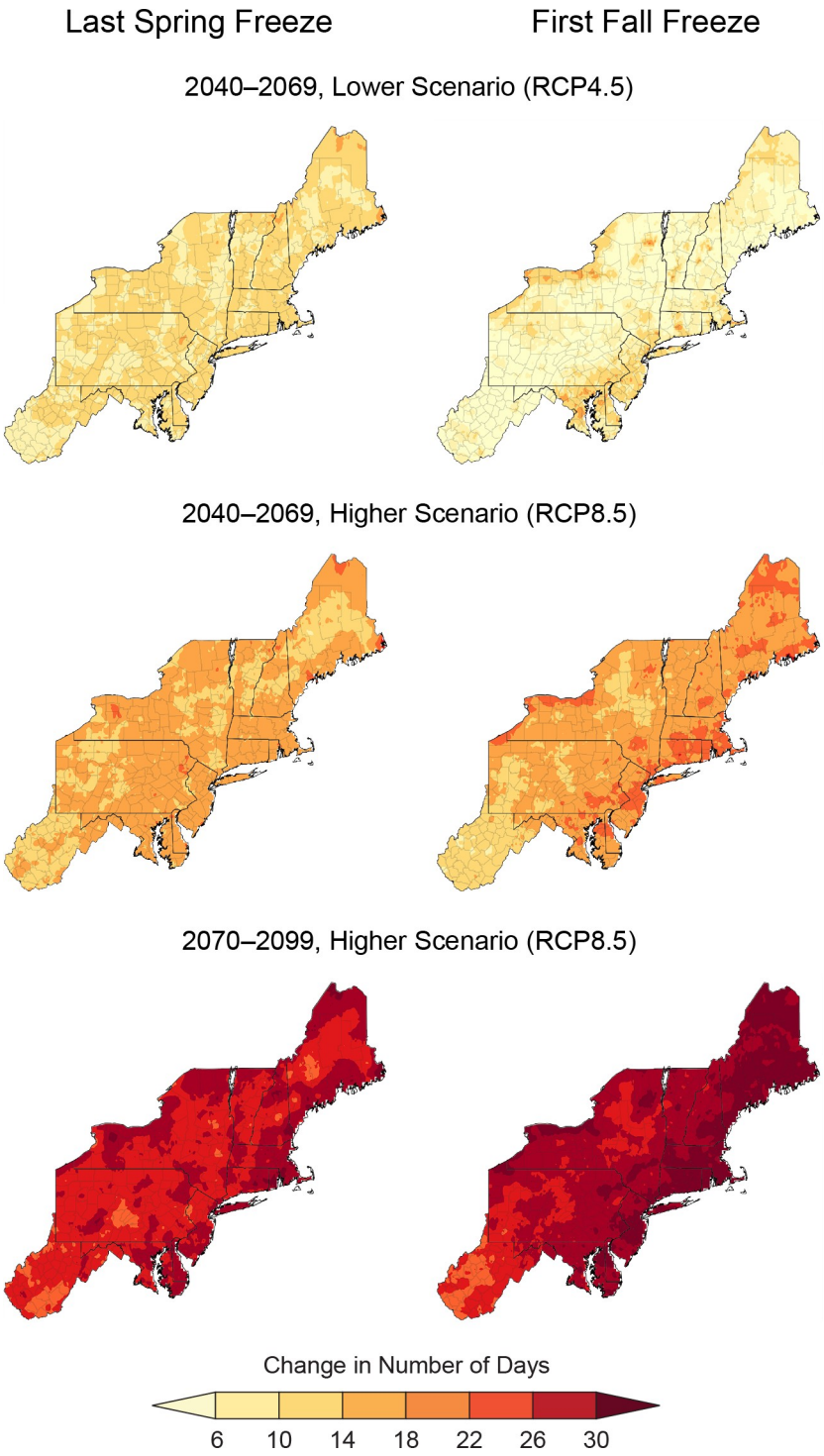
from storms and sea level rise will vary at different locations along the coast.[12,13]

Northeastern cities, with their abundance of concrete and asphalt and relative lack of vegetation, tend to have higher temperatures than surrounding regions due to the urban heat island effect. During extreme heat events, nighttime temperatures in the region's big cities are generally several degrees higher than surrounding regions, leading to higher risk of heat-related death. Urban areas are at risk for large numbers of evacuated and displaced populations and damaged infrastructure due to both extreme precipitation events and recurrent flooding, potentially requiring significant emergency response efforts and consideration of a long-term commitment to rebuilding and adaptation, and/or support for relocation where needed. Much of the infrastructure in the Northeast, including drainage and sewer systems, flood and storm protection assets, transportation systems, and power supply, is nearing the end of its planned life expectancy. Climate-related disruptions will only exacerbate existing issues with aging infrastructure. Sea level rise has amplified storm impacts in the Northeast (Key Message 2), contributing to higher surges that extend farther inland, as demonstrated in New York City in the aftermath of Superstorm Sandy in 2012.[14,15,16] Service and resource supply infrastructure in the Northeast is at increasing risk of disruption, resulting in lower quality of life, economic declines, and increased social inequality.[17] Loss of public services affects the capacity of communities to function as administrative and economic centers and triggers disruptions of interconnected supply chains (Ch. 16: International, Key Message 1).

Increases in annual average temperatures across the Northeast range from less than 1°F (0.6°C) in West Virginia to about 3°F (1.7°C) or more in New England since 1901.[18,19] Although the relative risk of death on very hot days is lower today than it was a few decades ago, heat-related illness and death remain significant public health problems in the Northeast.[20,21,22,23] For example, a study in New York City estimated that in 2013 there were 133 excess deaths due to extreme heat.[24] These projected increases in temperature are expected to lead to substantially more premature deaths, hospital admissions, and emergency department visits across the Northeast.[23,25,26,27,28,29] For example, in the Northeast we can expect approximately 650 additional premature deaths per year from extreme heat by the year 2050 under either a lower (RCP4.5) or higher (RCP8.5) scenario and from 960 (under RCP4.5) to 2,300 (under RCP8.5) more premature deaths per year by 2090.[29]

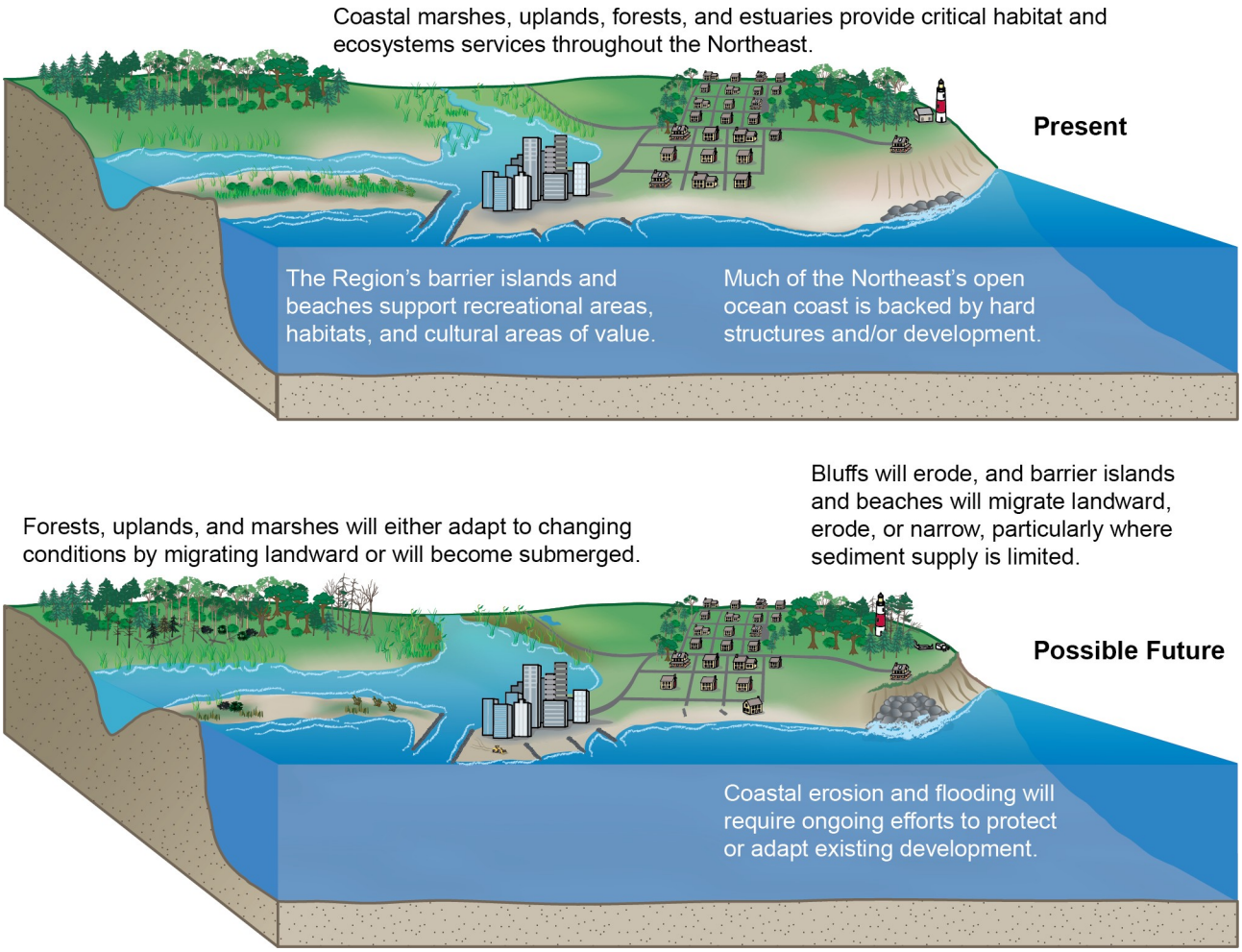
Communities, towns, cities, counties, states, and tribes across the Northeast are engaged in efforts to build resilience to environmental challenges and adapt to a changing climate. Developing and implementing climate adaptation strategies in daily practice often occur in collaboration with state and federal agencies (e.g., New Jersey Climate Adaptation Alliance 2017, New York Climate Clearinghouse 2017, Rhode Island STORMTOOLS 2017, EPA 2017, CDC 2015[30,31,32,33,34]). Advances in rural towns, cities, and suburban areas include low-cost adjustments of existing building codes and standards. In coastal areas, partnerships among local communities and federal and state agencies leverage federal adaptation tools and decision support frameworks (for example, NOAA's Digital Coast, USGS's Coastal Change Hazards Portal, and New Jersey's Getting to Resilience). Increasingly, cities and towns across the Northeast are developing or implementing plans for adaptation and resilience in the face of changing climate (e.g., EPA 2017[33]). The approaches are designed to maintain and enhance the everyday lives of residents and promote economic development. In some cities, adaptation planning has been used to respond to present and future challenges in the built environment. Regional efforts have recommended changes in design standards when building, replacing, or retrofitting infrastructure to account for a changing climate.

Lengthening of the Freeze-Free Period



These maps show projected shifts in the date of the last spring freeze (left column) and the date of the first fall freeze (right column) for the middle of the century (as compared to 1979–2008) under the lower scenario (RCP4.5; top row) and the higher scenario (RCP8.5; middle row). The bottom row shows the shift in these dates for the end of the century under the higher scenario. By the middle of the century, the freeze-free period across much of the Northeast is expected to lengthen by as much as two weeks under the lower scenario and by two to three weeks under the higher scenario. By the end of the century, the freeze-free period is expected to increase by at least three weeks over most of the region. *From Figure 18.3 (Source: adapted from Wolfe et al. 2018[35]).*

Coastal Impacts of Climate Change



(top) The northeastern coastal landscape is composed of uplands and forested areas, wetlands and estuarine systems, mainland and barrier beaches, bluffs, headlands, and rocky shores, as well as developed areas, all of which provide a variety of important services to people and species. (bottom) Future impacts from intense storm activity and sea level rise will vary across the landscape, requiring a variety of adaptation strategies if people, habitats, traditions, and livelihoods are to be protected. *From Figure 18.7 (Source: U.S. Geological Survey)*.

Background

The Northeast region is characterized by four distinct seasons and a diverse landscape that is central to the region's cultural identity, quality of life, and economic success. It is both the most heavily forested and most densely populated region in the country. Residents have ready access to beaches, forests, and other natural areas and use them heavily for recreation. Colorful autumn foliage, winter recreation, and summer vacations in the mountains or at the beach are all important parts of the Northeast's cultural identity, and this tourism contributes billions of dollars to the regional economy. The seasonal climate, natural systems, and accessibility of certain types of recreation are threatened by declining snow and ice, rising sea levels, and rising temperatures. By 2035, and under both lower and higher scenarios (RCP4.5 and RCP8.5), the Northeast is projected to be more than 3.6°F (2°C) warmer on average than during the preindustrial era. This would be the largest increase in the contiguous United States and would occur as much as two decades before global average temperatures reach a similar milestone.[36]

The region's oceans and coasts support a rich maritime heritage and provide an iconic landscape, as well as economic and ecological services. Highly productive marshes,[37,38] fisheries,[39,40] ecosystems,[41,42] and coastal infrastructure[43,44] are sensitive to changing environmental conditions, including shifts in temperature, ocean acidification, sea level, storm surge, flooding, and erosion. Many of these changes are already affecting coastal and marine ecosystems, posing increasing risks to people, traditions, infrastructure, and economies (e.g., Colburn et al. 2016[45]). These risks are exacerbated by increasing demands on these ecosystems to support human use and development. The Northeast has experienced some of the highest rates of sea level rise[46] and ocean warming[39] in the United States, and these exceptional increases relative to other regions are projected to continue through the end of the century.[47,48,49,50]

The Northeast is quite varied geographically, with a wide spectrum of communities including densely populated cities and metropolitan regions and relatively remote hamlets and villages (Figure 18.1). Rural and urban areas have distinct vulnerabilities, impacts, and adaptation responses to climate change.[51,52] The urbanized parts of the Northeast are dependent on the neighboring rural areas' natural and recreational services, while the rural communities are dependent on the economic vitality and wealth-generating capacity of the region's major cities. Rural and urban communities together are under increasing threat of climate change and the resulting impacts, and adaptation strategies reveal their interdependence and opportunities for successful climate resilience.[51] Rural–urban linkages[53,54,55] in the region could also be altered by climate change impacts.

In rural areas, community identity is often built around the prominence of small, multigenerational, owner-operated businesses and the natural resources of the local area. Climate variability can affect human migration patterns[56] and may change flows into or out of the Northeast as well as between rural and urban locations. Published research in this area, however, is limited. The Northeast has long been losing residents to other regions of the country.[57] Droughts and flooding can adversely affect ecosystem function, farm economic viability, and land use. Although future projections of major floods remain ambiguous, more intense precipitation events (Ch. 2: Climate, KM 6)[58] have increased the risk

of some types of inland floods, particularly in valleys, where people, infrastructure, and agriculture tend to be concentrated. With little redundancy in their infrastructure and, therefore, limited economic resilience, many rural communities have limited ability to cope with climate-related changes.

Population Density

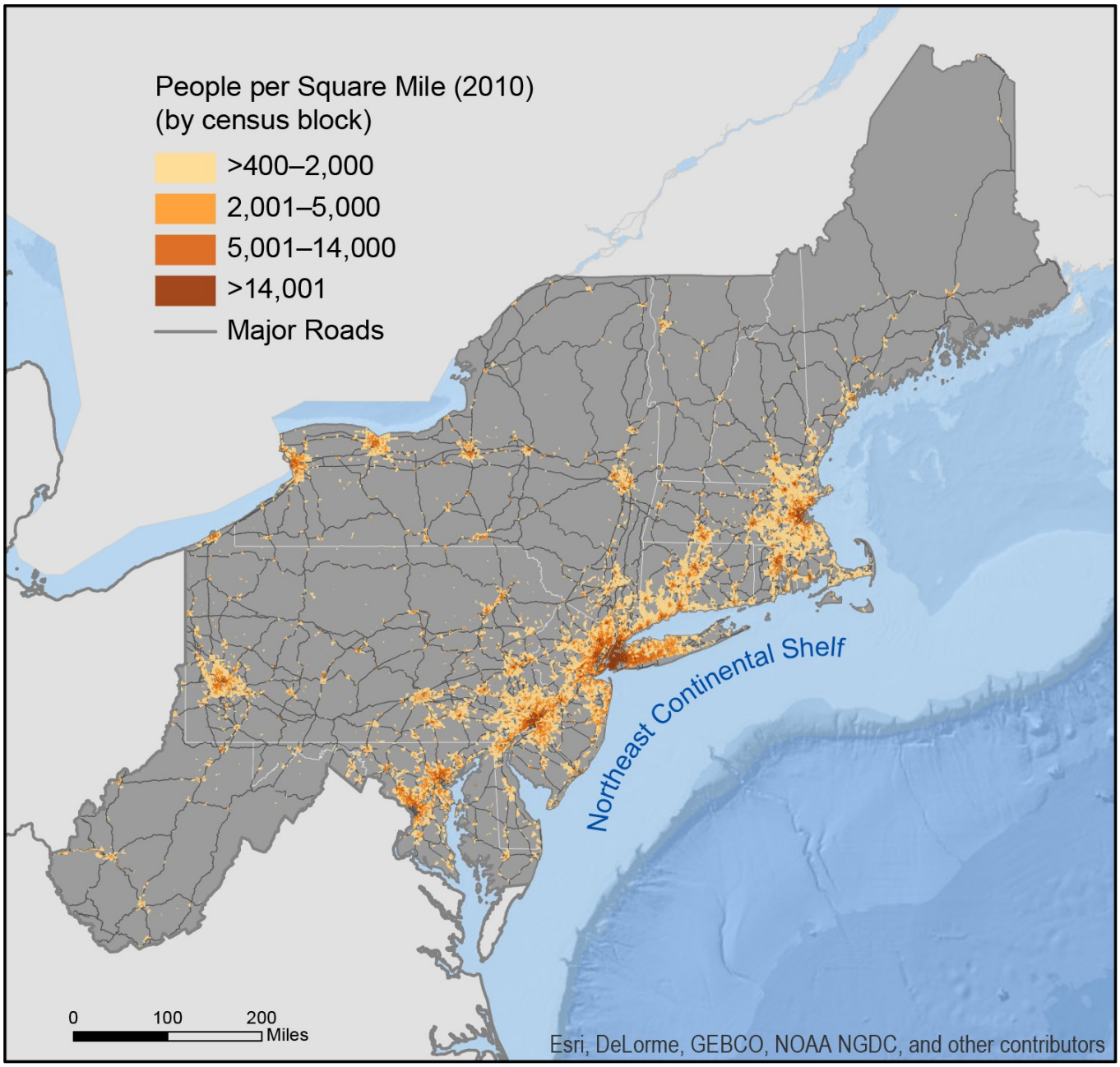


Figure 18.1: A map showing primary roads and population density highlights the diverse characteristics of the region in terms of settlement patterns, interconnections among population centers of varying sizes, and variability in relief across the ocean shelf. Sources: U.S. Department of Transportation, U.S. Geological Survey, and ERT, Inc. *This caption was revised in June 2019. See Errata for details: https://nca2018.globalchange.gov/downloads*

Residents in urban areas face multiple climate hazards, including temperature extremes, episodes of poor air quality, recurrent waterfront and coastal flooding, and intense precipitation events that can lead to increased flooding on urban streams. These physical changes may lead to large numbers of evacuated and displaced populations and damaged infrastructure; sustaining communities may require significant investment and planning to provide emergency response efforts, a long-term commitment to rebuilding and adaptation, and support for relocation. Underrepresented communities, such as the poor, elderly, language-isolated, and recent immigrants, are more vulnerable due to their limited ability to prepare for and cope with extreme weather and climate events.[59] Service infrastructure in the Northeast is at increasing risk of disruption, resulting in lower quality of life, economic declines, and enhanced social inequality.[17] Interdependencies across critical infrastructure sectors such as water, energy, transportation, and telecommunication (and related climate security issues) can lead to cascading failures during extreme weather and climate-related disruptions (Ch. 17: Complex Systems).[17,59,60] The region's high density of built environment sites and facilities, large number of historic structures, and older housing and infrastructure compared to other regions suggest that urban centers in the Northeast are particularly vulnerable to climate shifts and extreme weather events. For example, because much of the historical development of industry and commerce in New England occurred along rivers, canals, coasts, and other bodies of water, these areas often have a higher density of contaminated sites, waste management facilities, and petroleum storage facilities that are potentially vulnerable to flooding. As a result, increases in flood frequency or severity could increase the spread of contaminants into soils and waterways, resulting in increased risks to the health of nearby ecosystems, animals, and people—a set of phenomena well documented following Superstorm Sandy.[61,62,63]

The changing climate of the Northeast threatens the health and well-being of residents through environmental changes that lead to health-related impacts and costs, including additional deaths, emergency room visits and hospitalizations, higher risk of infectious diseases, lower quality of life, and increased costs associated with healthcare utilization. Health impacts of climate change vary across people and communities of the Northeast and depend on social, socioeconomic, demographic, and societal factors; community adaptation efforts; and underlying individual vulnerability (see Key Message 5) (see also Ch. 28: Adaptation).

Maintaining functioning, sustainable communities in the face of climate change requires effective adaptation strategies that anticipate and buffer impacts, while also enabling communities to capitalize upon new opportunities. Many northeastern cities already have or are rapidly developing short-term and long-term plans to mitigate climate effects and to plan for efficient investments in sustainable development and long-term adaptation strategies. Although timely adaptation to climate-related impacts would help reduce threats to people's health, safety, economic well-being, and ways of life, changes to those societal elements will not be avoided completely.

Key Message 1

Changing Seasons Affect Rural Ecosystems, Environments, and Economies

The seasonality of the Northeast is central to the region's sense of place and is an important driver of rural economies. Less distinct seasons with milder winter and earlier spring conditions are already altering ecosystems and environments in ways that adversely impact tourism, farming, and forestry. The region's rural industries and livelihoods are at risk from further changes to forests, wildlife, snowpack, and streamflow.

The distinct seasonality of the Northeast's climate supports a diverse natural landscape adapted to the extremes of cold, snowy winters and warm to hot, humid summers. This natural landscape provides the economic and cultural foundation for many rural communities, which are largely supported by a diverse range of agricultural, tourism, and natural resource-dependent industries (Ch. 10: Ag & Rural, KM 4).[1] The outdoor recreation industry contributes nearly $150 billion in consumer spending to the Northeast economy and supports more than one million jobs across the region.[64] Additionally, agriculture, fishing, forestry, and related industries together generate over $100 billion in economic activity annually, supporting more than half a million jobs in production and processing region-wide.[65] Projected changes in the Northeast's seasons will continue to affect terrestrial and aquatic ecosystems, forest productivity, agricultural land use, and other resource-based industries.[1] Alpine, freshwater aquatic, and certain forest habitats are most at risk.[66] Without efforts to mitigate climate change, warming winters and earlier spring conditions under a higher scenario (RCP8.5) will affect native ecosystems and the very character of the rural Northeast.[67]

Seasonal differences in Northeast temperature have decreased in recent years as winters have warmed three times faster than summers.[3] By the middle of this century, winters are projected to be milder still, with fewer cold extremes, particularly across inland and northern portions of the Northeast.[3] This will likely result in a shorter and less pronounced cold season with fewer frost days and a longer transition out of winter into the growing season.[68] Under the higher scenario (RCP8.5), the trend of decreasing seasonality continues for the northern half of the region through the end of the century, but by then summer temperatures across the Mid-Atlantic are projected to rise faster than those in winter.[4]

A Changing Winter–Spring Transition

Forests are already responding to the ongoing shift to a warmer climate, and changes in the timing of leaf-out affect plant productivity, plant–animal interactions, and other essential ecosystem processes.[69,70] Warmer late-winter and early-spring temperatures in the Northeast have resulted in trends towards earlier leaf-out and blooming, including changes of 1.6 and 1.2 days per decade, respectively, for lilac and honeysuckle (Ch. 7: Ecosystems, Figure 7.3).[71] The increase in growing season length is partially responsible for observed increases in forest growth and carbon sequestration.[72]

While unusual winter or early-spring warmth has caused plants to start growing and emerge from winter dormancy earlier in the spring, the increased vulnerability of species to subsequent cold spells is yet unknown. Early emergence from winter dormancy causes plants to lose their tolerance to cold temperatures and risk damage by temperatures they would otherwise tolerate. Early budbreak followed by hard freezes has led to widespread loss of fruit

crops and reduced seasonal growth of native tree species in the Northeast.[35,73]

Shifting seasonality can also negatively affect the health of forests (Ch. 6: Forests, KM 1) and wildlife, thereby impacting the rural industries dependent upon them. Warmer winters will likely contribute to earlier insect emergence[74] and expansion in the geographic range and population size of important tree pests such as the hemlock woolly adelgid, emerald ash borer, and southern pine beetle.[75,76,77] Increases in less desired herbivore populations are also likely, with white-tailed deer and nutria (exotic South American rodents) already being a major concern in different parts of the region.[78] According to State Farm Insurance,[79] motorists in West Virginia and Pennsylvania are already the first and third group of claimants most likely to file an insurance claim that is deer-related. Erosion from nutria feeding in lower Eastern Shore watersheds of Maryland has resulted in widespread conversion of marsh to shallow open water, changing important ecosystems that can buffer against the adverse impacts from climate change.[80] Species such as moose, which drive a multimillion-dollar tourism industry, are already experiencing increased parasite infections and deaths from ticks.[81,82,83] Warmer spring temperatures are associated with earlier arrivals of migratory songbirds,[84] while birds dependent upon spruce–fir forests in the northern and mountainous parts of the region are already declining and especially vulnerable to future change.[85] Northern and high-elevation tree species such as spruce and fir are among the most vulnerable to climate change in the Northeast.[70,86,87]

A nutria shows off its signature orange teeth. These large South American rodents are already a major concern in parts of the Northeast. Photo credit: ©Jason Erickson/iStock/Getty Images Plus.

Challenges for Natural Resource-Based Industries

Shorter, more moderate winters will present new challenges for rural industries. Poor surface and road conditions or washout have the potential to limit future logging operations, which need frozen or snow-covered soils to meet environmental requirements for winter operations.[70,88] Maple syrup production is linked to climate through potential shifts in sugar maple habitat,[89] tapping season timing and duration,[90,91] and the quality of both the trees and sap.[92,93] Climate change is making sugar maple tapping more challenging by increasing variability within and between seasons. Research into how the industry can adapt to these changes is ongoing.[89,94,95] With changes in weather and ecology come shifts in the cultural relationships to seasons as they have historically existed. Indigenous women from across these northeastern forests have come together to protect and sustain cultural traditions of the land they call Maple Nation. These climate impacts not only threaten the maple tree itself but also the seeds, soil, water, plants, and cultural lifeways that Indigenous peoples and tribal nations in the region associate with them.[96,97]

On the other hand, the impacts of warming on forests and ecosystems during the summer and autumn are less well understood.[98] In the summer, flowering in many agricultural crops and tree fruits is regulated in part by nighttime temperature, and growers risk lower yields as these temperatures rise.[35] Warmer autumn temperatures[98] influence processes such as leaf senescence (the change in leaf color as photosynthesis ceases), fruit ripening, insect phenology,[35] and the start of bird migration and animal hibernation.[99] October temperatures are the best predictor of leaf senescence in the northern hemisphere,[100] but other climatic factors can also shift the timing of autumn processes. Agricultural drought can advance leaf coloring and leaf drop, while abundant soil moisture can delay senescence.[101,102] Early frost events or strong winds can also result in sudden leaf senescence and loss.[98] Many deciduous trees are projected to experience an overall increase in their amount of autumn foliage color.[103]

As Northeast winters warm, scenarios project a combination of less early winter snowfall and earlier snowmelt, leading to a shorter snow season.[104,105] The proportion of winter precipitation falling as rain has already increased and will likely continue to do so in response to a northward shift in the snow–rain transition zone projected under both lower and higher scenarios (RCP4.5 and RCP8.5).[106,107,108] The shift in precipitation type and fewer days below freezing[3,4,35] are expected to result in fewer days with snow on the ground; decreased snow depth, water equivalent, and extent; an earlier snowmelt;[105,109,110] and less lake ice.[111] Warming during the winter–spring transition has already led to earlier snowmelt-related runoff in areas of the Northeast with substantial snowpack (Figure 18.2).[112] Earlier snowmelt-related runoff and lower spring peak streamflows in these areas are expected in the 2041–2095 period compared with the 1951–2005 period.[105]

Historical Changes in the Timing of Snowmelt-Related Streamflow

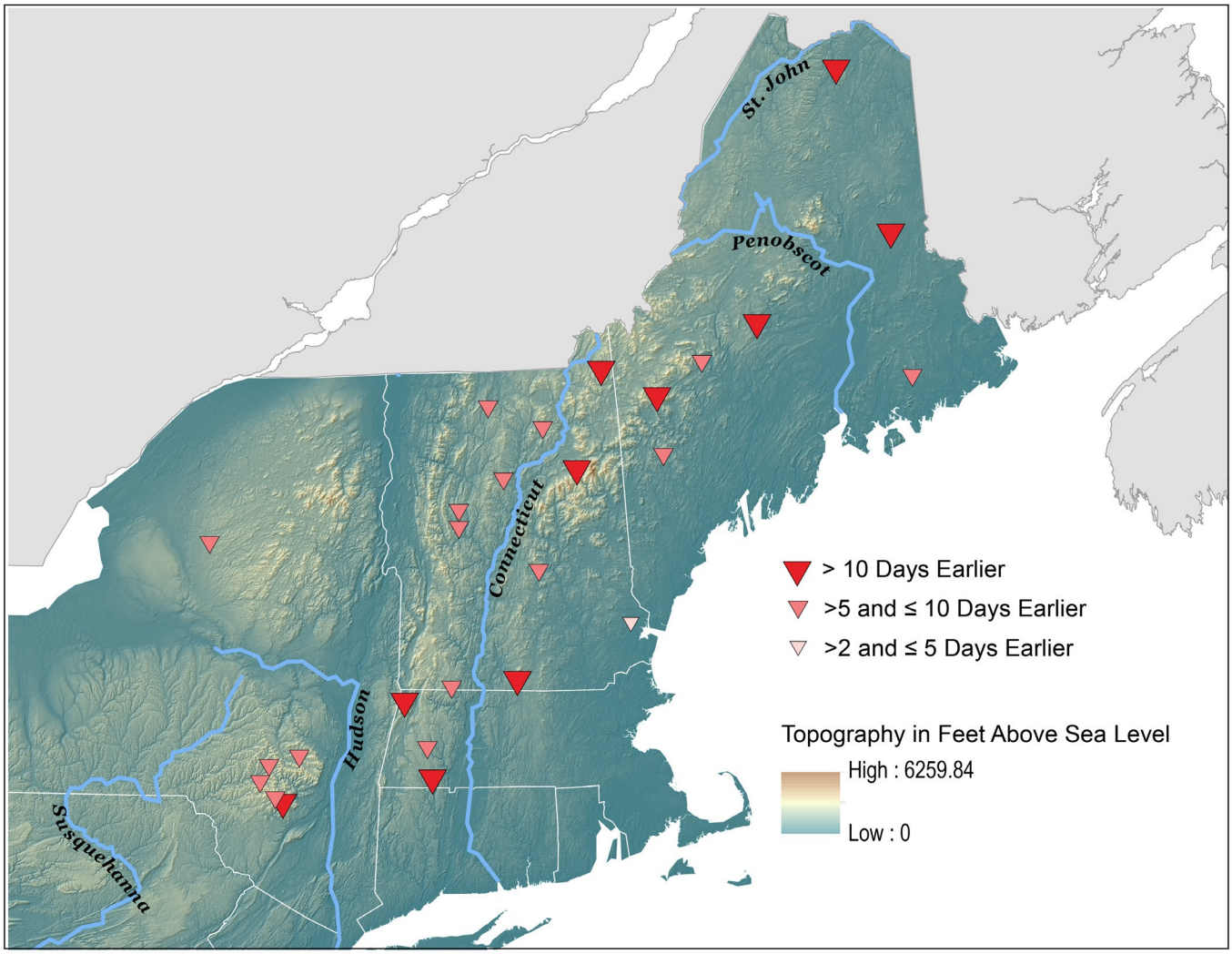


Figure 18.2: This map of part of the Northeast region shows consistently earlier snowmelt-related streamflow timing for rivers from 1960 to 2014. Each symbol represents the change for an individual river over the entire period. Changes in the timing of snowmelt potentially interfere with the reproduction of many aquatic species[113] and impact water-supply reservoir management because of higher winter flows and lower spring flows.[114] The timing of snowmelt-related streamflow in the Northeast is sensitive to small changes in air temperature. The average winter–spring air temperature increase of 1.67°F in the Northeast from 1940 to 2014 is thought to be the cause of average earlier streamflow timing of 7.7 days.[112] The timing of snowmelt-related streamflow is a valuable long-term indicator of winter–spring changes in the Northeast. Source: adapted from Dudley et al. 2017;[112] Digital Elevation Model CGIAR–CSI (CGIAR Consortium for Spatial Information). Reprinted with permission from Elsevier.

The Northeast winter recreation industry is an important economic resource for rural areas, supporting approximately 44,500 jobs and generating between $2.6–$2.7 billion in revenue annually.[115,116] Like other outdoor tourism industries, it is strongly influenced by weather and climate, making it particularly vulnerable to climate change.[116,117,118] Even under the lower scenario (RCP4.5), the average length of the winter recreation season and the number of recreational visits are projected to decrease by mid-century.[118] Under the same scenario, lost time for snowmaking is expected to delay the start of the ski season across southern areas, potentially impacting revenues during the winter holiday season. Activities that rely on natural snow and ice cover are projected to remain economically viable in only far northern parts of the region by end of century under the higher scenario (RCP8.5).[117,118]

Sensitivity to projected changes in winter climate varies geographically, and venues are adapting by investing in artificial snowmaking, opening higher-elevation trails, and offering a greater range of activities and services.[115,117] As the margin for an economically viable winter recreation season (a season with more than 100 days for skiing; more than 50 for snowmobiling) shifts northward and toward higher elevations, some affected areas will be able to extend their seasons with artificial snowmaking. However, the capacity of some vulnerable southern and low-elevation locations to adapt in the long term is expected to be limited by warming nighttime temperatures.[115,116,119] Markets farther north may benefit from a greater share of regional participation depending on recreationist preferences like travel time[118,120] and perceived snow cover conditions informed by local weather, referred to as the backyard effect.[121]

Intense Precipitation

The recent dominant trend in precipitation throughout the Northeast has been towards increases in rainfall intensity,[2,58] with recent increases in intensity exceeding those in other regions in the contiguous United States. Further increases in rainfall intensity are expected,[3] with increases in precipitation expected during the winter and spring with little change in the summer.[4] Monthly precipitation in the Northeast is projected to be about 1 inch greater for December through April by end of century (2070–2100) under the higher scenario (RCP8.5).[4]

Studies suggest that Northeast agriculture, with nearly $21 billion in annual commodity sales,[122] will benefit from the changing climate over the next half-century[35,123] due to greater productivity over a longer growing season (Figure 18.3) (see also Ch. 10: Ag & Rural). However, excess moisture is already a leading cause of crop loss in the Northeast.[35] Recent and projected increases in precipitation amount, intensity, and persistence[124,125] indicate increasing impacts on agricultural operations. Increased precipitation can result in soil compaction,[126] delays in planting, and reductions in the number of days when fields are workable.[127] If the trend in the frequency of heavy rainfall prior to the last frost continues, overly wet fields could potentially prevent Northeast farmers from taking full advantage of an earlier spring.[35] Increased soil erosion and agricultural runoff—including manure, fertilizer, and pesticides[128,129]—are linked to excess nutrient loading of water bodies as well as possible food safety or public health issues from food and waterborne infections.[130] Warmer winters are likely to increase livestock productivity in the Northeast[129] but are expected to also increase pressure from weeds and pests,[35] demand for pesticides,[128] and the risk of human health effects from increased chemical exposures.[130]

The projected changes in precipitation intensity and temperature seasonality would also affect streams and the biological communities that live in them. Freshwater aquatic ecosystems are vulnerable to changes in streamflow, higher temperatures, and reduced water quality.[131] Such ecosystems are especially vulnerable to increases in high flows, decreases in low flows, and the timing of snowmelt.[113,132,133] The impact of heavy precipitation on streamflows partly depends upon watershed conditions such as prior soil moisture and snowpack conditions, which vary throughout the year.[134,135,136,137] Although the annual minimum streamflows have increased during the last century,[138,139,140] late-summer warming[4,141] could lead to decreases in the minimum streamflows in the late summer and early fall by mid-century.[142]

Species that are particularly vulnerable to temperature and flow changes include stream invertebrates, freshwater mussels, amphibians, and coldwater fish.[66,131,143] For example, a recent study of the habitat suitable for dragonflies and damselflies (species that are a good indicator of ecosystem health along rivers) in the Northeast projected, under both the lower and higher scenarios (RCP4.5 and RCP8.5), habitat declines of 45%–99% by 2080, depending on the species.[144] Other particularly vulnerable groups include species with water-dependent habitats, such as salamanders and coldwater fish.[66,145] Increasing temperatures within freshwater streams threaten coldwater fisheries across northern New England and south through the Appalachian Mountains. A decrease in recreational fishing revenue is expected by end of this century under a higher scenario (RCP8.5) with the loss of coldwater habitat.[29,131,146]

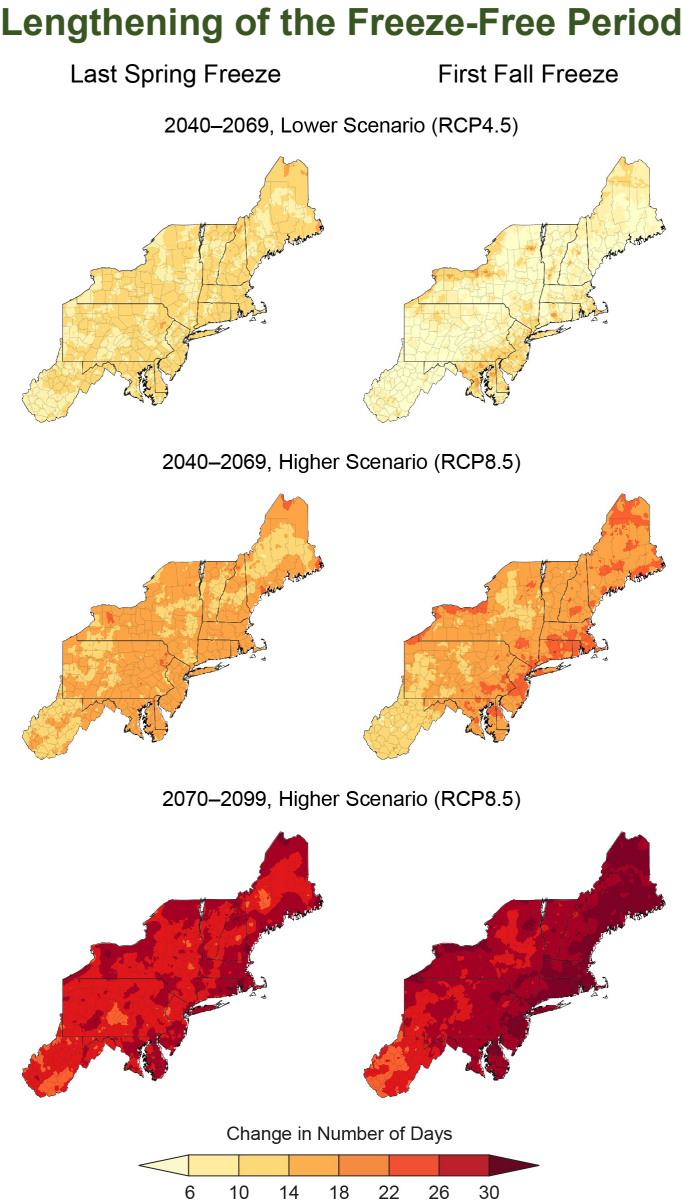


Figure 18.3: These maps show projected shifts in the date of the last spring freeze (left column) and the date of the first fall freeze (right column) for the middle of the century (as compared to 1979–2008) under the lower scenario (RCP4.5; top row) and the higher scenario (RCP8.5; middle row). The bottom row shows the shift in these dates for the end of the century under the higher scenario. By the middle of the century, the freeze-free period across much of the Northeast is expected to lengthen by as much as two weeks under the lower scenario and by two to three weeks under the higher scenario. By the end of the century, the freeze-free period is expected to increase by at least three weeks over most of the region. Source: adapted from Wolfe et al. 2018.[35]

Key Message 2

Changing Coastal and Ocean Habitats, Ecosystem Services, and Livelihoods

The Northeast's coast and ocean support commerce, tourism, and recreation that are important to the region's economy and way of life. Warmer ocean temperatures, sea level rise, and ocean acidification threaten these services. The adaptive capacity of marine ecosystems and coastal communities will influence ecological and socioeconomic outcomes as climate risks increase.

Ocean and coastal ecosystems are being affected by large changes in a variety of climate-related environmental conditions. These ecosystems support fishing and aquaculture,[5] tourism and recreation, and coastal communities.[6] They also provide important ecosystem services (benefits to people provided by the functions of various ecosystems), including carbon sequestration,[147] wave attenuation,[148,149] and fish[150] and shorebird[151] habitats. Observed and projected increases in temperature, acidification, storm frequency and intensity, and sea levels are of particular concern for coastal and ocean ecosystems, as well as local communities and their interconnected social and economic systems (Box 18.1).

Change in Sea Surface Temperature on the Northeast Continental Shelf

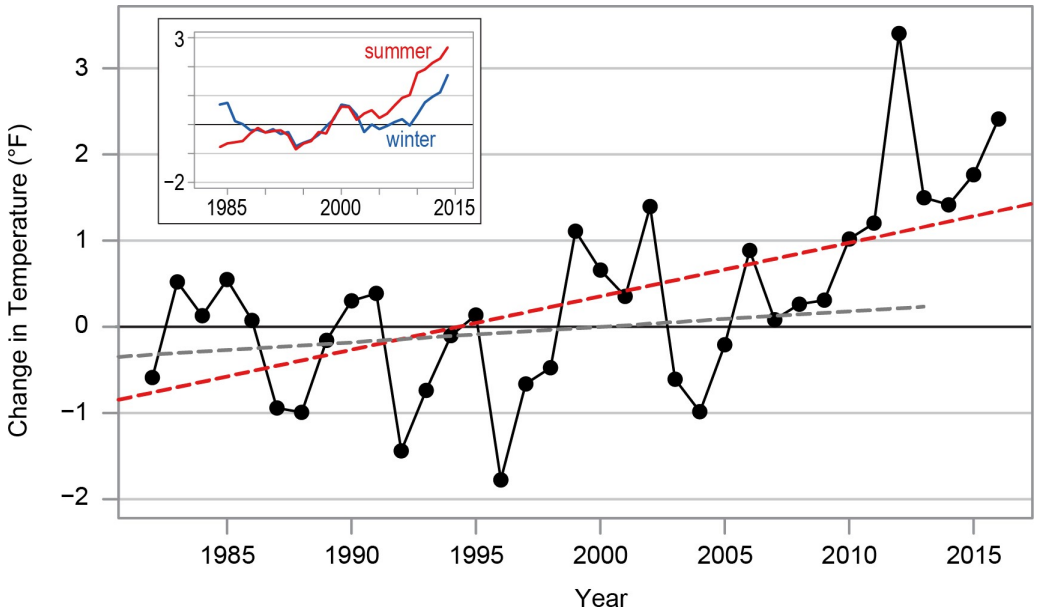


Figure 18.4: The figure shows annual average sea surface temperature (SST) differences from the 1982–2011 average (black dots and line). Over the period 1982–2016, sea surface temperature on the Northeast Continental Shelf has warmed at a rate of 0.06°F (0.033°C) per year (red dashed line). This rate is three times faster than the 1982–2013 global SST warming rate of 0.018°F (0.01°C) per year (gray dotted line).[39] The inset shows Northeast Continental Shelf seasonal SST differences from the 1982–2011 average as five-year rolling means for summer (July, August, September; red line) and winter (January, February, March; blue line). These seasons are centered on the warmest (summer) and coolest (winter) months for Northeast Shelf SSTs. Both seasons have warmed over the time period, but the summer warming rate has been stronger. Source: Gulf of Maine Research Institute.

Ocean Warming

Ocean and coastal temperatures along the Northeast Continental Shelf have warmed by 0.06°F (0.033°C) per year over the period 1982–2016 (Figure 18.4), which is three times faster than the 1982–2013 global average rate of 0.018°F (0.01°C) per year.[39] Over the last decade (2007–2016), the regional warming rate has been four times faster than the long-term trend, with temperatures rising 0.25°F (0.14°C) per year (Figure 18.4). Variability in ocean temperatures over the Northeast Continental Shelf (see Figure 18.1 for the location) has been related to the northern position of the Gulf Stream, the volume of water entering from the Labrador Current, and large-scale background warming of the oceans.[39,48,152,153] In addition to this warming trend, seasonality is also changing. Warming has been strongest during the summer months, and the duration of summer-like sea surface temperatures has expanded.[154] In parts of the Gulf of Maine, the summer-like season lengthened by two days per year since 1982, largely due to later fall cooling; the summer-like period expanded less rapidly (about 1 day per year) in the Mid-Atlantic, primarily due to earlier spring warming.[154]

Increasing temperatures and changing seasonality on the Northeast Continental Shelf have affected marine organisms and the ecosystem in various ways (Ch. 7: Ecosystems, KM 1; Ch. 9: Oceans). Seasonal ocean temperature changes have shifted characteristics of the spring phytoplankton blooms[158] and the timing of fish and invertebrate reproduction,[163,164] migration of marine fish that return to freshwater to spawn,[165,166] and marine fisheries.[155] As the timing of ecosystem conditions and biological events shifts, interactions between species and human activities such as fishing or whale watching will likely be affected.[42,155,163,166,167,168] These changes have the potential to affect economic activity and social features of fishing communities, working waterfronts, travel and tourism, and other natural resource-dependent local economies.

The warming trend experienced in the Northeast Continental Shelf has been associated with many fish and invertebrate species moving northward and to greater depths (Ch. 1: Overview, Figure 1.2h).[7,8,9,10,11] As these shifts have occurred, communities of animals present in a given area have changed substantially.[169] Species interactions can be affected if species do not shift at the same rate; generally, species groups appear to be moving together,[10] but overlap between pairs of specific species has changed.[42]

Rising ocean temperatures have also affected the productivity of marine populations. Species at the southern extent of their range, such as northern shrimp, surf clams, and Atlantic cod, are declining as waters warm,[39,170,171] while other species, such as black sea bass, are experiencing increased productivity.[11] Some species, such as American lobster and surf clam, have declined in southern regions where temperatures have exceeded their biological tolerances but have increased in northern areas as warming waters have enhanced their productivity.[40,171,172,173] The productivity of some harvested and cultured species may also be indirectly influenced by changing levels of marine pathogens and diseases. For example, increasing prevalence of shell disease in lobsters and several pathogens in oysters have been associated with rising water temperatures;[174,175] other pathogens that infect shellfish pose risks to human health (see Key Message 4).

Temperature-related changes in the distribution and productivity of species are affecting fisheries. Some fishermen now travel farther to catch certain species[176] or target new species that are becoming more prevalent as waters warm.[155] However, these types of responses do not always keep pace with ecosystem change due to constraints associated with markets, shoreside infrastructure, and regulatory limits such as access to quota licenses or permits.[177,178,179] In addition, stock assessment and fishery management processes do not explicitly account for temperature

influences on the managed species. In the case of Gulf of Maine cod, rising temperatures have been associated with changes in recruitment, growth, and mortality; failure to account for declining productivity as a result of warming led to catch advice that allowed for overfishing on the stock.[39,180] Proactive conservation and management measures can support climate resilience of fished species. For example, long-standing industry and management measures to protect female and large lobsters have supported the growth of the Gulf of Maine–Georges Bank stock

Box 18.1: Ocean Heat Wave Provides Glimpse of Climate Future

In 2012, sea surface temperatures on the Northeast Continental Shelf rose approximately 3.6°F (2°C) above the 1982–2011 average. This departure from normal was similar in magnitude to the changes projected for the end of the century under the higher scenario (RCP8.5) and represented the largest, most intense warm water event ever observed in the Northwest Atlantic Ocean (Ch. 9: Oceans).[155,156,157] This heat wave altered seasonal cycles of phytoplankton and zooplankton,[158,159] brought Mid-Atlantic fish species into the Gulf of Maine,[155] and altered the occurrence of North Atlantic right whales in the Gulf of Maine.[160] Commercial fisheries were also affected. A fishery for squid developed quickly along the coast of Maine, but the New England lobster fishery was negatively affected. Specifically, early spring warming triggered an early start of the fishing season, creating a glut of lobster in the supply chain and leading to a severe price collapse.[155] During 2012, the dockside price for lobster hit its lowest level in the past decade and dropped from an average per-pound value of $3.62 for June and July 2000–2011 to just $2.37 in those months in 2012. The experience during the 2012 ocean heat wave revealed vulnerabilities in the lobster industry and prompted a variety of adaptive responses, such as expanding processing capacity and further developing domestic and international markets[161] in an attempt to buffer against similar industry impacts in the future. Although an outlier when compared with our current climate, the ocean temperatures in 2012 were well within the range projected for the region by the end of the century under the higher scenario (RCP8.5).[162] The 2012 ocean heat wave provided a glimpse of impacts affecting ecological and social systems, and experiences during this event can serve as a stress test to guide adaptation planning in years to come (akin to 2015 in the Northwest) (see Ch. 24: Northwest, Box 24.7).

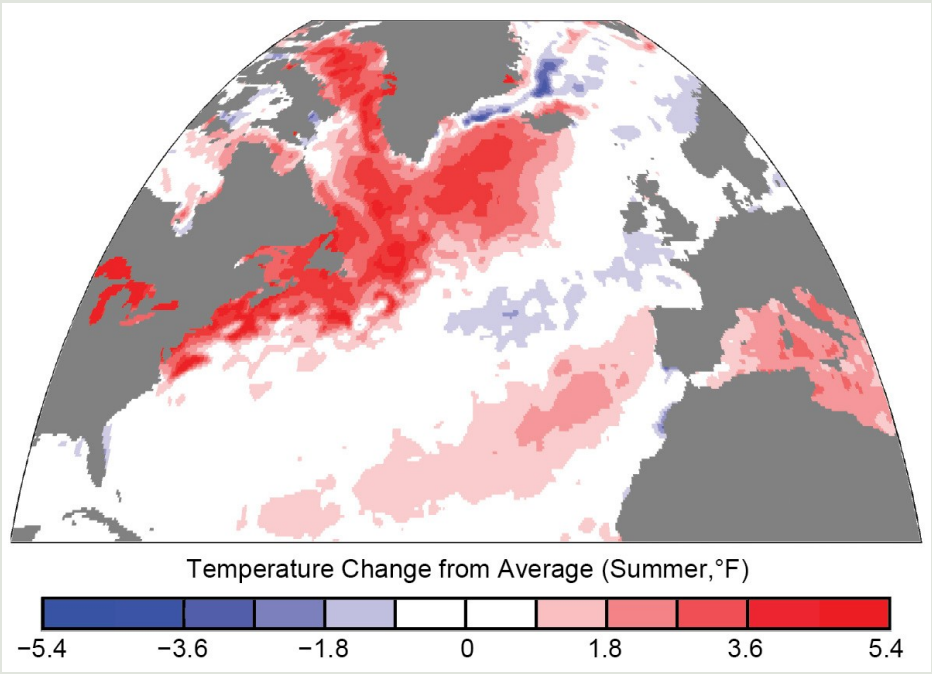


Figure 18.5: The map shows the difference between sea surface temperatures (SST) for June–August 2012 in the Northwest Atlantic and the average values for those months in 1982–2011.[155] While ocean temperatures during 2012 were exceptionally high compared to the current climate, they were within the range of end-of-century temperatures projected for the region under the higher scenario (RCP8.5). This heat wave affected the Northeast Continental Shelf ecosystem and fisheries, and similar extreme events are expected to become more common in the future (Ch. 9: Oceans). Source: adapted from Mills et al. 2013.[155] Reprinted with permission from Elsevier.

as waters warmed, but the lack of these measures in southern New England exacerbated declines in that stock as temperatures increased.[40]

Ocean Acidification

In addition to warming, coastal waters in the Northeast, particularly in the Gulf of Maine, are sensitive to the effects of ocean acidification because they have a low capacity for maintaining stable pH levels.[181,182] These waters are particularly vulnerable to acidification due to hypoxia (low-oxygen conditions)[183] and freshwater inputs, which are expected to increase as climate change progresses.[142,181,184] At the coastal margins, acidification is exacerbated by nutrient loading from land-based runoff and atmospheric deposition during heavy rainfall events. When added to the system, these nutrients promote the growth of algae that release carbon dioxide, which contributes to acidification, as they decay.[185]

Fisheries and aquaculture rely on shell-forming organisms that can suffer in more acidic conditions (Ch. 9: Oceans).[181,182,186] Some of the most valuable wild- and culture-based fisheries in the region harvest shelled organisms—including lobsters, scallops, blue crabs, oysters, surf clams, and mussels.[5] To date, there have been few studies of how local populations and different life stages will be affected by ocean acidification,[182] but actions taken by industry to counter the potential negative impacts are emerging. For example, when an oyster hatchery in Maine experienced low survival rates of larval oysters following exposure to low pH water during large runoff events, it collaborated with scientists to develop systems to monitor and control carbonate conditions in the facility (Ch. 9: Oceans).[187]

Future Projections of Ocean Warming and Acidification

Climate projections indicate that in the future, the ocean over the Northeast Continental Shelf will experience more warming than most other marine ecosystems around the world.[48,49] Continued warming and acidification are expected to further affect species and fisheries in the region. Future projections indicate that declines in the density of a zooplankton species, *Calanus finmarchicus*—an important food source for many fish and whales in the Northeast Shelf region—will occur as waters continue to warm through the end of the century.[188] Northward species distribution trends are projected to continue as ocean waters warm further.[189] A species vulnerability assessment indicated that approximately 50% of the commercial, forage, and protected fish and invertebrate species on the Northeast Continental Shelf will be highly or very highly vulnerable to climate change through 2050 under the higher scenario (RCP8.5).[143] In general, species in the southern portion of the region are expected to remain stable through mid-century, but many species in the northern portion are expected to be negatively affected by warming and acidification over that timeframe.[143,186] Species population models projected forward under future ocean conditions also indicate declines of species that support some of the most valuable and iconic fisheries in the Northeast, including Atlantic cod,[39,190] Atlantic sea scallops,[191] and American lobster.[40] In addition, species that are already endangered and federally protected in the Northeast—such as Atlantic sturgeon, Atlantic salmon, and right whales—are expected to be further threatened by climate change.[192,193,194,195]

Changes in Distribution and Abundance of Marine Species

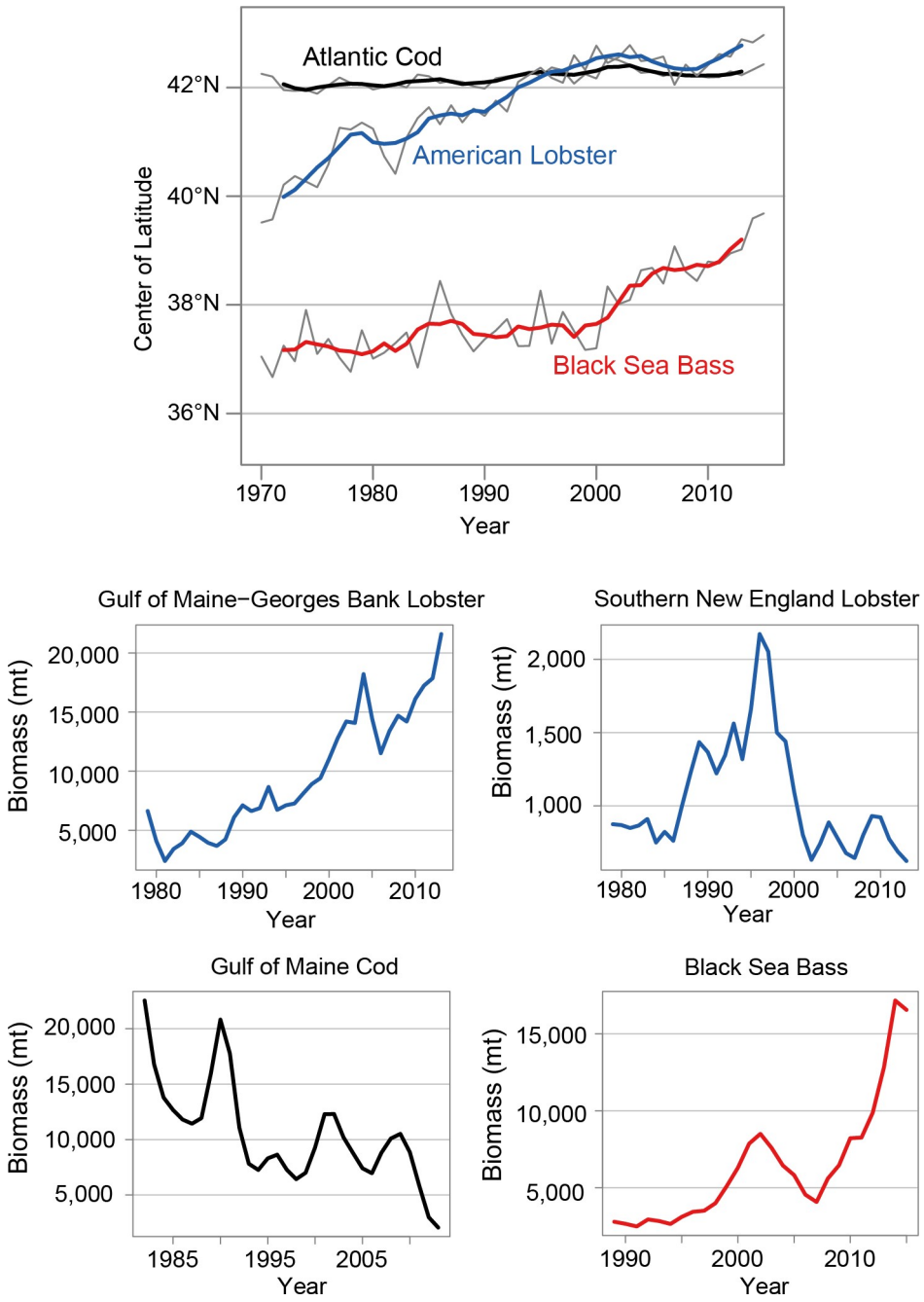


Figure 18.6: The figure shows changes over time in geographic distribution (top panel) and biomass (four bottom panels) for various marine species along the Northeast Shelf. As waters in the region have warmed, the spatial distributions of many fish species have been shifting northward, while population trends of several marine species show more variability over time. The top panel shows shifts in spatial distribution over time for select fish species, based on their latitudinal centers of biomass. The four panels on the bottom show biomass estimates for the same marine resource stocks. Gulf of Maine cod, a coldwater species, has not shifted in location but has declined in biomass, while black sea bass (a warmwater species) has moved northward and increased in biomass as waters have warmed. The lobster distribution shift reflects declines in productivity of the southern stock and increasing biomass of the northern stock. Sources: (black sea bass) adapted from Northeast Fisheries Science Center 2017;[204] (all others) Gulf of Maine Research Institute.

A number of coastal communities in the Northeast region have strong social and cultural ties to marine fisheries, and in some communities, fisheries represent an important economic activity as well.[196,197] Future ocean warming and acidification, which are expected under all scenarios considered, would affect fish stocks and fishing opportunities available to coastal communities. Fisheries targeting species at the southern extent of their range have already experienced substantial declines in landings with rising ocean temperatures,[170,173,198,199,200] and this pattern is projected to continue in the future (e.g., Cooley et al. 2015, Pershing et al. 2015, Le Bris et al. 2018[39,40,191]). Fishers may need to travel farther to fishing locations for species they currently catch,[189] increasing fuel and crew costs. Distribution shifts (Figure 18.6) can also create opportunities to target new species moving into an area.[155] The impacts and opportunities associated with these changes will not be evenly shared within or among fisheries, fleets, or communities; as such, adaptation may alter social dynamics, cultural ties, and economic benefits.[201,202,203]

Sea Level Rise, Storms, and Flooding

Along the Mid-Atlantic coast (from Cape Hatteras, North Carolina, to Cape Cod, Massachusetts), several decades of tide gauge data through 2009 have shown that sea level rise rates were three to four times higher than the global average rate.[46,205,206] The region's sea level rise rates are increased by land subsidence (sinking)—largely due to vertical land movement related to the melting of glaciers from the last ice age—which leaves much of the land in this region sinking with respect to current sea level.[47,207,208,209] Additionally, shorter-term fluctuations in the variability of ocean dynamics,[210,211] atmospheric shifts,[212,213] and ice mass loss from Greenland and Antarctica[214] have been connected to these recent accelerations in the sea level rise rate in the region. For example, a slowdown of the Gulf Stream during a shorter period of extreme sea level rise observed over 2009–2010 has been linked to a weakening of the Atlantic meridional overturning circulation—the northward flow of upper-level warm, salty waters in the Atlantic (including the Gulf Stream current) and the southward flow of colder, deeper waters.[215] These higher-than-average rates of sea level rise measured in the Northeast have also led to a 100%–200% increase in high tide flooding in some places, causing more persistent and frequent (so-called nuisance flooding) impacts over the last few decades.[44,47,216,217]

Coastal flood risks from storm-driven precipitation and surges are major drivers of coastal change[218,219] and are also amplified by sea level increases.[217,220,221] Storms have unique climatological features in the Northeast—Nor'easters (named for the low-pressure systems typically impacting New England and the Mid-Atlantic with strong northeasterly winds blowing from the ocean over coastal areas) typically occur between September and April, and when coupled with the Atlantic hurricane season between June and September, the region is susceptible to major storms nearly year-round. Storm flood heights driven by hurricanes in New York City increased by more than 3.9 feet (1.2 m) over the last thousand years.[14] When coupled with storm surges, sea level rise can pose severe risks of flooding, with consequent physical and mental health impacts on coastal populations (see Key Messages 4 and 5).

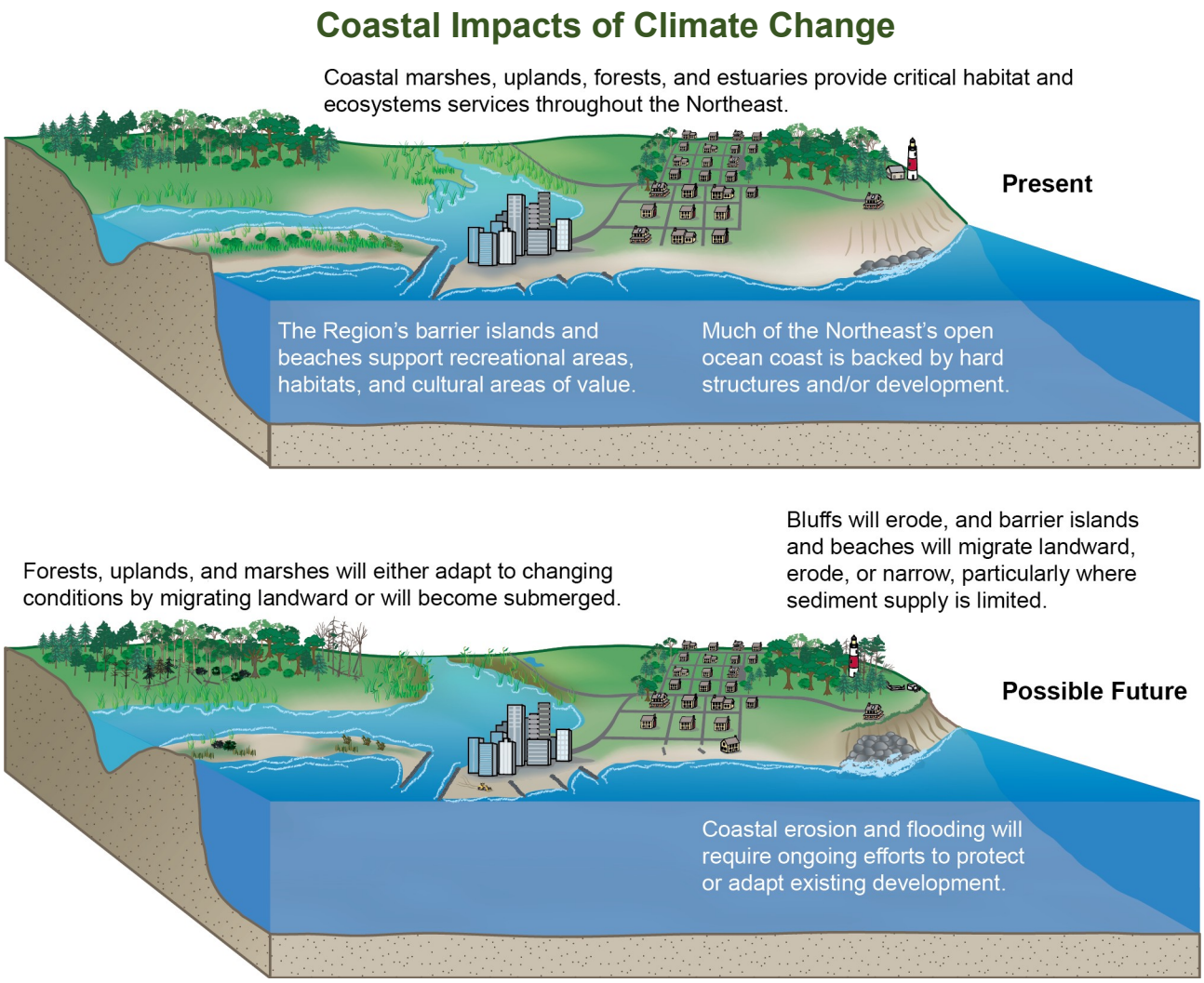


Figure 18.7: (top) The northeastern coastal landscape is composed of uplands and forested areas, wetlands and estuarine systems, mainland and barrier beaches, bluffs, headlands, and rocky shores, as well as developed areas, all of which provide a variety of important services to people and species. (bottom) Future impacts from intense storm activity and sea level rise will vary across the landscape, requiring a variety of adaptation strategies if people, habitats, traditions, and livelihoods are to be protected. Source: U.S. Geological Survey.

Landscape Change and Impacts on Ecosystems Services

Because of the diversity of the Northeast's coastal landscape, the impacts from storms and sea level rise will vary at different locations along the coast (Figure 18.7).[12,13] Rocky and heavily developed coasts have limited infiltration capacity to absorb these impacts, and thus, these low-elevation areas will become gradually inundated.[222,223] However, more dynamic environments, such as mainland and barrier beaches, bluffs, and coastal wetlands, have evolved over thousands of years in response to physical drivers. Such responses include erosion, overwashing, vertical accretion (increasing elevation due to sediment movement), flooding in response to storm events,[218,224,225] and landward migration over the longer term as sea level has risen.[226] Uplands, forests, and agricultural lands can provide transitional areas for these more dynamic settings, wherein the land gradually converts to a tidal marsh.

Varied ecosystem services and natural features have long attracted and sustained people along the coast of the Northeast region. Ecosystem services—including the provisioning of

groundwater resources, the filtering of non-point source pollution, sequestering carbon, mitigating storm impacts and erosion, and sustaining working waterfronts and cultural features such as iconic regional landscapes, recreation, and traditions—are facing multiple climate threats. Marshes and beaches serve as the first line of defense for coastal property and infrastructure in the face of storms.[227] They also provide critical habitat for a variety of migratory shorebirds and, when combined with nearshore seagrass and estuaries, serve as nurseries for many commercial marine species.[37,38,150,151,228,229] Regional marshes trap and store carbon[147,230,231,232] and help to capture non-point source pollution before it enters seawater.[233,234,235] Regional beaches are important tourist and recreational attractions, and many coastal national parks and national historic sites throughout the region help preserve cultural heritage and iconic coastal landscapes.[236,237] The Northeast coast is also home to many Indigenous peoples whose traditions and ways of life are deeply tied to land and water (Box 18.2). Coastal tribes often have limited resources, infrastructure, and land ownership, and these limitations can worsen the impacts of climate change and prohibit relocation (Ch. 15: Tribes, KM 1 and 3).

Box 18.2: Indigenous Peoples and Tribal Nations

Indigenous peoples and tribal nations of the Northeast region have millennia-long relationships with the diverse landscapes and climate zones found throughout the region.[238,239,240] Currently, for the 18 federally recognized, numerous state-recognized, and federally unrecognized tribal nations of the Northeast,[241,242] the challenges of adapting to a changing climate add additional uncertainty to existing efforts for reclamation of land and sovereignty and the revitalization of languages and cultures (Ch. 15: Tribes, KM 1 and 3).[97,243] However, in response to a regional shift in the seasons, there has been an increase in climate adaptation work by tribes over the last decade (Ch.15: Tribes, Figure 15.1). These projects have been framed by Indigenous knowledges to address impacts to culturally and economically important resources and species, such as brown ash, sweetgrass, forests, and sugar maple, as well inland and ocean fisheries.[238,244,245,246] These projects provide important results for the tribal nations themselves but could also provide examples of adaptation and survival for other tribal nations and non-tribal communities to consider as they work towards a deeper and more complex engagement to address future landscapes.[97,240] Although not all tribally led climate research and projects across regions have been reported or published, there are even fewer publicly available examples in the Northeast region, and especially for state-recognized and unrecognized tribes. This seems to present itself as a potential future research opportunity for tribal engagement and collaborations in the Northeast (Ch. 15: Tribes).[97]

Projections of Future Sea Level Rise and Coastal Flooding

Projections for the region suggest that sea level rise in the Northeast will be greater than the global average of approximately 0.12 inches (3 mm) per year.[247,248] According to Sweet et al. (2017),[47] the more probable sea level rise scenarios—the Intermediate-Low and Intermediate scenarios from a recent federal interagency sea level rise report (App. 3: Data & Scenarios)—project sea level rise of 2 feet and 4.5 feet (0.6 m and 1.4 m) on average in the region by 2100, respectively.[47] The worst-case and lowest-probability scenarios, however, project that sea levels in the region would rise upwards of 11 feet (3 m) on average by the end of the century.[47] The higher projections for the region as compared with most others in the United States are due to continued changes in oceanic and atmospheric dynamics, thermal expansion, ice melt contributions from Greenland and Antarctica, and ongoing subsidence in the region due to tectonics and non-tectonic effects such as groundwater withdrawal.[47,50,249,250,251,252] Furthermore, the strongest hurricanes are anticipated to become both more frequent and more intense in the future, with greater amounts of precipitation (Ch. 2: Climate, Box 2.5).[50,253,254,255] Thirty-two percent of open-coast north and Mid-Atlantic beaches are predicted to overwash during an intense future nor'easter type storm,[256] a number that increases to more than 80% during a Category 4 hurricane.[257,258]

Future Adaptability of the Coastal Landscape

The dynamic ability of coastal ecosystems to adapt to climate-driven changes depends heavily upon sufficient sediment supply, elevation and slope, barriers to migration,[225] tidal restrictions, wave climatology,[219,259] and the rates of sea level rise. Although nearly 70% of the Northeast coast has some physical ability to dynamically change,[13] an estimated 88% of the Northeast population lives on developed coastal landforms that have limited ability to naturally adapt to sea level rise.[260] Built infrastructure along the coast, such as seawalls, bulkheads, and revetments, as well as natural barriers, such as coastal bluffs, limits landward erosion; jetties and groins interrupt alongshore sediment supply; and culverts and dams create tidal restrictions that can limit habitat suitability for fish communities (see Figure 18.7).[261] An estimated 26% of open ocean coast from Maine to Virginia contains engineering structures.[262] While these structures can help mitigate hazards to people and property, they also reduce the land area for ecosystem migration, as well as the adaptive capacity of natural coastal environments.[43,227,263,264] The ability of marshes in the region to respond to sea level-induced change varies by location, with some areas increasing in elevation, experiencing vegetation shifts, and/or expanding in extent while others are not.[265,266,267,268,269,270,271] Forest diebacks, or "ghost forests," due to wetland encroachment[70,272] are being observed in southern New Jersey and Maryland (Figure 18.8), although one study found that southern New England forests are not showing similar signs of dieback.[273]

Forest Dieback Due to Sea Level Rise

Figure 18.8: Atlantic white cedars dying near the banks of the Bass River in New Jersey show wetland encroachment on forested areas. Photo credit: Ted Blanco/Climate Central.

Projected changes in climate will threaten the integrity of coastal landforms and ecosystems that provide services people and animals rely on and that act as important natural buffers to hazards. Under more extreme scenarios (such as the higher scenario, RCP8.5), marshes are unlikely to survive and, thus, would convert to open water.[224,274,275] At lower rates of sea level rise, marsh health will depend heavily upon site-specific hydrologic, physical, and sediment supply conditions.[259,275,276,277,278] Long-term coastal erosion, as driven by sea level rise and storms, is projected to continue, with one study finding the shoreline likely to erode inland at rates of at least 3.3 feet (1 m) per year among 30% of sandy beaches along the U.S. Atlantic coast.[279] Continued increases in the rate of sea level rise—on the order of 0.08 inches (2 mm) per year above the 20th-century rate—could cause much of the open ocean coasts in the Mid-Atlantic to transition to a state wherein coastal barrier systems migrate landward more rapidly, experience reductions in width or height, and overwash and breach more frequently.[280] Such an increase is projected to occur this century under the Intermediate-Low scenario, which suggests that global sea levels will rise approximately 0.24 inches (6 mm) per year.[47]

An ongoing challenge, now and in the future, is to adequately account for and determine the monetary value of the ecosystem services provided by marine and coastal environments[6,41,281] and to adaptively manage the ecosystems to achieve targets that are responsive to both development and conservation.[282]

These changes to the coastal landscape would threaten the sustainability of communities and their livelihoods. Historical settlement patterns and ongoing development combine to increase the regional vulnerability of coastal communities to sea level rise, coastal storms, and increased inundation during high tides and minor storms. For example, estimates of coastal property losses and protective investments through 2100 due to sea level rise and storm surge vary from less than $15 billion for southeastern Massachusetts to in excess of $30 billion for coastal New Jersey and Delaware under either the lower (RCP4.5) or higher (RCP8.5) scenarios (discounted at 3%).[29] Saltwater intrusion can also impact drinking water supplies, including the alteration of groundwater systems.[283,284] A growing area of research explores potential migration patterns in response to climate-related coastal impacts, where coastal states such as Massachusetts, New Jersey, and New York are anticipated to see large outflows of migrants, a pattern that would stress regional locations further inland.[285] In addition to property and infrastructure impacts (Key Message 3), the facilities and cultural resources that support coastal tourism and recreation (such as parking lots, pavilions, and boardwalks), as well as cultural landscapes and historic structures,[236,237] will be at increased risk from high tide flooding, storm surge, and long-term inundation. In some locations, these culturally and socially important structures also support economic activity; for example, many fishing communities rely on small docks and other shoreside infrastructure for their fishing operations, increasing the risk of substantial disruption if they are lost to sea level rise and increasing storm frequency.[45,286]

Key Message 3

Maintaining Urban Areas and Communities and Their Interconnectedness

The Northeast's urban centers and their interconnections are regional and national hubs for cultural and economic activity. Major negative impacts on critical infrastructure, urban economies, and nationally significant historic sites are already occurring and will become more common with a changing climate.

Climate–Infrastructure Interaction and Heightened Risks

Northeastern cities, with their abundance of concrete and asphalt and relative lack of vegetation, tend to have higher temperatures than surrounding regions due to the urban heat island effect (increased temperatures, typically measured during overnight periods, in highly urbanized areas in comparison to outlying suburban, exurban, and rural locations). During extreme heat events, nighttime temperatures in the region's big cities are generally several degrees higher than surrounding regions, leading to higher risk of heat-related death. In urban areas, the hottest days in the Northeast are also often associated with high concentrations of urban air pollutants including ground-level ozone (Ch. 13: Air Quality, KM 1). This combination of heat stress and poor urban air quality can pose a major health risk to vulnerable groups: young children, elderly, socially or linguistically isolated, economically disadvantaged, and those with preexisting health conditions, including asthma. Vulnerability is further heightened as key infrastructure, including electricity for air conditioning, is more likely to fail precisely when it is most needed—when demand exceeds available supply—with the potential for substantial negative health consequences.[287] Finally, vulnerability to heat waves is not evenly distributed throughout the region. Rather, outdoor versus indoor air temperatures, baseline health, occupation, and access to air conditioning are important determinants of vulnerability (see Key Message 4).

Urban areas are at risk for large numbers of evacuated and displaced populations and damaged infrastructure due to both extreme precipitation events and recurrent flooding, potentially requiring significant emergency response efforts and consideration of long-term commitment to rebuilding and adaptation, and/or support for relocation where needed. Poor, elderly, historically marginalized, recent immigrants, and linguistically or socially isolated individuals as well as those populations with existing health disparities are more vulnerable to precipitation events and flooding due to a limited ability to prepare for and cope with such events.[59]

Critical Infrastructure Service Disruption

Much of the infrastructure in the Northeast, including drainage and sewer systems, flood and storm protection assets, transportation systems, and power supply, is nearing the end of its planned life expectancy. Current water-related infrastructure in the United States is not designed for the projected wider variability of future climate conditions compared to those recorded in the last century (Ch. 3: Water, KM 2). In order to make Northeast systems resilient to the kind of extreme climate-related disruptions the region has experienced recently—and the sort of disruptions projected for the future—would require significant new investments in infrastructure. For example, in Pennsylvania, bridges are expected to be more prone to damage during extreme weather events, because the state leads the country in the highest percentage of structurally deficient bridges.[288] Pennsylvania's water treatment and wastewater systems are also notably aging, requiring an estimated $28 billion in new

investment over the next 20 years for repairs and to meet increasing demands.[288]

Climate-related disruptions will only exacerbate existing issues with aging infrastructure. Sea level rise has amplified storm impacts in the Northeast region (Key Message 2), contributing to higher surges that extend further inland, as demonstrated in New York City.[14,15,16] Sea level rise is leading to an increase in the frequency of coastal flooding, a trend that is projected to grow for cities such as Baltimore and Washington, DC.[289] High tide flooding has increased by a factor of 10 or more over the last 50 years for many cities in the Northeast region and will become increasingly synonymous with regular inundation, exceeding 30 days per year for an estimated 20 cities by 2050 even under a very low scenario (RCP2.6).[216] More frequent high tide flooding (also referred to as nuisance, or sunny day, flooding) will be experienced at low-elevation cities and towns in the region (Figure 18.9). Sea level rise (see Key Message 2) under higher scenarios will likely increase property losses from hurricanes and other coastal storms for the region by $6–$9 billion per year by 2100, while changes in hurricane activity could raise these estimates to $11–$17 billion per year.[260] In other words, projected future costs are estimated to continue along a steep upward trend relative to what is being experienced today. However, there is limited published research that quantifies the costs associated with increased damage across an entire system in response to amplified storm events. Actions to replace and/or significantly modify the Northeast's aging infrastructure provide opportunities to incorporate climate change adaptation and resilience into standard capital upgrades, reducing these future costs.

Mitigation in the Northeast

The Northeast region has traditionally been a leader in greenhouse gas mitigation action, serving as a potential model for other states. The Regional Greenhouse Gas Initiative is the first mandatory market-based program in the United States to cap and reduce CO_2 emissions from the power sector through a cooperative effort among Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

King Tide Flooding in Northeast

Figure 18.9: The photo shows king tide flooding on Dock Street in Annapolis, Maryland, on December 21, 2012. Photo credit: Amy McGovern (CC BY 2.0).

Impacts on Urban Economies

Service and resource supply infrastructure in the Northeast region is at increasing risk of disruption, resulting in lower quality of life, economic declines, and increased social inequality.[17] Loss of public services affects the capacity of communities to function as administrative and economic centers and triggers disruptions of interconnected supply chains (Ch. 16: International, KM 1). Interdependencies across critical infrastructure sectors such as water, energy, transportation, and telecommunication can lead to cascading failures during extreme weather and climate-related disruptions,[17,59] as occurred during the 2003 blackout in New York City (Ch. 17: Complex Systems, Box 17.5; Ch. 11: Urban). For example, the Northeast is projected to experience a significant increase in summer heat and the number and/or duration of heat waves that will further stress summertime energy peak

load demands from higher air conditioning use and the greater need to pump and treat water. Energy supply failures can also affect transportation operations, and even after electricity is restored, a significant time lag can occur until transportation services such as subway signals and traffic lights return to operation.[290] Understanding and coping with these interdependencies require cross-sector analysis and engagement by the private sector and within and across different levels of government. As a result, the connection between climate impacts, adaptation, and sustained economic development of cities is a major concern in the region.

The large number of manufacturing, distribution, and storage facilities, as well as historic structures, in the region are also vulnerable to climate shifts and extremes. For example, power plants in New York City tend to be located along the coastline for easy access to water for cooling and maritime-delivered fuel and are often located within about 16 feet (5 m) of sea level.[59] This is not unusual, as there are many power plants and petroleum storage facilities located along the Northeast coastline.[291]

The historic preservation community has begun to address the issue of climate change.[292,293] Many historic districts in cities and towns, such as Annapolis, Maryland, and Newport, Rhode Island, are at low elevations along the coast and now face the threat of rising sea levels.

Preparedness in Cities and Towns

Projected increases in coastal flooding, heavy precipitation, runoff, and extreme heat would have negative impacts on urban centers with disproportionate effects on at-risk communities. Larger cities, including Boston, MA, Burlington, VT, Hartford, CT, Newark, NJ, Manchester, NH, New York, Philadelphia, PA, Pittsburgh, PA, Portland, ME, Providence, RI, and Washington, DC, have begun to plan for climate change and in some instances have started to implement action, particularly when upgrading aging infrastructure (e.g., NYC Special Initiative for Rebuilding and Resiliency 2013, Climate Ready Boston 2016, City of Philadelphia 2016, City of Pittsburgh 2017[294,295,296,297]). Examples from municipalities of varying sizes are common (e.g., U.S. EPA 2017[33]). These cities seek to maintain the within-city and intercity connectivity that fosters growth, diversity, liveliness of urban neighborhoods, and protection of vulnerable populations, including the elderly, young, and disadvantaged. Further, city leaders hope to avoid forced migration of highly vulnerable populations and the loss of historical and cultural resources. City managers and stakeholders recognize that extreme heat events, sea level rise, and storm surge have the potential to lead to complex disasters and sustained critical infrastructure damage. Specific actions cities are taking focus largely on promoting the resilience of critical infrastructure, enhancing the social resilience of communities (especially of vulnerable populations), promoting ecosystem service hazard mitigation, and developing new indicators and monitoring systems to achieve a better understanding of climate risks and to identify adaptation strategies (see Key Message 5) (see also Ch. 11: Urban). In the Northeast region, Superstorm Sandy illustrated urban coastal flooding risk, and many localities, not just those directly impacted by the storm, have developed increased coastal resilience plans and efforts. New York City has been able to put in place a broad set of efforts in a variety of critical infrastructure sectors, including making the subway more protected from flooding (Figure 18.10).

Subway Air Vent Flood Protection

Figure 18.10: The photo shows a subway air vent with a multiuse raised flood protection grate that was installed as part of the post–Superstorm Sandy coastal resilience efforts on West Broadway in lower Manhattan, New York City. Photo credit: William Solecki.

Many Northeast cities are served by combined sewer systems that collect and treat both storm water and municipal wastewater. During heavy rain events, combined systems can be overwhelmed and release untreated sewage into local bodies of water.[298] Moderate flooding events are expected to become more frequent in most of the Northeast during the 21st century because of more intense precipitation related to climate change.[58,142] Finally, increased precipitation and high streamflows also increase streambed erosion, especially when coupled with wetter soils prior to storm events.[299,300] Erosion at bridges can cause bridge failures,[301] leading to transportation disruption, injuries, and potential fatalities.

The impacts of changes in precipitation and temperature on water supply system behavior in the Northeast are complex. Future potable water supplies are expected to be adequate to meet future demand on average across the Northeast, but the number of watersheds where demand exceeds supply is projected to increase under most climate change scenarios.[302] Studies of specific water systems in the Northeast show mixed results. The New York City reservoir system shows high resilience and reliability under different climate change scenarios.[303] Projected flows in the Potomac River, the primary water supply for the Washington, DC, metropolitan area, are lower in most climate change scenarios, with minor to major impacts on water supply.[304]

Key Message 4

Threats to Human Health

Changing climate threatens the health and well-being of people in the Northeast through more extreme weather, warmer temperatures, degradation of air and water quality, and sea level rise. These environmental changes are expected to lead to health-related impacts and costs, including additional deaths, emergency room visits and hospitalizations, and a lower quality of life. Health impacts are expected to vary by location, age, current health, and other characteristics of individuals and communities.

Health Effects of Extreme Heat

Present-day high temperatures (heat) have been conclusively linked to a higher risk of illness and death, particularly among older adults, pregnant women, and children (Ch 14: Human Health). A number of studies have replicated these findings specifically in the Northeast (see Box 18.3; e.g., Wellenius et al. 2017, Bobb et al. 2014, Hondula et al. 2012[305,306,307]). Ambient temperatures and heat-related health effects can vary significantly over small geographic areas due to local land cover (for example, due to the urban heat island effect; see Key Message 3) (see also Ch. 5: Land Changes, KM 1), topography, and the resilience of individuals and communities.[307,308] For

example, older or sicker individuals and those persons who are without access to air conditioning, living in older homes, socially isolated, or working outdoors are considered particularly vulnerable to the effects of heat.[309,310,311]

Annual average temperature over the contiguous United States has increased by 1.2°F (0.7°C) over the last few decades and by 1.8°F (1.0°C) relative to the beginning of the last century. Recent decades are the warmest in at least the past 1,500 years.[312] Average annual temperatures across the Northeast have increased from less than 1°F (0.6°C) in West Virginia to about 3°F (1.7°C) or more in New England since 1901.[18,19] Although the relative risk of death on very hot days is lower today than it was a few decades ago, heat-related illness and death remain significant public health problems in the Northeast.[20,21,22,23] For example, a study in New York City estimated that in 2013 there were 133 excess deaths due to extreme heat.[24]

Annual average temperature in the contiguous United States is expected to increase by an additional 2.5°F (1.4°C) over the next few decades regardless of future greenhouse gas emissions (Ch 2: Climate).[50] By 2050, average annual temperatures in the Northeast are expected to increase by 4.0°F (2.2°C) under the lower scenario (RCP4.5) and 5.1°F (2.8°C) under the higher scenario (RCP8.5) relative to the near present (1975–2005),[50] with several more days of extreme heat occurring throughout the region each year.

These projected increases in temperature are expected to lead to substantially more premature deaths, hospital admissions, and emergency department visits due to heat across the Northeast.[23,25,26,27,28,29] For example, in the Northeast we can expect approximately 650 more excess deaths per year caused by extreme heat by 2050 under either a lower or higher scenario (RCP4.5 or RCP8.5) and 960 (under RCP4.5) to 2,300 (under RCP8.5) more excess deaths per year by 2090.[29]

The risks associated with present-day and projected future heat can be minimized by reducing greenhouse gas emissions, minimizing exposure through urban design, or increasing individual and community resilience.[23,29,313] For example, in the Northeast region, Philadelphia and New York City have been leaders in implementing policies and investing in infrastructure aimed at reducing the number of excess deaths from extreme heat.[314] Compared to the higher scenario (RCP8.5), 1,400 premature deaths from extreme temperatures could be avoided in the Northeast each year by 2090 if global greenhouse gas emissions are consistent with the lower scenario (RCP4.5), resulting in $21 billion in annual savings (in 2015 dollars).[29]

Box 18.3: Rising Temperatures and Heat-Related Emergency Room Visits in Rhode Island

Moderate and extreme heat events already pose a health risk today,[305,306,315,316] and climate change could increase this risk. Of note, days of moderate heat occur much more often compared to days of extreme heat, such that days of moderate heat may, in aggregate, be associated with a larger number of adverse health events.[315] Average summertime temperatures are projected to continue to rise through the end of the century, raising concern about the public health impact of climate change across Northeast communities. A nationwide study projected that some of the largest increases in heat-related mortality would occur in the Northeast region, with an additional 50–100 heat-related deaths per year per million people by 2050 and 120–180 additional deaths per million people by 2100 under the mid-high scenario (RCP6.0).[28] Heat health risks seem to be highest at the start of the warm weather each year[317] and among vulnerable populations such as outdoor workers, young children, and the elderly.

Box 18.3: Rising Temperatures and Heat-Related Emergency Room Visits in Rhode Island, *continued*

In the small, coastal northeastern state of Rhode Island (population of about 1 million), maximum daily temperatures in the summer have trended upwards over the last 60 years such that Rhode Islanders experienced about three more weeks of uncomfortably hot weather over 2015–2016 than in the 1950s (Figure 18.11, left panel). A recent study looking at visits to hospital emergency rooms (ERs) found that the risk of heat-related ER visits increased sharply as maximum daily temperatures climbed above 80°F (Figure 18.11, middle panel).[26] The researchers projected that with continued climate change, Rhode Islanders could experience an additional 400 (6.8% more) heat-related ER visits each year by 2050 and up to an additional 1,500 (24.4% more) such visits each year by 2095 under the higher scenario (RCP8.5; Figure 18.11, right panel). Importantly, about 1,000 fewer annual heat-related ER visits are projected for the end of the century under the lower scenario (RCP4.5) compared to the higher scenario (RCP8.5), representing the potential protective benefit of limiting greenhouse gas emissions. Such reductions would also lead to improvements in air pollution and health starting today.[318,319]

In response to the health threat from heat, local National Weather Service offices issue heat advisories and excessive heat warnings when the forecast calls for very hot weather. Based on the results of a study across multiple states,[305] the National Weather Service Northeast Region updated its heat advisory guidelines to be issued when the heat index is forecast to exceed 95°F for any amount of time on two or more days or 100°F for any amount of time on a single day. Many communities in the Northeast have implemented plans to respond to these heat alerts to better protect the public's health (for example, with the Centers for Disease Control and Prevention's Building Resilience Against Climate Effects program), although gaps in knowledge remain.[34,314] Uncertainties exist in the estimation of the cumulative impact on health of multiple aspects of weather, including heat, drought,[320] and heavy precipitation,[321,322,323] all of which have potential adverse impacts on human health.

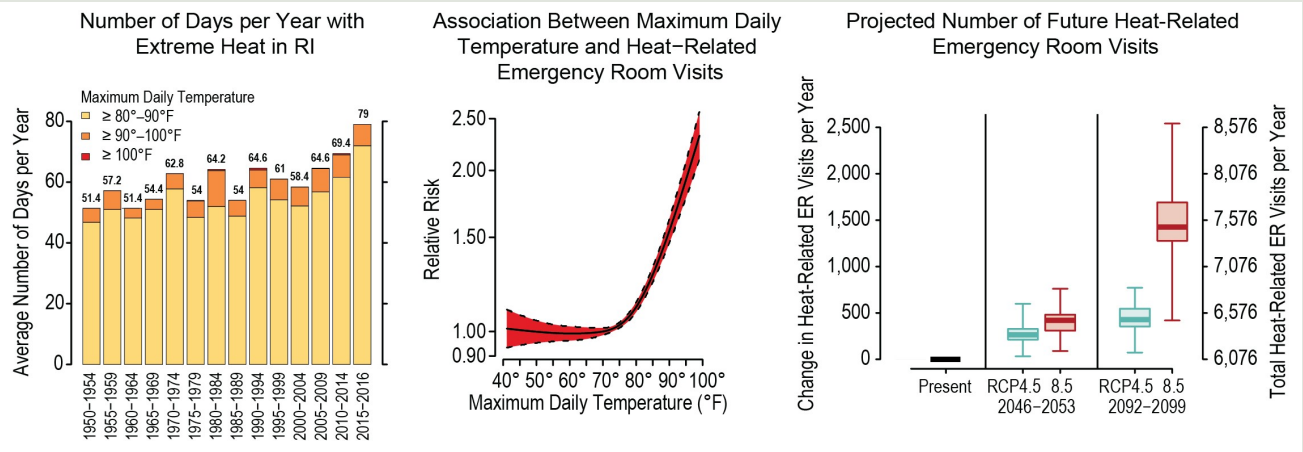


Figure 18.11: This figure shows the observed and projected impacts of excess heat on emergency room visits in Rhode Island. (left) In Rhode Island, maximum daily temperatures in the summer have trended upwards over the last 60 years, such that residents experienced about three more weeks of health-threatening hot weather over 2015–2016 than in the 1950s. (middle) A recent study looking at visits to hospital emergency rooms (ERs) found that the incidence rate of heat-related ER visits rose sharply as maximum daily temperatures climbed above 80°F. (right) The study estimates that with continued climate change, Rhode Islanders could experience an additional 400 (6.8% more) heat-related ER visits each year by 2050 and up to an additional 1,500 (24.4% more) such visits each year by 2095 under the higher scenario (RCP8.5). About 1,000 fewer annual heat-related ER visits are projected for the end of the century under the lower scenario (RCP4.5) compared to the higher scenario (RCP8.5), reflecting the estimated health benefits of adhering to a lower greenhouse gas emissions scenario. Sources: (left) Brown University; (middle, right) adapted from Kingsley et al. 2016.[26] Reproduced from Environmental Health Perspectives.

Health Effects of Air Pollution, Aeroallergens, and Wildfires

Climate change is increasing the risk of illness and death due to higher concentrations of air pollutants in many parts of the United States (Ch. 13: Air Quality). In the Northeast, climate change threatens to reverse improvements in air quality that have been achieved over the past couple of decades. For example, climate change is projected to influence future levels of ground-level ozone pollution in the Northeast by altering weather conditions and impacting emissions from human and natural sources.[324,325,326] This "climate penalty," whereby reductions in ozone precursor emissions are at least partially offset by a changing climate, is projected to lead to substantially more ozone pollution-related deaths;[324,325,327] 200–300 more excess deaths per year by 2050 compared to 2000 by one estimate.[325]

Excess deaths due to ground-level ozone pollution are projected to increase substantially under both lower (RCP4.5) and higher (RCP8.5) scenarios.[327] Reducing global emissions of greenhouse gases from a higher scenario to a lower scenario could prevent approximately 360 deaths per year due to air quality in 2090, saving approximately $5.3 billion per year (in 2015 dollars, undiscounted).[327] Moreover, many sources of the greenhouse gas emissions that contribute to climate change also contribute to degraded air quality today, with adverse effects on people's health. The adverse health risks from air pollution can be reduced in the present and in the future by addressing these common emission sources.[319]

More frequent and severe wildfires due to climate change pose an increasing risk to human health through impacts on air quality (Ch. 13: Air Quality, KM 2). Wildfire smoke can travel hundreds of miles, as occurred in 2015 when Canadian wildfire smoke caused air quality exceedance days in Baltimore, Maryland.[328]

Climate change is also expected to lengthen and intensify pollen seasons in parts of the United States, potentially leading to additional cases of allergic rhinitis (also known as hay fever) and allergic asthma episodes (Ch. 13: Air Quality, KM 3).[29,329] Among individuals with allergic asthma, exposure to certain types of pollen can result in worsening of symptoms leading to increases in allergy medication sales and emergency room visits for asthma, as already documented in New York City.[330]

Indoors, climate change is expected to bring conditions that foster mold growth, such as more dampness, and more frequent power outages that impair ventilation. Damp indoor conditions and mold are both known to be associated with respiratory illnesses including asthma symptoms and wheezing.[331] When damp conditions occur in buildings, rapid action could be warranted—remediation in a northeastern office building after the development of respiratory or severe non-respiratory symptoms by building inhabitants was not effective in reducing symptoms.[332]

Changing Ecosystems and Risk of Vector-Borne Disease

The risk posed by vector-borne diseases (those transmitted by disease-carriers such as fleas, ticks, and mosquitoes) such as Lyme disease and West Nile virus under a changing climate is also of concern in the Northeast region. These diseases, specifically tick-related Lyme disease, have been linked to climate, particularly with abundant late-spring and early-summer moisture. By 2065–2080, under the higher scenario (RCP8.5) it is projected that the period of elevated risk of Lyme disease transmission in the Northeast will begin 0.9–2.8 weeks earlier between Maine and Pennsylvania, compared to the climate observed over 1992–2007).[67] Similarly, a recent analysis estimates that there would be an additional 490 cases of West Nile neuroinvasive disease per year in the Northeast by 2090 under the higher

scenario (RCP8.5) versus 210 additional cases per year under the lower scenario (RCP4.5).[29] The geographic range of suitable habitats for other mosquito vectors such as the northern house mosquito (*Culex pipiens* and *Culex restuans*, which transmit West Nile virus) and the Asian tiger mosquito (*Aedes albopictus*, which can also transmit West Nile virus and other mosquito-borne diseases) is expected to continue shifting northward into New England in the next several decades and through the end of the century as a result of climate change.[333,334]

Gastrointestinal Illness from Waterborne and Foodborne Contaminants

Another consequence of climate change is the spread of marine toxins and pathogens (Key Message 2). Some of these pathogens pose health risks through consumption of contaminated seafood. Harmful algal blooms, which can cause paralytic shellfish poisoning in humans, have become more frequent and longer lasting in the Gulf of Maine.[335] Similarly, pathogenic strains of the waterborne bacteria *Vibrio*—which are already causing thousands of foodborne illnesses per year—have expanded northward and have been responsible for increasing cases of illness in oyster consumers in the Northeast region.[336,337,338]

Combined sewer systems (where municipal wastewater and storm water use the same pipes) are particularly common in the Northeast given the older infrastructure typical of the region.[339] When runoff from heavy precipitation exceeds the capacity of these systems, combined sewer overflow containing untreated sewage is released into local waterways, potentially impacting the quality of water used for recreation or drinking. For example, a study in Massachusetts found an increased risk of gastrointestinal illness with heavy precipitation causing combined sewer overflows.[322] Increased risk of campylobacteriosis and salmonella has been documented in Maryland with increased heavy precipitation and streamflows.[340,341] Moderate flooding events are expected to become more frequent in most of the Northeast during the 21st century because of more intense precipitation related to climate change.[105,142] This could, therefore, increase the frequency of combined sewer overflows and waterborne disease. Some cities and towns are making substantial investments to reduce or eliminate the risks of combined sewer overflows (Figure 18.12).

Storm-related power outages can also pose a risk of foodborne illness.[343] Increased diarrheal illnesses from consumption of spoiled food have also been documented in New York City in 2003 following a power outage that affected millions in the Northeast (Ch. 17: Complex Systems, Box 17.5).[344]

District of Columbia Water and Sewer Authority's Clean Rivers Project

Figure 18.12: The District of Columbia Water and Sewer Authority's Clean Rivers Project[342] aims to reduce combined sewer overflows into area waterways. The Clean Rivers Project is expected to reduce overflows annually by 96% throughout the system and by 98% for the Anacostia River. In addition, the project is expected to reduce the chance of flooding in the areas it serves from approximately 50% to 7% in any given year and reduce nitrogen discharged to the Chesapeake Bay by approximately 1 million pounds per year. Photo credit: Daniel Lobo (CC BY 2.0).

Box 18.4: Role of Public Health and Healthcare Sector in Resilience and Prevention

There are numerous examples of how the public health and healthcare sectors are preparing for climate change and making energy saving changes, as highlighted in the U.S. Department of Health and Human Services' report on enhancing healthcare resilience.[345] One such example occurred in Greenwich, Connecticut, where Greenwich Hospital installed a combined heat and power system that conserves energy and provided stability in the wake of Superstorm Sandy.[346]

In June 2016, severe flooding in West Virginia resulted from a "thousand-year storm"[347] and highlighted the important role of the healthcare sector in building resilience to extreme precipitation events. A recent study of the event described the role of state and federal government working in partnership with healthcare volunteer organizations to effectively mobilize a response in the setting of such a disaster.[348] It emphasized the critical importance of healthcare professionals in providing emotional and mental health support to the response volunteers and the affected communities, as well as a need to increase capacity in these areas.[348] See Key Message 5 in this chapter and Chapter 14: Human Health, Key Message 3 for more information on additional adaptation efforts that protect health.

Figure 18.13: A Red Cross volunteer talks with a community resident after the 2016 West Virginia floods. Additionally, local medical professionals mobilized to staff temporary clinical sites. Photo credit: National Guard Bureau Public Affairs.

Mental Health and Well-Being

In addition to the adverse impacts on people's physical health, climate change is also associated with adverse impacts on mental health (Ch. 14: Human Health, KM 1). Specifically in the Northeast region, sea level rise, storm surge, and extreme precipitation events associated with climate change will contribute to higher risk of flooding in both coastal and inland areas—particularly in urban areas with large amounts of impervious surface that increases water runoff. In addition to the risks of physical injury, waterborne disease, and healthcare service disruption caused by flooding, lasting mental health consequences, such as anxiety, depression, and post-traumatic stress disorder can impact affected communities, as was observed in the wake of Superstorm Sandy in 2012 (Box 18.4).[349] Extreme weather events can have both immediate, short-term effects, as well as longer-term impacts on mental health and well-being that can last years after the specific event.

Extreme heat can also affect mental health and well-being. Higher outdoor temperatures are associated with decreases in subtle aspects of well-being such as decreased joy and happiness[350] and increased aggression and violence.[351] Underlying mental health conditions and geography also affect vulnerability. For example, a study of hospitalization for heat-related illness among people with mental health disorders showed increased risk in rural versus urban areas, possibly due to lower availability of mental health services in these rural areas.[352]

Separately, large population changes from climate-driven human migration could substantially influence both coastal and inland communities in the Northeast region (see also Key Messages 2 and 5).[285] The impacts of human migration on health and well-being depend on myriad factors, including the context of the migration.[353]

Regional Variation in Health Impacts and Vulnerability

Although climate change affects all residents of the Northeast region, risks are not experienced equally. The impact of climate change on an individual depends on the degree of exposure, the individual sensitivity to that exposure, and the individual or community-level capacity to recover (Ch. 14: Human Health, KM 2).[354] Thus, health impacts of climate change will vary across people and communities of the Northeast region depending on social, socioeconomic, demographic, and societal factors; community adaptation efforts; and underlying individual vulnerability (see Key Message 5) (see also Ch. 28: Adaptation). Particularly vulnerable groups include older or socially isolated adults, children, low-income communities, and communities of color.

Key Message 5

Adaptation to Climate Change Is Underway

Communities in the Northeast are proactively planning and implementing actions to reduce risks posed by climate change. Using decision support tools to develop and apply adaptation strategies informs both the value of adopting solutions and the remaining challenges. Experience since the last assessment provides a foundation to advance future adaptation efforts.

Communities, towns, cities, counties, states, and tribes across the Northeast are engaged in efforts to build resilience to environmental challenges and adapt to a changing climate. Developing and implementing climate adaptation strategies in daily practice often occur in collaboration with state and federal agencies (e.g., New Jersey Climate Adaptation Alliance, New York Climate Clearinghouse, Massachusetts StormSmart Coasts and Climate Action Tool, Rhode Island StormTools, EPA, CDC).[30,31,32,33,34,355,356] Advances in rural towns, cities, and suburban areas include low-cost adjustments of existing building codes and standards. In coastal areas, partnerships among local communities and federal and state agencies leverage federal adaptation tools and decision support frameworks (the National Oceanic and Atmospheric Administration's [NOAA] Digital Coast, the U.S. Geological Survey's [USGS] Coastal Change Hazards Portal, New Jersey's Getting to Resilience).

Increasingly, cities and towns across the Northeast region are developing or implementing plans for adaptation and resilience in the face of a changing climate (e.g., EPA 2017[33]). These approaches are designed to maintain and enhance the everyday life of residents and promote economic development. In some cities, adaptation planning has been used to respond to present and future challenges in the built environment. Regional efforts have recommended changes in design standards when building, replacing, or retrofitting infrastructure to account for a changing climate (Box 18.5). For example, the Port Authority of New York and New Jersey provided guidelines for engineers to account for projected changes in temperature, precipitation, and sea level rise when designing infrastructure assets.[357] The cities of Philadelphia, Pennsylvania,[296] Utica, New York,[358] and Boston, Massachusetts,[295] promote the use of green infrastructure to build resilience, particularly in response to flooding risk (Ch. 8: Coastal, Figure 8.2). In Jamaica Bay, New York, post–Superstorm Sandy efforts have fostered a set of local, regional, state, and federal actions that link resilience efforts to current climate risk, along with the potential for accelerated sea level rise and its implications for increased flood frequency (Ch. 28: Adaptation, KM 1).[359]

The issue of water security has emerged from vulnerability assessments and cuts across urban and rural communities. One example is the Washington, DC, metropolitan area's potential use of the Potomac and Occoquan estuaries as water supplies and of retired quarries as water storage facilities.[304] Adaptive reservoir operations have been implemented in the Northeast and other regions of the United States to better manage plausible future climate conditions and to meet other management goals (Ch. 3: Water, KM 3). Tribal nations have also focused on adaptation and the vulnerability of their water supplies, based on long-standing local values and traditional knowledge, including the use of water for drinking, habitat for fish and wildlife, agriculture, and cultural purposes.[97,360,361]

While resilience efforts have focused on microscale adaptations to current climate risks, communities are increasingly seeing a need for larger-scale adaptation efforts. Wide disparities in adaptive capacity exist among communities in the region. Larger, often better-resourced communities have created climate offices and programs, while response has lagged in smaller or poorer communities that are often more dependent on county- or state-level programs and expertise. The move from small-scale to larger-scale and more transformative adaptation efforts involves complex policy transition planning, social and economic development, and equity considerations (Ch. 28: Adaptation, KM 4).[362,363] This includes attention to community concerns about green gentrification—the practice of making environmental improvements in urban areas—that generally increases property values but often also drives out lower-income residents.[364]

Box 18.5: Adapting the Northeast's Cultural Heritage

A defining characteristic of the Northeast region is its rich, dense record of cultural heritage, marked by historic structures, archaeological sites, and cultural landscapes. The ability to preserve this cultural heritage is challenged by climate change. National parks and historic sites in the Northeast are already witnessing cultural resource impacts from climate change, and more impacts are expected in the future.[236] These cultural resources present unique adaptation challenges, and the region is moving forward with planning for future adaptation.

Superstorm Sandy caused substantial damage to coastal New York Harbor parks, including Gateway National Recreation Area and Statue of Liberty National Monument, where buildings and the landscape surrounding the statue and on Ellis Island were impacted and the museum collections were threatened by the loss of climate control systems that were flooded.[370,371] Sea level rise amplifies the impacts of storm events such as Superstorm Sandy, and the parks are using recovery as an opportunity to rebuild with more resilience to future storms.[371,372,373] Heating and electrical systems in historic buildings have been elevated from basement levels. Design changes, such as using non-mold-growing materials and other engineering solutions, have been made while maintaining the buildings' historic character. Following the storm, Gateway National Recreation Area added climate change vulnerability to their planning process for prioritizing historic structures between preserve, stabilize, or ruin. The recreation area has been implementing these priorities as part of the recovery process, providing examples of climate adaptation implementation.[359,374] The human community on Rockaways peninsula also responded to Sandy by using urban forestry and agricultural practices to recover and to buffer against the impact of future storms (see Building Resiliency at the Rockaways 360 tour[375]).

Decision Support Tools and Adaptation Actions

While adaptation is progressing in a variety of forms in the Northeast region, many efforts have focused on assessing risks and developing decision support tools. Many of these assessments and tools have proven useful for specific purposes. Structured decision-making is where decision-makers engage at the outset to define a problem, objectives, alternative management actions, and the consequences and tradeoffs of such actions—before making any decisions. It is being increasingly applied to design management plans, determine research needs, and allocate resources to preserve habitat and resources throughout the region.[151,365,366,367] There has been little attention devoted to evaluating and communicating the suitability and robustness of the many tools that are now available. Efforts to evaluate decision support tools and processes in a rigorous scientific manner would help stakeholders choose the best tools to answer particular questions under specific circumstances.

One significant advancement that communities and infrastructure managers have made in recent years has been the development of risk, impact, and adaptation indicators, as well as monitoring systems to measure and understand climate change and its impacts.[15] In recognizing the economic impacts of infrastructure service loss and disruption, government agencies have begun adaptation analyses to identify those infrastructure elements most critical for regional economic resilience during climate-related disruptions, as well as to identify communities most exposed to acute and chronic climate risks.[45,368,369]

Resource managers, community leaders, and other stakeholders are altering the management of coastal areas and resources in the context of climate change (Boxes 18.6 and 18.7).

Box 18.6: Building Resilience in the Chesapeake Bay Watershed

The Chesapeake Bay watershed is experiencing stronger and more frequent storms, an increase in heavy precipitation events, increasing bay water temperatures, and a rise in sea level. These trends vary throughout the watershed and over time but are expected to continue over the next century under all scenarios considered. The trends are altering both the ecosystems and mainland and island communities of the Chesapeake Bay watershed. Achieving watershed goals would require changes in policies, programs, and/or projects to achieve restoration, sustainability, conservation, and protection goals for the entire system.

To gain a better understanding of the likely impacts of climate change, as well as potential management solutions for the watershed, the 2014 Chesapeake Bay Watershed Agreement committed the NOAA Chesapeake Bay Program (CBP) Partnership to take action to "increase the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure and communities, to withstand adverse impacts from changing environmental and climate conditions." This new Bay Agreement goal builds on the 2010 Total Maximum Daily Load (TMDL) documentation and 2009 Presidential Executive Order 13508[376,377] that called for an assessment of the impacts of a changing climate on the Chesapeake Bay's water quality and living resources. To achieve this goal and regulatory mandates, the CBP Partnership is undertaking efforts to monitor and assess trends and likely impacts of changing climatic and sea level conditions on the Chesapeake Bay ecosystem and to pursue, design, and construct restoration and protection projects to enhance resilience. The CBP Climate

Box 18.6: Building Resilience in the Chesapeake Bay Watershed, *continued*

Resiliency Workgroup's Management Strategy recognizes that it is important to build community and institutional capacity and to develop analytical capability to build cross-science disciplinary knowledge and better understanding of societal responses. A significant activity now underway is geared towards the midpoint assessment of progress towards the 2025 Chesapeake Bay TMDL goal for water quality standard attainment. As part of the TMDL midpoint assessment, the CBP Partnership has developed tools and procedures to quantify the effects of climate change on watershed flows and pollutant loads, storm intensity, increased estuarine temperatures, sea level rise, and ecosystem influences, including loss of tidal wetland attenuation with sea level rise. Current modeling efforts are underway to assess potential climate change impacts under a range of projected climate change outcomes for 2025 and 2050.[378]

Addressing climate change within the context of established watershed planning and regulatory efforts is extremely complex and requires sound climate science, climate assessments, modeling, policy development, and stakeholder engagement (Ch. 28: Adaptation, Figure 28.1). The CBP Partnership is tackling this challenge on all of these fronts, with priority directed to understanding what is needed to achieve the 2025 nutrient reduction goals and the best management practices required to achieve climate-resilient rehabilitation goals.

For example, research in Delaware is exploring the use of seashore mallow as a transitional salt-tolerant crop because of gradual wetland migration onto agricultural lands as sea levels rise.[379] Commercial and recreational fisheries and tourism depend upon living marine resources. Climate adaptation in ocean fisheries will entail coping and long-term planning responses at multiple levels of communities, industry, and management systems.[380] Fishers have traditionally switched species as needed based on ecosystem or market conditions; this will continue to be an important adaptation option, but it is increasingly constrained by regulatory approaches in fisheries.[155,178,179,202] Longer-term planning for climate adaptation has included state commissions to evaluate ocean acidification threats,[381,382] federal efforts to articulate science strategies,[383,384,385] species vulnerability assessments,[143,186] coupled social–ecological vulnerability assessments for fishing communities,[45] and planning for the potential inland migration of coastal populations due to sea level rise.[386]

The winter recreation industry has long considered snowmaking an adaptation to climate change.[387] Snowmaking improvements should assist with the viability of some Northeast ski areas,[117] while new tourism opportunities emerge.[388]

In order to sustain and advance these and other planned efforts towards climate change adaptation and resilience, decision-makers in the Northeast need to be aware of existing constraints and emerging issues. Constraints from the management, economic, and social context are highly uncertain.[389] These efforts have faced a variety of barriers and limitations, including lack of funding and jurisdictional and legal constraints.[390,391] In many cases, adaptation has been limited to coping responses that address short-term needs and are feasible within the current institutional context, whereas longer-term, more transformative efforts will likely require complex policy transition planning and frameworks that can address social and economic equality.[363] The need for solutions that support industry and community flexibility in responding to climate-related changes has also been recognized.[45,178]

Earth's changing climate is one of several stressors on human and natural systems, and it can work to exacerbate existing vulnerabilities and inequalities. Implementing resilience planning and climate change adaptation in

Box 18.7: Science for Balancing Wildlife and Human Needs in the Face of Sea Level Rise

Policymakers, agencies, and natural resource managers are under increasing pressure to manage coastal areas to meet social, economic, and natural resource demands, particularly as sea levels rise. Scientific knowledge of coastal processes and habitat use can support decision-makers as they balance these often-conflicting human and ecological needs. In collaboration with a wide network of natural resource professionals from state and federal agencies (including the U.S. Fish and Wildlife Service and National Park Service) and private conservation organizations, a research team from the U.S. Geological Survey (USGS) is conducting research and developing tools to identify suitable coastal habitats for species of concern, such as the piping plover (*Charadrius melodus*)—an ecologically important species with low population numbers—under a variety of sea level rise scenarios.

The multidisciplinary USGS team uses historical and current habitat availability and coastal characteristics to develop models that forecast likely future habitat from Maine to North Carolina.[392,393] The collaborative partners, both researchers and managers, are critical to the program: they aid in data collection efforts through the "iPlover" smartphone application[394] and help scientists focus research on specific management questions. Because these shorebirds favor sandy beaches that overwash frequently during storms, the resulting habitat maps also define current and future areas of high hazard exposure for humans and infrastructure.

(a)

(b)

(c)

Figure 18.14: (a, b) These photographs show suitable piping plover habitat for (c) rearing chicks along the U.S. Atlantic coast. Photo credits: (a, b) Sara Zeigler, U.S. Geological Survey; (c) Josh Seibel, U.S. Fish and Wildlife Service.

Land-use planners can use results to determine optimal locations for constructing recreational facilities that minimize impacts on sensitive habitats and have a low probability of being overwashed. Alternatively, results can help resource managers proactively protect the highest-quality habitats to meet near- and long-term conservation goals and, in so doing, increase beach access for users by reducing human–bird conflicts and improving the certainty of beach availability for recreational use.

order to preserve the cultural, economic, and natural heritage of the Northeast would require ongoing collaboration among tribal, rural, and urban communities as well as municipal, state, tribal, and federal agencies. The number and scope of existing adaptation plans in the Northeast show that many people in the region consider this heritage to be important.

Acknowledgments

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Opening Image Credit

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Traceable Accounts

Process Description

It is understood that authors for a regional assessment must have scientific and regional credibility in the topical areas. Each author must also be willing and interested in serving in this capacity. Author selection for the Northeast chapter proceeded as follows:

First, the U.S. Global Change Research Program (USGCRP) released a Call for Public Nominations. Interested scientists were either nominated or self-nominated and their names placed into a database. The concurrent USGCRP Call for Public Nominations also solicited scientists to serve as chapter leads. Both lists were reviewed by the USGCRP with input from the coordinating lead author (CLA) and from the National Climate Assessment (NCA) Steering Committee. All regional chapter lead (CL) authors were selected by the USGCRP at the same time. The CLA and CL then convened to review the author nominations list as a "first cut" in identifying potential chapter authors for this chapter. Using their knowledge of the Northeast's landscape and challenges, the CLA and CL used the list of national chapter topics that would be most relevant for the region. That topical list was associated with scientific expertise and a subset of the author list.

In the second phase, the CLA and CL used both the list of nominees as well as other scientists from around the region to build an author team that was representative of the Northeast's geography, institutional affiliation (federal agencies and academic and research institutions), depth of subject matter expertise, and knowledge of selected regional topics. Eleven authors were thus identified by December 2016, and the twelfth author was invited in April 2017 to better represent tribal knowledge in the chapter.

Lastly, the authors were contacted by the CL to determine their level of interest and willingness to serve as experts on the region's topics of water resources, agriculture and natural resources, oceans and marine ecosystems, coastal issues, health, and the built environment and urban issues.

On the due diligence of determining the region's topical areas of focus

The first two drafts of the Northeast chapter were structured around the themes of water resources, agriculture and natural resources, oceans and marine ecosystems, coastal issues, health, and the built environment and urban issues. During the USGCRP-sponsored Regional Engagement Workshop held in Boston on February 10, 2017, feedback was solicited from approximately 150 online participants (comprising transportation officials, coastal managers, urban planners, city managers, fisheries managers, forest managers, state officials, and others) around the Northeast and other parts of the United States, on both the content of these topical areas and important focal areas for the region. Additional inputs were solicited from other in-person meetings such as the ICNet workshop and American Association of Geographers meetings, both held in April 2017. All feedback was then compiled with the lessons learned from the USGCRP CLA-CL meeting in Washington, DC, also held in April 2017. On April 28, 2017, the author team met in Burlington, Vermont, and reworked the chapter's structure around the risk-based framing of interest to 1) changing seasonality, 2) coastal/ocean resources, 3) rural communities and livelihoods, 4) urban interconnectedness, and 5) adaptation.

Key Message 1

Changing Seasons Affect Rural Ecosystems, Environments, and Economies

The seasonality of the Northeast is central to the region's sense of place and is an important driver of rural economies. Less distinct seasons with milder winter and earlier spring conditions (*very high confidence*) are already altering ecosystems and environments (*high confidence*) in ways that adversely impact tourism (*very high confidence*), farming (*high confidence*), and forestry (*medium confidence*). The region's rural industries and livelihoods are at risk from further changes to forests, wildlife, snowpack, and streamflow (*likely*).

Description of evidence base

Multiple lines of evidence show that changes in seasonal temperature and precipitation cycles have been observed in the Northeast.[3,4,109,110,124,154,158] Projected increases in winter air temperatures under lower and higher scenarios (RCP4.5 and RCP8.5)[3,4] will result in shorter and milder cold seasons, a longer frost-free season,[3] and decreased regional snow cover and earlier snowmelt.[108,109,110,395,396,397] Observed seasonal changes to streamflows in response to increased winter precipitation, changes in snow hydrology,[112,138,139,140] and an earlier but prolonged transition into spring[68] are projected to continue.[105]

These changes are affecting a number of plant and animal species throughout the region, including earlier bloom times and leaf-out,[71,73,158] spawning,[164] migration,[84,166,398] and insect emergence,[74] as well as longer growing seasons,[72] delayed senescence, and enhanced leaf color change.[103] Milder winters will likely contribute to the range expansion of wildlife and insect species,[399] increase the size of certain herbivore populations[78] and their exposure to parasitism,[81,82] and increase the vulnerability of an array of plant and animal species to change.[66,103,143]

Warmer winters will likely contribute to declining yields for specialty crops[35] and fewer operational days for logging[88] and snow-dependent recreation.[115,116,118] Excess moisture is the leading cause of crop loss in the Northeast,[35] and the observed increase in precipitation amount, intensity, and persistence is projected to continue under both lower and higher scenarios.[3,4,124,125]

Major uncertainties

Warmer fall temperatures affect senescence, fruit ripening, migration, and hibernation, but are less well studied in the region[98] and must be considered alongside other climatic factors such as drought. Projections for summer rainfall in the Northeast are uncertain,[4] but evaporative demand for surface moisture is expected to increase with projected increases in summer temperatures.[3,4] Water use is highest during the warm season;[141,400] how much this will affect water availability for agricultural use depends on the frequency and intensity of drought during the growing season.[302]

Description of confidence and likelihood

There is *high confidence* that the combined effects of increasing winter and early-spring temperatures and increasing winter precipitation (*very high confidence*) are changing aquatic and terrestrial habitats and affecting the species adapted to them. The impact of changing seasonal temperature, moisture conditions, and habitats will vary geographically and impact interactions

among species. It is *likely* that some will not adapt. There is *high confidence* that over the next century, some species will decline while other species introduced to the region thrive as conditions change. There is *high confidence* that increased precipitation in early spring will negatively impact farming, but the response of vegetation to future changes in seasonal temperature and moisture conditions depends on plant hardiness for *medium confidence* in the level of risk to specialty crops and forestry. A reduction in the length of the snow season by mid-century is *highly likely* under lower and higher scenarios, with *very high confidence* that the winter recreation industry will be negatively impacted by the end of the century under lower and higher scenarios (RCP4.5 and RCP8.5).

Key Message 2

Changing Coastal and Ocean Habitats, Ecosystem Services, and Livelihoods

The Northeast's coast and ocean support commerce, tourism, and recreation that are important to the region's economy and way of life. Warmer ocean temperatures, sea level rise, and ocean acidification (*high confidence*) threaten these services (*likely*). The adaptive capacity of marine ecosystems and coastal communities will influence ecological and socioeconomic outcomes as climate risks increase (*high confidence*).

Description of evidence base

Warming rates on the Northeast Shelf have been higher than experienced in other ocean regions,[39] and climate projections indicate that warming in this region will continue to exceed rates expected in other ocean regions.[48,49] Multiple lines of research have shown that changes in ocean temperatures and acidification have resulted in distribution,[7,8,10] productivity,[39,173,191,401] and phenology shifts[155,158,163,164,166] in marine populations. These shifts have impacted marine fisheries and prompted industry adaptations to changes.[155,176,200]

Research also shows that sea level rise has been[12,46,205,206] and will be higher in the Northeast with respect to the rest of the United States[12,249,250,251] due largely to vertical land movement,[207,208,209] varying atmospheric shifts and ocean dynamics,[210,211,212,213,215,252] and ice mass loss from the polar regions.[214] High tide flooding has increased[216,402] and will continue to increase,[403] and storm surges due to stronger and more frequent hurricanes[50,254,255] have been and will be amplified by sea level rise.[217,220,221,289] Climate-related coastal impacts on the landscape include greater potential for coastal flooding, erosion, overwash, barrier island breaching and disaggregation, and marsh conversion to open water,[12,216,223,226,256,257,258,259,263,279,404] which will directly affect the ability of ecosystems to sustain many of the services they provide. Changes to salt marshes in response to sea level rise have already been observed in some coastal settings in the region, although their impacts are site specific and variable.[265,266,267,268,269,270,271,405] Studies quantifying sea level rise impacts on other types of coastal settings (such as beaches) in the region are more limited; however, there is consensus on what impacts under higher rates of relative sea level rise might look like due to geologic history and modern analogs elsewhere (such as the Louisiana coast).[12,226,404] Although probabilistically low, worst-case sea level rise projections that account for ice sheet collapse[47,406] would result in sea level rise rates far beyond the rates at which natural systems are likely able to adapt,[274,275,280] affecting not only ecosystems function and services but also likely substantially changing the coastal landscape largely through inundation.[223]

Major uncertainties

Although work to value coastal and marine ecosystems services is still evolving,[6,41,281] changes to coastal ecosystem services will depend largely on the adaptability of the coastal landscape, direct hits from storms, and rate of sea level rise, which have identified uncertainties. Lower sea level rise rates are more probable, though the timing of ice sheet collapse[407] and the variability of ocean dynamics are still not well understood[210,211,215] and will dramatically affect the rate of rise.[47,406] It is also difficult to anticipate how humans will contend with changes along the coast[389] and how adjacent natural settings will respond. Furthermore, specific tipping points for many coastal ecosystems are still not well resolved[275,277,280] and vary due to site-specific conditions[224,274]

The Northeast Shelf is sensitive to ocean acidification, and many fisheries in the region are dependent on shell-forming organisms.[181,182,186] However, few studies that have investigated the impacts of ocean acidification on species biology and ecology used native populations from the region[182] or tested the effects at acidification levels expected over the next 20–40 years.[143] Moreover, there are limited studies that consider the effects of climate change in conjunction with multiple other stressors that affect marine populations.[39,40,178,408] Limited understanding of the adaptive capacity of species to environmental changes presents major uncertainties in ecosystem responses to climate change.[143,409] How humans will respond to changes in ecosystems is also not well known, yet these decisions will shape how marine industries and coastal communities are affected by climate change.[45]

Description of confidence and likelihood

Warming ocean temperatures (*high confidence*), acidification (*high confidence*), and sea level rise (*very high confidence*) will alter coastal and ocean ecosystems (*likely*) and threaten the ecosystems services provided by the coasts and oceans (*likely*) in the Northeast. There is *high confidence* that ocean temperatures have caused shifts in the distribution, productivity, and phenology of marine species and *very high confidence* that high tide flooding and storm surge impacts are being amplified by sea level rise. Because much will depend on how humans choose to address or adapt to these problems, and as there is considerable uncertainty over the extent to which many of these coastal systems will be able to adapt, there is *medium confidence* in the level of risk to traditions and livelihoods. It is *likely* that under higher scenarios, sea level rise will significantly alter the coastal landscape, and rising temperatures and acidification will affect marine populations and fisheries.

Key Message 3

Maintaining Urban Areas and Communities and Their Interconnectedness

The Northeast's urban centers and their interconnections are regional and national hubs for cultural and economic activity. Major negative impacts on critical infrastructure, urban economies, and nationally significant historic sites are already occurring and will become more common with a changing climate. (*High Confidence*)

Description of evidence base

The urban built environment and related supply and management systems are at increased risk of disruption from a variety of increasing climate risks. These risks emerge from accelerated sea level rise as well as increased frequency of coastal and estuarine flooding, intense precipitation events, urban heating and heat waves, and drought.

Coastal flooding can lead to adverse health consequences, loss of life, and damaged property and infrastructure.[368] Much of the region's major industries and cities are located along the coast, with 88% of the region's population and 68% of the regional gross domestic product.[260] High tide flooding is also increasingly problematic and costly.[47] Rising sea level and amplified storm events can increase the magnitude and geographic size of a coastal flood event. The frequency of dangerous coastal flooding in the Northeast would more than triple with 2 feet of sea level rise.[93] In Boston, the areal extent of a 1% (1 in 100 chance of occurring in any given year) flood is expected to increase multifold in many coastal neighborhoods.[295] However, there will likely be notable variability across coastal locations. Using the 2014 U.S. National Climate Assessment's Intermediate-High scenario for sea level rise (a global rise of 1.2 meters by 2100), the median number of flood events per year for the Northeast is projected to increase from 1 event per year experienced today to 5 events by 2030 and 25 events by 2045, with significant variation within the region.[410]

Intense precipitation events can lead to riverine and street-level flooding affecting urban environments. Over recent decades, the Northeast has experienced an increase of intense precipitation events, particularly in the spring and fall.[411] From 1958 to 2016, the number of heaviest 1% precipitation events (that is, an event that has a 1% chance of occurring in any given year) in the Northeast has increased by 55%.[58] A recent study suggests that this trend began rather abruptly after 1996, though uniformly across the region.[411]

Urban heating and heat waves threaten the health of the urban population and the integrity of the urban landscape. Due to the urban heat island effect, summer surface temperatures across Northeast cities were an average of 13°F to 16°F (7°C to 9°C) warmer than surrounding rural areas over a three-year period, 2003 to 2005.[412] This is of concern, as rising temperatures increase heat- and pollution-related mortality while also stressing energy demands across the urban environment.[413] However, the degree of urban heat island intensity varies across cities depending on local factors such as whether the city is coastal or inland.[414] Recent analysis of mortality in major cities of the Northeast suggests that the region could experience an additional 2,300 deaths per year by 2090 from extreme heat under RCP8.5 (compared to an estimated 970 deaths per year under the lower scenario, RCP4.5) compared to 1989–2000.[29] Another study that considered 1,692 cities around the world suggested that without mitigation, total economic costs associated with climate change could be 2.6 times higher due to the warmer temperatures in urban versus extra-urban environments.[415]

Changes in temperature and precipitation can have dramatic impacts on urban water supply available for municipal and industrial uses. Under a higher scenario (RCP8.5), the Northeast is projected to experience cumulative losses of $730 million (discounted at 3% in 2015 dollars) due to water supply shortfalls for the period 2015 to 2099.[29] Under a lower scenario (RCP4.5), the Northeast is projected to sustain losses of $510 million (discounted at 3% in 2015 dollars).[29] The losses are largely projected for the more southern and coastal areas in the region.

Major uncertainties

Projecting changes in urban pollution and air quality under a changing climate is challenging given the associated complex chemistry and underlying factors that influence it. For example, fine particulates ($PM_{2.5}$; that is, particles with a diameter of or less than 2.5 micrometers) are affected by cloud processes and precipitation, amongst other meteorological processes, leading to considerable uncertainty in the geographic distribution and overall trend in both modeling analysis and the literature.[29] Land use can also play an unexpected role, such as planting trees as a mitigation option that may lead to increases in volatile organic compounds (VOCs), which, in a VOC-limited environment that can exist in some urban areas such as New York City, may increase ozone concentrations (however, it is noted that most of the Northeast region is limited by the availability of nitrogen oxides).[327]

Interdependencies among infrastructure sectors can lead to unexpected and amplified consequences in response to extreme weather events. However, it is unclear how society may choose to invest in the built environment, possibly strengthening urban infrastructure to plausible future conditions.

Description of confidence and likelihood

There is *high confidence* that weather-related impacts on urban centers already experienced today will become more common under a changing climate. For the Northeast, sea level rise is projected to occur at a faster rate than the global average, potentially increasing the impact of moderate and severe coastal flooding.[47]

By the end of the century and under a higher scenario (RCP8.5), Coupled Model Intercomparison Project Phase 5 (CMIP5) models suggest that annual average temperatures will increase by more than 9°F (16°C) for much of the region (2071–2100 compared to 1976–2005), while precipitation is projected to increase, particularly during winter and spring.[50]

Extreme events that impact urban environments have been observed to increase over much of the United States and are projected to continue to intensify. There is *high confidence* that heavy precipitation events have increased in intensity and frequency since 1901, with the largest increase in the Northeast, a trend projected to continue.[50] There is *very high confidence* that extreme heat events are increasing across most regions worldwide, a trend very likely to continue.[50] Extreme precipitation from tropical cyclones has not demonstrated a clear observed trend but is expected to increase in the future.[50,253] Research has suggested that the number of tropical cyclones will overall increase with future warming.[416] However, this finding is contradicted by results using a high-resolution dynamical downscaling study under a lower scenario (RCP4.5), which suggests overall reduction in frequency of tropical cyclones but an increase in the occurrence of storms of Saffir–Simpson categories 4 and 5.[50]

Key Message 4

Threats to Human Health

Changing climate threatens the health and well-being of people in the Northeast through more extreme weather, warmer temperatures, degradation of air and water quality, and sea level rise (*very high confidence*). These environmental changes are expected to lead to health-related impacts and costs, including additional deaths, emergency room visits and hospitalizations, and a lower quality of life (*very high confidence*). Health impacts are expected to vary by location, age, current health, and other characteristics of individuals and communities (*very high confidence*).

Description of evidence base

Extreme storms and temperatures, overall warmer temperatures, degradation of air and water quality, and sea level rise are all associated with adverse health outcomes from heat,[20,21,22,23,305,306,307] poor air quality,[324,325,326] disease-transmitting vectors,[67,333,334] contaminated food and water,[322,340,341,344] harmful algal blooms,[335] and traumatic stress or health service disruption.[17,349] The underlying susceptibility of populations determines whether or not there are health impacts from an exposure and the severity of such impacts.[307,308]

Major uncertainties

Uncertainty remains in projections of the magnitude of future changes in particulate matter, humidity, and wildfires and how these changes may influence health risks. For example, health effects of future extreme heat may be exacerbated by future changes in absolute or relative humidity.

Health impacts are ultimately determined by not just the environmental hazard but also the amount of exposure, size and underlying susceptibility of the exposed population, and other factors such as health insurance coverage and access to timely healthcare services. In projecting future health risks, researchers acknowledge these challenges and use different analytic approaches to address this uncertainty or note it as a limitation.[23,28,326]

In addition, there is a paucity of literature that considers the joint or cumulative impacts on health of multiple climatic hazards. Additional areas where the literature base is limited include specific health impacts related to different types of climate-related migration, the impact of climatic factors on mental health, and the specific timing and geographic range of shifting disease-carrying vectors.

Description of confidence and likelihood

There is *very high confidence* that extreme weather, warmer temperatures, degradation of air and water quality, and sea level rise threaten the health and well-being of people in the Northeast. There is *very high confidence* that these climate-related environmental changes will lead to additional adverse health-related impacts and costs, including premature deaths, more emergency department visits and hospitalizations, and lower quality of life. There is *very high confidence* that climate-related health impacts will vary by location, age, current health, and other characteristics of individuals and communities.

Key Message 5

Adaptation to Climate Change Is Underway

Communities in the Northeast are proactively planning (*high confidence*) and implementing (*medium confidence*) actions to reduce risks posed by climate change. Using decision support tools to develop and apply adaptation strategies informs both the value of adopting solutions and the remaining challenges (*high confidence*). Experience since the last assessment provides a foundation to advance future adaptation efforts (*high confidence*).

Description of evidence base

Reports on climate adaptation and resilience planning have been published by city, state, and tribal governments and by regional and federal agencies in the Northeast. Examples include the Interstate Commission on the Potomac River Basin (for the Washington, DC, metropolitan area),[304] Boston,[295] the Port Authority of New York and New Jersey,[357] the St. Regis Mohawk Tribe,[360] the U.S. Army Corps of Engineers,[368] the State of Maine,[381] and southeastern Connecticut.[417] Structured decision-making is being applied to design management plans, determine research needs, and allocate resources[365] to preserve habitat and resources throughout the region.[151,366,367]

Major uncertainties

The percentage of communities in the Northeast that are planning for climate adaptation and resilience and the percentage of those using decision support tools are not known. More case studies would be needed to evaluate the effectiveness of adaptation actions.

Description of confidence and likelihood

There is *high confidence* that there are communities in the Northeast undertaking planning efforts to reduce risks posed from climate change and *medium confidence* that they are implementing climate adaptation. There is *high confidence* that decision support tools are informative and *medium confidence* that these communities are using decision support tools to find solutions for adaptation that are workable. There is *high confidence* that early adoption is occurring in some communities and that this provides a foundation for future efforts. This Key Message does not address trends into the future, and therefore likelihood is not applicable.

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