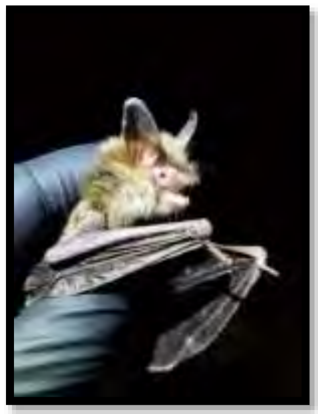
APPENDIX I

Endangered Species Management Plan for Indiana (*Myotis sodalis*) and Northern Long-Eared Bats (*Myotis septentrionalis*) for Camp Dawson Preston County, West Virginia

WEST VIRGINIA ARMY NATIONAL GUARD (WVANG)



Northern long-eared bat (*Myotis septentrionalis*)

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Executive Summary

On behalf of Camp Dawson, as a result of northern long-eared bats (NLEBs) captures and likely Indiana bat calls within Camp Dawson, an Endangered Species Management Plan (ESMP) that includes procedures for managing and protecting the species was prepared.

Based upon MAXENT modeling, 2016 survey results, and ongoing land management practies, three management areas will be designated (two at Briery Tract and one on Pringle Tract) for bats. Camp Dawson will conduct any future tree clearing during winter months (November 15-March 31) to avoid direct take of bats. Bat habitat enhancements implemented by Camp Dawson within the management areas will consist of the onsite girdling of 70 trees, installation of 20 artificial roosts, herbicide treatment, and continued prescribed fire to maintained warm season grass fields (Appendix C) to create and maintain roosting/foraging habitat for bats.

AllStar Ecology, LLC (ASE) recommends consultation with the U.S. Fish and Wildlife Service for notification of proposed management strategies.

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Compliance

Under the Sikes Act (16 USC 670a et seq.), Army Regulation (AR) 200-3, and Department of Defense Instruction 4715.3, the collection of natural resource baseline information at the Camp Dawson Collective Training Area is required (Appendix A). AllStar Ecology, LLC surveyed the area for the presence of Indiana and/or NLEBs during the summer of 2016 (see associated mist netting report). During the presence/absence survey, likely Indiana bat calls were detected and northern long-eared bats (NLEBs) were caught.

Army Regulation (AR) 200-3, Chapter 11 requires any installation having a federally listed (Indiana and NLEBs) or proposed species or critical habitat onsite to prepare an Endangered Species Management Plan (ESMP) that includes procedures for managing and protecting the species.

Goals and Objectives

- To maintain current habitat and increase the overall amount and quality of roosting and foraging habitat for Indiana and NLEBs through artificial roost installation, herbaceous prescribed fire, and girdling of trees

- Conduct ongoing operations at Camp Dawson without adverse effects to bats

Consultation and Coordination

Coordination with the USFWS should be initiated when any future project may affect any amount of potential habitat (e.g., forested area, potential hibernaculum) for Indiana and/or NLEBs (Appendix F). Coordination may result in additional presence/absence surveys or conservation measures being required.

Introduction

Indiana Bat (*Myotis sodalis*)

Geographic Range

The Indiana bat is found only in North America. Its range extends from Iowa, Missouri, and northern Arkansas east to West Virginia and North Carolina, and north into Vermont, New Hampshire, Massachusetts, and New York. The Indiana bat hibernates in the southern reaches of its range in caves during the winter. During the summer months, bats migrate to summer roosting sites (Kurta et al. 2002).

Physical Description

The Indiana bat is a small member of the *Myotis* genus, weighing approximately 7 g (range of 5–11 g) with a forearm length size range of 35 to 41 mm (Barbour and Davis 1969). Their wingspans range from 240–267 mm. Color can vary from dark grey to brown in color and are distinguished from other closely related species such as the little brown bat (*Myotis lucifugus*) by their distinctly keeled calcar, the small piece of cartilage extending from foot along the edge of the tail membrane. The fur of the Indiana bat tends to be less shiny than that of the closely related little brown bat. The female Indiana bat tends to be slightly larger than the male of the species (Whitaker and Hamilton 1998).

Habitat

The Indiana bat hibernates most commonly in limestone cave structures, though some have been located hibernating under exfoliating bark of trees. Temperatures in hibernacula range from 37°F (3.0° C) to 45° F (7.2 ° C) (Brack et al. 2002). They have been identified at elevations ranging from sea level to 5,728 ft (1,746 m). During the summer months (May to August) bats roost under the bark of trees, under bridges, and sometimes in buildings (Barclay and Kurta 2007). Trees used by Indiana bats for summer roosts include shagbark hickories (*Carya ovata*), oaks (*Quercus* spp.), elms (*Ulmus* spp.), maples (*Acer* spp.), pines (*Pinus* spp.), and ash (*Fraxinus* spp.) (Silvis et al. 2016).

Reproduction

Indiana bats are polygynous, with one male mating with multiple females in a colony. Fall swarming, a period of mating and intense foraging prior to hibernation, takes place in October to November near the entrances of hibernacula (Whitaker and Hamilton 1998). Bats copulate in fall, most commonly in October, with females demonstrating delayed fertilization. Females store sperm over winter, allowing for young to be born in early summer at the end of their hibernation period (Barbour and Davis 1969). The gestation period lasts 68 days. Females give birth to one pup per year (on average). Pups are born between late June and early July, with early-born pups potentially volant by mid-July (Fenton 1985). Females form maternity colonies in summer, allowing for the care of young. Males are not present at this time, but form small bachelor colonies. Females feed young through lactation lasting approximately 31 days.

Behavior

Indiana bats are considered social bats, but groups have no documented cases of social hierarchy. While genders typically roost separately during summer, males and females hibernate together during the winter. Maternity colonies contain adult females and juveniles, and rarely contain male bats. Indiana bats migrate seasonally, with bats moving north from winter hibernacula to warmer summer roosts, often travelling thousands of kilometers (Whitaker and Hamilton 1998). The home range of Indiana bats can vary depending on individuals, with an average range size of 625 ha (>1500 acres) during fall months to 225 ha (>550 acres) during spring. Bats do not defend their territories (Rommé et al. 2002).

Indiana bats are insectivorous and use echolocation to maneuver. They have developed eye site, aiding in the long movement from winter to summer roosting locations. Bats have been identified consuming a variety of insect taxa: beetles (*Coleoptera*), flies (*Diptera*), bees and wasps (*Hymenoptera*), butterflies and moths (*Lepidoptera*) and caddisflies (*Trichoptera*). Lactating females have been found eating greater amounts of *Coleopterans* and *Trichopterans* than non-lactating females (Linzey 2001).

Status

The Indiana bat was listed as endangered in 1967 (Endangered Species Preservation Act of 1966; 32 FR 4001) and remains listed as endangered under the Endangered Species Act (ESA) of 1973, as amended. Listing was designated due to increased human disturbance of winter hibernacula, which lead to high mortality rates. They are highly vulnerable to disturbance because they roost in large groups in only a few known locations. The largest hibernaculum documented contained 168,000 individuals (Parham 2016). Other threats to the Indiana bat include loss of summer habitat, commercialization of hibernacula, use of pesticide, and most recently the introduction of a fungus (*Pseudogeomyces destructans*) that causes White-nose syndrome.

Northern long-eared bat (*Myotis septentrionalis*)

Geographical Range

The NLEB bat is only found in North America. Its range extends from southern Canada, south through the Midwest to Louisiana, Mississippi, Alabama, and Georgia. Much is unknown about hibernation sites as the species often hibernates in small groups or singly within cracks and crevices that are inaccessible to biologists. Most hibernacula are relatively close to summer roosting habitat (longest known migration: 56 km) (Foster and Kurta 1999).

Physical Description

The NLEB weighs approximately 7 g (range of 5-9 g) with a forearm length size range of 34 to 38 mm (Caceres and Barclay 2000). Their fur can be medium to dark brown on the ventral side and orange-brown or yellow-brown to light brown on the dorsal side. The total maximum body length is 95 mm. NLEBs can be easily distinguished from other *Myotis* bats in eastern North America based on their long ears and long, pointed tragus.

Habitat

Similar to the Indiana bat, the NLEB hibernates in abandoned mines or caves (Caceres and Barclay 2000). Temperatures in hibernacula range from 33° F (0.6° C) to 57° F (13.9° C) (Webb et al. 1996). Elevations of NLEB habitat vary greatly across their range as it appears that roost-stand selection is related to local landscape history, use, and configuration (Silvis et al. 2016). During the summer months (May to July) bats roost underneath exfoliating bark, within tree cavities/crevices, buildings, and bat boxes (Burke 1999; Foster and Kurta 1999; Broders et al. 2006; Johnson et al. 2012). Trees preferred by NLEBs include black locust (*Robinia pseudoacacia*), maples, shagbark hickory, pines, sassafras (*Sassafras albidum*), sourwood (*Oxydendrum arboreum*), and yellow birch (*Betula alleghaniensis*) (Lacki and Schwierjohann 2001; Perry and Thill 2007; Garroway and Broders 2008; Johnson et al. 2009).

Reproduction

NLEBs males mate with females during fall swarming which can take place from late July until September through early October (Caceres and Barclay 2000). Like Indiana bats, females store sperm over winter and fertilize a single egg in the spring. The gestation period is 60 days (Wisconsin Department of Natural Resources 2016). The young are born between mid-May and mid-June in southeastern portions of its range but as late as mid-July in northern portions (Caceres and Barclay 2000). Females feed young through lactation, with pups typically becoming volant 3 weeks after birth (Wisconsin Department of Natural Resources 2016). Again, like Indiana bats, female NLEBs form maternity colonies in summer allowing for the care of young, while some males form bachelor colonies.

Behavior

Like Indiana bats, male and female NLEBs hibernate together during the winter, with genders roosting separately in summer months. Maternity colonies contain adult females and juveniles, and rarely contain male bats. NLEBs migrate seasonally, with hibernation occurring October-April and bats emerging again in April. Bats then migrate to summer roosts typically located ≤56 km of the hibernacula. The average roosting area varies between 0.3 and 58.3 ha, with clustering of roosts common (Sasse and Pekins 1996; Johnson et al. 2009; Silvis et al. 2014; Silvis et al. 2015). NLEBs typically use a small number of roosts (3-7) (O'Keefe 2009; Krynak 2010; Silvis et al. 2014). Female NLEB have a much larger foraging area at 55.6 ha than males with 13.5 ha (Owen et al. 2003; Broders et al. 2006).

NLEBs are insectivorous and use echolocation to aide in navigation. They have developed eye site, aiding in migration. NLEBs consume a variety of prey through gleaning and aerial hawking (Ratcliffe and Dawson 2003) including: *Lepidoptera* (moths and butterflies), *Neuroptera* (Lacewings, mantiflies), *Coleoptera* (beetles), *Diptera* (true flies), *Hemiptera* (cicadas, aphids), *Ephemeroptera* (mayflies), *Hymenoptera* (wasp and bees), and *Arachnida* (spiders). Lepidoptera are the preferred prey (Brack and Whitaker 2001; Whitaker 2004; Dodd et al. 2012).

Status

The NLEB was listed as threatened in April 2015 and a final 4(d) rule to provide measures necessary and advisable for conservation of the NLEB was published in January 2016. The species remains as threatened under the Endangered Species Act (ESA) of 1973, as amended. Listing was designated due to a severe population decline (in many cases, 90-100%) due to White-nose syndrome. Other threats to the NLEB include loss of summer and winter habitat.

Methods

Management Area Selection

Proposed management areas were selected through an Indiana bat summer habitat suitability model (De La Cruz and Ward 2016), 2016 survey results, and ongoing management practices. The model uses MAXENT (maximum entropy modeling), a machine-learning process to assess the probable distribution of a species by evaluating presence data in combination with available ecological resources (Phillips et al. 2006). Presence data was taken from the presence/absence survey conducted in 2013 at Camp Dawson (De La Cruz et al. 2013). Ecological variables used in the model were slope, landuse/landcover, forest fragmentation, solar radiation, proximity to permanent water, elevation, and aspect. Finally, ArcGIS was used to analyze the data and organize the habitat-suitability distribution into the following classes: poor (0-20%), fair (41-60%), good (61-80%), and high (81-100%) (Appendix E). Good and high areas of habitat suitability were preferred when selecting management areas. The management areas total 140 acres (two sites) and 132 acres for Briery and Pringle Tracts, respectively.

Management Strategies and Actions

The conservation of summer maternity roosts and winter hibernacula is the basis of Myotine bat management in North America (Jung et al. 1999; Menzel et al. 2002; Brooks and Ford 2005; Loeb and O'Keefe 2006). Summer maternity roosts are assumed to be critical, limiting resources for bats in both forested and formerly forested environments (Fenton 1997; Kunz and Fenton 2003). The current consensus is that management efforts should ensure that suitable roosts, particularly maternity roosts, are maintained on the landscape in the long term (Lacki and Schwierjohann 2001; Owen et al. 2004; Perry and Thill 2007).

New Construction

It is recommended any new construction that will require tree clearing be coordinated with USFWS (Appendix F). Per the USFWS, any forested habitat is considered potential Indiana or NLEB habitat. When consulting with USFWS, additional surveys may be required in order to clear. It is also recommended to try and clear in areas of lower quality as indicated by the habitat suitability model (De La Cruz and Ward 2016) (Appendix E).

Seasonal Tree Clearing

To avoid direct take of any Indiana and/or NLEBs Camp Dawson will seasonally cut trees (November 15th-March 31st) when bats are not present on the landscape.

Emergence Surveys

If a small number (1-20) of trees (tree ≥ 3 inches DBH) need to be cut outside of the seasonal tree clearing window (April 1st-November 14th), these trees may be cut but prior approval must be obtained from USFWS. A qualified biologist must perform emergence surveys on trees to be cut. If emergence survey results determine no bats are occupying the trees, trees must be cut the following morning with a qualified biologist present to inspect felled trees for the presence of bats.

Artificial Roost Installation

As an additional method to create summer roosting habitat, artificial roosts in the form of 2-chambered rocket boxes and 4-chambered nursery boxes are proposed to be installed onsite (Appendix B). This past spring, ASE installed several hundred artificial roosts, including rocket and nursery boxes, throughout West Virginia with a total occupancy rate of 42% being observed (ASE unpublished data). Furthermore, seven (7) rocket boxes and two (2) nursery boxes were found to contain NLEB maternity colonies ranging in size from 8–60 individuals (ASE unpublished data). Indiana bats have also been found to occupy rocket boxes (Kiser and Kiser 2004; Tuttle et al. 2013; Bergeson and O'Keefe 2016).

ASE proposes to install 10 of each 2-chambered rocket and 4-chambered nursery box bat houses near sites found to contain Indiana and/or NLEBs within proposed management areas (Appendix C). Placement of artificial roosts will be selected by a qualified biologist onsite. All artificial roosts should be installed between November 15th-March 31st to be available to bats as they enter the landscape post-hibernation. We recommend these artificial roosts will be monitored during the summer (June 1st-August 15th) twice a year for two years to document any bat occupation. If bats are found within any artificial roosts, emergence capture will ensue that evening to determine the bat species occupying the structure (Appendix D).

At the end of each calendar year, artificial roosts should be inspected for damage (e.g., severe leaning, pieces broken off, etc.). If it is determined an artificial roost is damaged beyond repair, the box should be replaced. If monitoring reveals presence of bats within artificial roosts, additional artificial roosts are recommended to be erected within the management area(s) the following year. As NLEBs and Indiana bats regularly use clumped resources, an additional 3-5 artificial roosts are recommended to be installed (Brack 2006). The placement of the artificial roosts should be selected by a qualified biologist onsite.

Tree Girdling

It must be noted that timber resource rights are held by Allegheny Wood Products (AWP) and any tree girdling must be approved by AWP prior to damaging any marketable trees.

In an effort to create additional summer roosting habitat, tree girdling is a method to create additional snags (standing dead trees) (Appendix B). Both Indiana and NLEBs have been found utilizing snags as summer roosts. ASE proposes to girdle 70 trees in clumps of no less than five (5) around sites found to contain Indiana and/or NLEBs within Camp Dawson (Appendix C). Final selection of girdled trees will be performed by a qualified biologist onsite with approval by appropriate Camp Dawson personnel and AWP. Trees selected for girdling will be located primarily within interior forest (Appendix C). Habitat features within the management areas are suitable for the girdling of trees due to the presence of permanent aquatic resources (i.e., wetlands, streams), flyway corridors, and high solar radiation. All trees should be girdled during November 15th-March 31st to be potentially be available to bats as they enter the landscape post-hibernation; note that suitable conditions for roosting in snags requires an advanced stage of tree decay therefore use of killed tree may take years.

Every year, it is recommended to assess created snags to see if they are still standing and determine decay stage. Snags are ephemeral resources and will fall over and become unusable to bats (Kurta et al. 1996; Kurta and Whitaker 1998). ASE recommends replacing any fallen snags by creating an additional snag near the existing snags (within 50 m).

Prescribed Fire

Prescribed fire will be used to maintain existing herbaceous fields to increase the abundance of flying insects (Perry 2011) for Indiana and NLEBs (Appendix C). Because fields will be burned near bat houses (forest edges), these fires should take place before maternity colony formation between April-May (Johnson et al. 2009; Johnson et al. 2010; Perry et al. 2015; Ford et al. 2016) or during winter when bats or not on the landscape, and special care should be taken not to harm the structural integrity of any box.

Sizeable portions of roosts used by Indiana and NLEBs have been located within burned units of forest, being observed locally at the Fernow Experimental Forest located in Tucker County, WV (Perry and Thill 2007; Johnson et al. 2009; Lacki et al. 2009; Johnson et al. 2010; Perry et al. 2015; Ford et al. 2016). Prescribed fires at Camp Dawson have been noted to expand outside of herbaceous units and kill trees, potentially providing additional bat roosts. Both bat species may benefit from prescribed fire because of increases in habitat quality providing an adequate tradeoff for any short-term roost lost (Silvis et al. 2016).

Timber Harvesting

Timber harvesting can be detrimental to bats, but only if the improper approach is taken. Clear-cutting is the most damaging approach to bat habitat as it removes all trees within a designated area. Once an area is clear-cut, it will take decades for the area to become forested again and usable for roosting by bats. With selective clearing enough trees will be left so the area remains viable summer bat habitat.

Selective clearing is the preferred method for timber harvesting in regards to preserving bat habitat. All shagbark hickories (*Carya ovata*), oaks, and early successional tree species such as black locust and sassafras should be kept as these species have been found to be used as roosts by NLEBs and Indiana bats (Lacki and Schwierjohann 2001; Perry and Thill 2007; Garroway and Broders 2008; Johnson et al. 2009). In addition, all snags should be kept as these are also utilized often by bats of both species. The emerald ash borer (*Agrilus planipennis*) is the cause of an ongoing die-off of ash (*Fraxinus* spp.) species throughout the eastern united states (McKenney et al. 2012) which may provide valuable roosting habitat to bats (Womack et al. 2013).

Herbicide Treatment

Herbicides can be used in combination with fire or alone to effectively treat undesirable plant species (e.g., *Rosa multiflora*, *Ailanthus altissima*, *Fallopia japonica*, *Alliaria petiolata*). Some undesirable plant species may be fire resistant or aren't located within the proposed burn unit and herbicides can be used to cover any areas leftover within the proposed management areas. Herbicide treatments vary, but any trees or large shrubs can be effectively eliminated through the hack and squirt technique. This method is useful in that it only targets individual trees and/or shrubs due to the hatchet cut, with little to no chance of drift to desirable species. For small undesirable shrubs, such as *Rosa multiflora*, a foliar applicator can be used. The foliar applicator can be applied with a backpack sprayer and, if used in low winds, can be very target specific as well. It is recommended that an evaluation of the management areas be conducted every year to determine if the areas needs to be treated again for undesirable plant species. With the elimination or suppression of the undesirable plant species insect abundance can increase (Perry 2011) and additional foraging opportunities can be created.

Insecticides

Improper application and broad use of insecticides that target prey species of NLEBs and/or Indiana bats could prove harmful. Carefully read any insecticide labels to determine any potential adverse side effects to NLEB and/or Indiana bat prey species. Broadcast spraying is not recommended as it is not target specific. If insect populations of *Lepidoptera* (moths and butterflies), *Neuroptera* (Lacewings, mantiflies), *Coleoptera* (beetles), *Diptera* (true flies), *Hemiptera* (cicadas, aphids), *Ephemeroptera* (mayflies), *Hymenoptera* (wasp and bees), and *Arachnida* (spiders) are severely depleted by over or misuse of insecticides, bats may have much larger energetic costs to forage farther from their roosts on Camp Dawson (O'Shea and Clark Jr. 2001). Larger energetic costs may reduce fitness, meaning some bats may not make the migratory journey back to winter hibernaculum as their fat reserves are depleted.

Additional Bat Surveys

ASE recommends Indiana and NLEB surveys be performed every 3 years to monitor populations. With *Myotis* species populations declining due to White-nose syndrome, the Indiana and NLEB should be monitored regularly to ensure appropriate management of the species.

It should be noted that, while it was captured in the past, no little browns (*Myotis lucifugus*) were captured in 2016, likely due to increased mortality from WNS. However, Camp Dawson's population of small-footed bats (*Myotis leibii*) appears stable and should be monitored into the future.

Table 1. Yearly Management Tasks for Camp Dawson Management Areas from 2021-2025.

Yearly Management Tasks (2021-2025)	
2021	
Before April	Erect artificial roosts/girdle trees
June-September	Apply herbicide in management areas
June 1st-August 15th	Check artificial roost occupancy
September-December	Check artificial roosts for damage
	Check snags
2022	
Before April	Erect replacement or additional artificial roosts/girdle trees
June-September	Apply herbicide in management areas (if necessary)
June 1st-August 15th	Check artificial roost occupancy
October-December	Check artificial roosts for damage
	Check snags
2023	
Before April	Erect replacement or additional artificial roosts/girdle trees
June 1st-August 15th	Summer survey
June-September	Apply herbicide in management areas (if necessary)
October-December	Check artificial roosts for damage
	Check snags
2024	
Before April	Erect replacement or additional artificial roosts/girdle trees
June-September	Apply herbicide in management areas (if necessary)
October-December	Check artificial roosts for damage
	Check snags
2025	
Before April	Erect replacement artificial roosts/girdled trees
June-September	Apply herbicide in management areas (if necessary)
October-December	Check artificial roosts for damage
	Check snags

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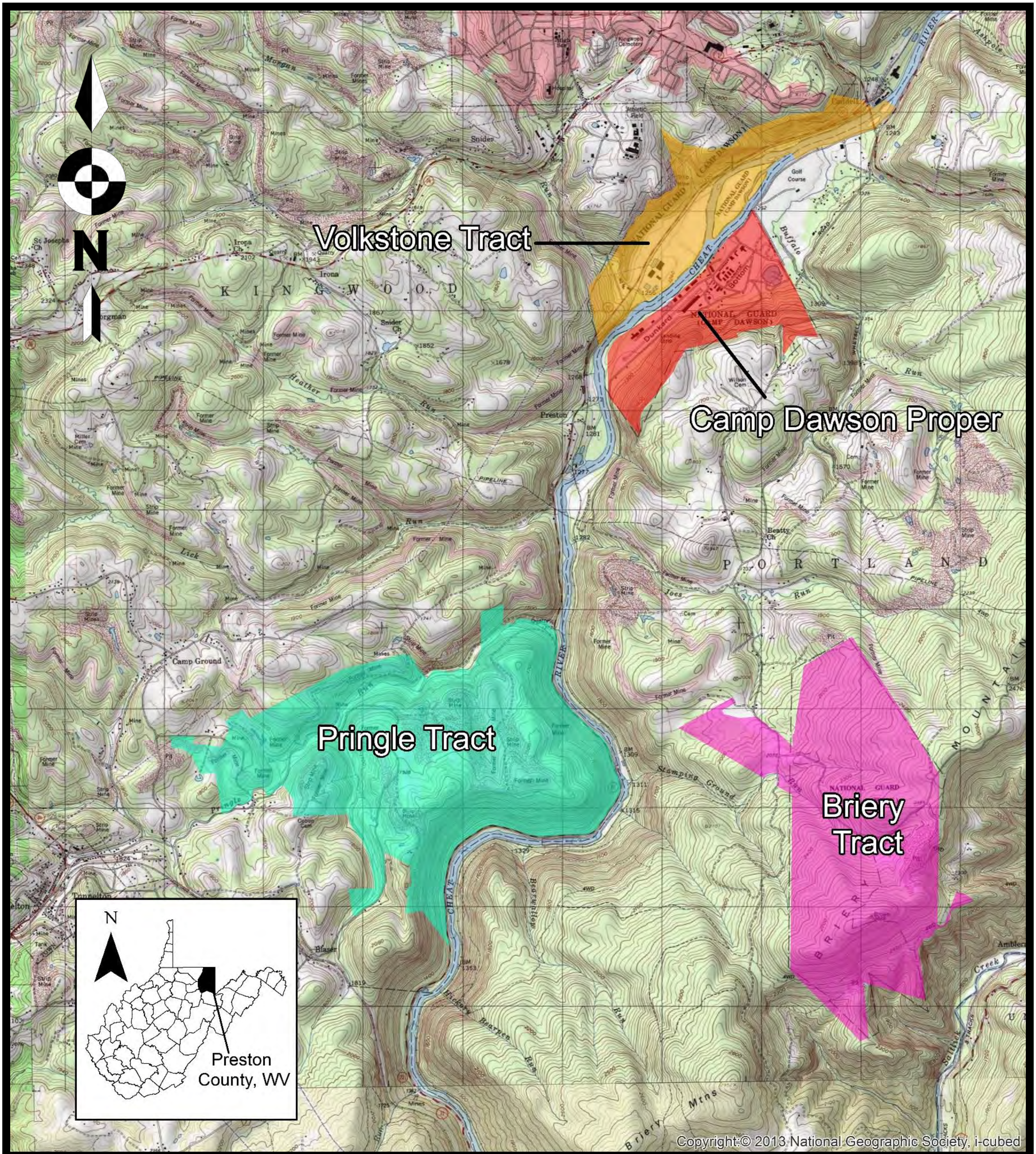
Appendix A: Vicinity Map (Kingwood 7 ½' USGS)



Project Location Map
Camp Dawson

Latitude 39.424798° **N**
Longitude -79.681091° **W**

A portion of the Kingwood 7 ½' Quadrangle

Scale: 1 : 50000

Prepared by:

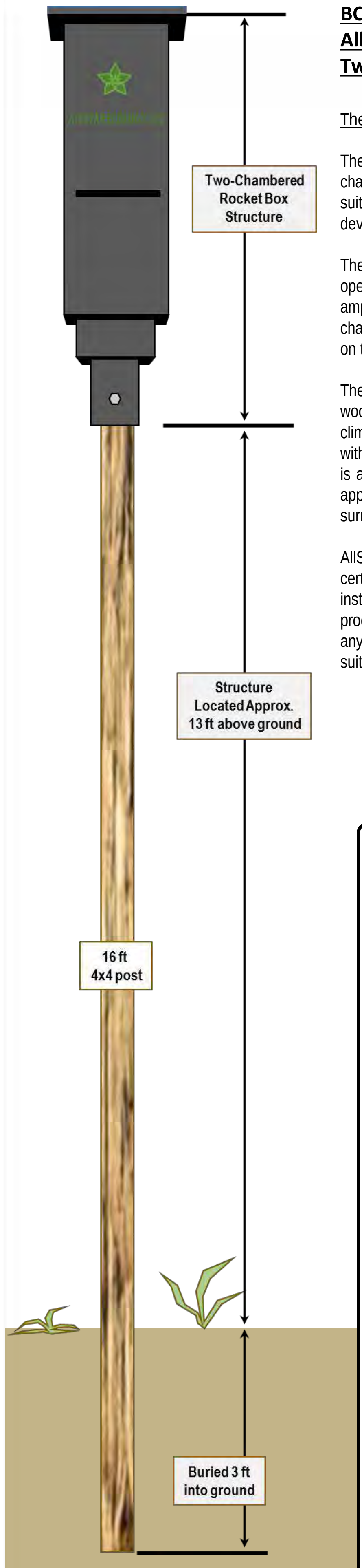
ALLSTAR ECOLOGY
Natural Resource Specialists

1582 Meadowdale Road, Fairmont, WV 26554
866-213-2666

Prepared for:

WEST VIRGINIA NATIONAL GUARD

Appendix B: Proposed Conservation Measures Plans



BCI-Certified
AllStar Ecology, LLC Constructed
Two-Chambered Rocket Box

The Structure

The Two-Chambered Rocket Box structure is a 4.5 foot tall structure that is designed to mimic the characteristics of natural bat roosts by providing spacious waterproof habitat that can be used as a suitable replacement for natural roosting habitat that may be removed or compromised through the development of a project.

The structure itself consists of two separate chambers that are accessible by bats through offset tiered openings located at the base of the structure. Each chamber is maintained by ¾ inch spacers that provide ample space for roosting and movement through the structure. Bats can freely move between the two chambers through via openings created on the inner walls. Airflow is maintained through a vent installed on the front panel of the structure.

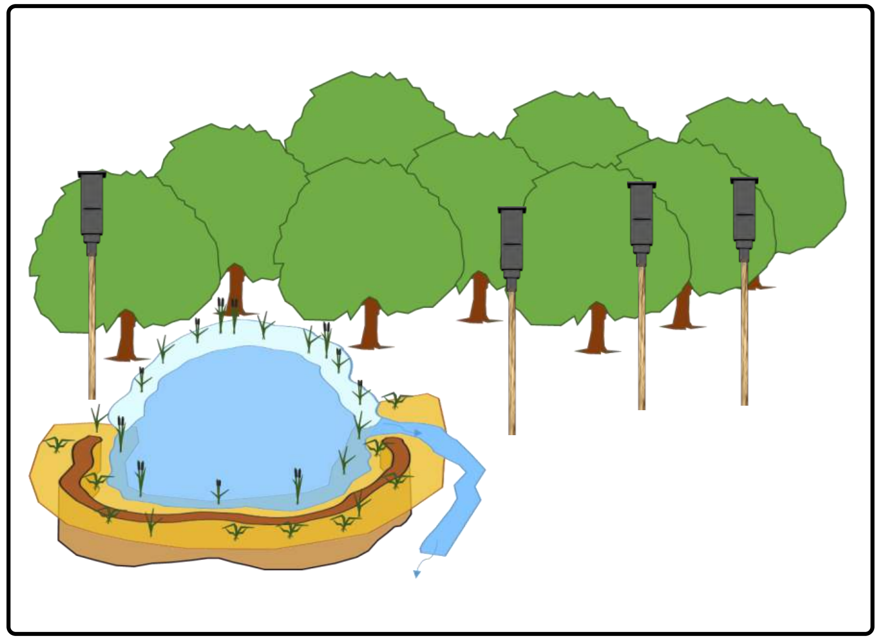
The Two-Chambered Rocket Box artificial roosting structure is constructed with animal-safe untreated wood. During construction, all inside faces of the structure are roughened to allow for bats to attach and climb to the top of the structure. Each structure is assembled with solid untreated pine boards, secured with stainless steel nails and screws. All seams are sealed to prevent intrusion by water. A waterproof roof is attached and sealed to the top of each structure. Each structure is secure to a 4 inch by 4 inch post approximately 13 ft above the ground. The 4 x 4 post is buried at least three feet into the ground and the surrounding soil is tamped and packed to stabilize the structure.

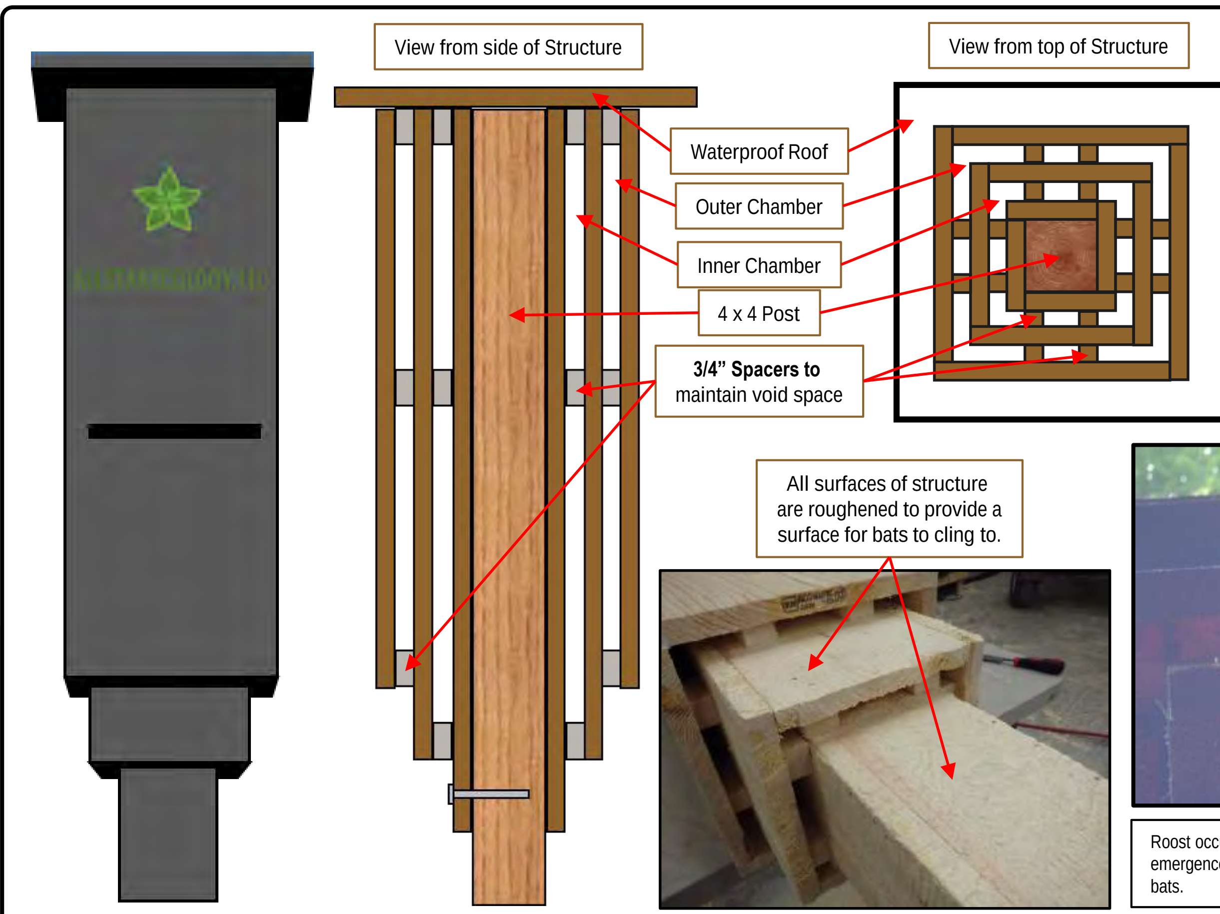
AllStar Ecology, LLC constructed Two-Chambered Rocket Boxes have received the "Bat Approved" certification from Bat Conservation International meaning the design, materials, construction and instructions have met the quality standards set by Bat Conservation International. Most commercially-produced bat houses are not suitable for bats, and often lack proper instructions. While there are never any guarantees, BCI-approved bat houses are likely to be used by bats when properly installed in a suitable location.

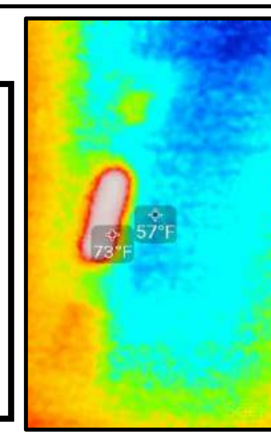
batcon.org
BAT CONSERVATION INTERNATIONAL

Placement on the Landscape

The placement of each structure is determined by AllStar Ecology, LLC bat biologists through AllStar Ecology, LLC. Myotine Suitable Habitat Assessment Model (MSHAM) which analyzes physical variables on the landscape in an effort to predict suitable habitat. Variables included in the model include forest fragmentation, slope, aspect and distance to waterbodies. Structures are placed in areas of high solar radiation and in close proximity to likely feeding areas and travel routes to allow for easy access to foraging and migration habitat.





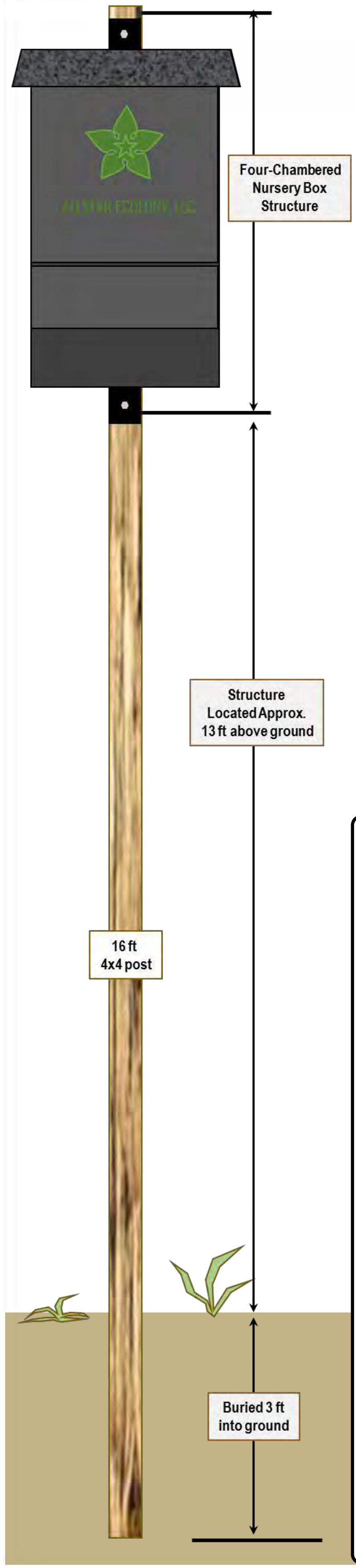


Monitoring of installed roosts include the use of thermal imaging cameras which capture body heat signatures of bats utilizing roosts. A difference between ambient air temperature outside of the roosts and the temperature of the roosting bats is noted.

Roost occupation is confirmed through low intensity red light followed by emergence mist netting to determine species and condition of roosting bats.

Artificial Roosts
BCI-Certified
Rocket Box

ALLSTAR ECOLOGY LLC



BCI-Certified
AllStar Ecology, LLC Constructed
Four-Chambered Nursery Box

The Structure

The Four-Chambered Nursery Box structure is a 3 foot tall structure that is designed to mimic the characteristics of natural bat roosts by providing spacious waterproof habitat that can be used as a suitable replacement for natural roosting habitat that may be removed or compromised through the development of a project.

The structure itself consists of four separate chambers that are accessible by bats through offset openings located at the base of the structure. Each chamber is maintained by ¾ inch spacers that provide ample space for roosting and movement through the structure. Bats can freely move between the chambers through via openings created on the inner walls. Airflow is maintained through a vent installed on the front panel of the structure.

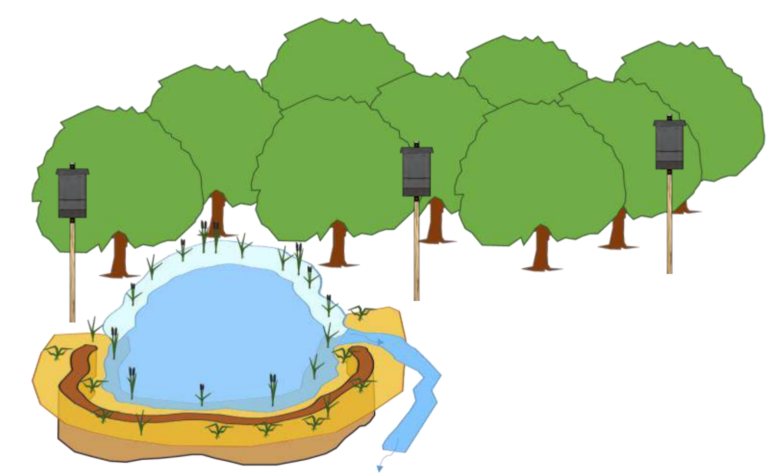
The Four-Chambered Nursery Box artificial roosting structure is constructed with animal-safe untreated wood. During construction, all inside faces of the structure are roughened to allow for bats to attach and climb to the top of the structure. Each structure is assembled with solid untreated pine boards, secured with stainless steel nails and screws. All seams are sealed to prevent intrusion by water. A waterproof roof is attached and sealed to the top of each structure. Each structure is secure to a 4 inch by 4 inch post approximately 13 ft above the ground. The 4 x 4 post is buried at least three feet into the ground and the surrounding soil is tamped and packed to stabilize the structure.

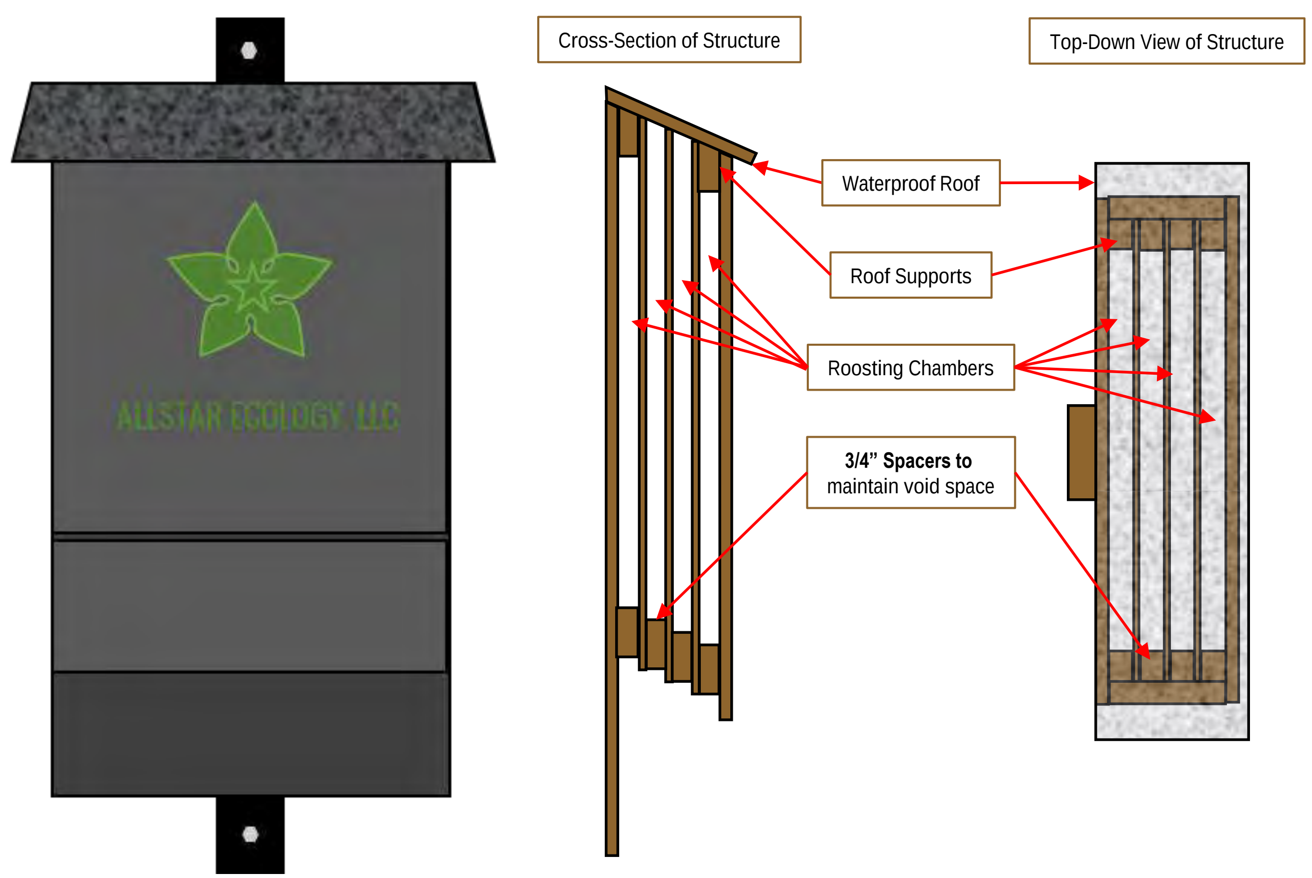
AllStar Ecology, LLC constructed Four-Chambered Nursey Boxes have received the "Bat Approved" certification from Bat Conservation International meaning the design, materials, construction and instructions have met the quality standards set by Bat Conservation International. Most commercially-produced bat houses are not suitable for bats, and often lack proper instructions. While there are never any guarantees, BCI-approved bat houses are likely to be used by bats when properly installed in a suitable location.

batcon.org
BAT CONSERVATION INTERNATIONAL

Placement on the Landscape

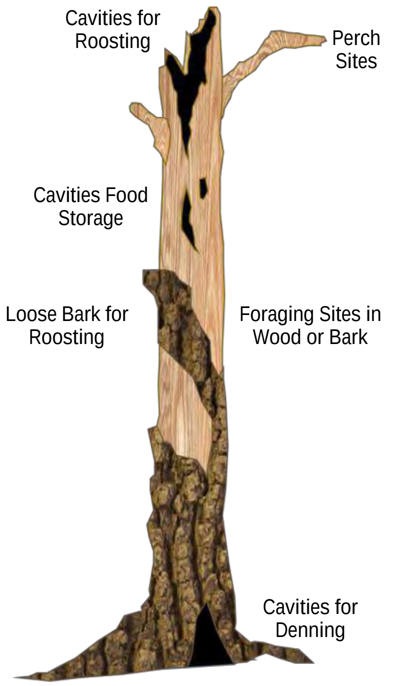
The placement of each structure is determined by AllStar Ecology, LLC bat biologists through AllStar Ecology, LLC. Myotine Suitable Habitat Assessment Model (MSHAM) which analyzes physical variables on the landscape in an effort to predict suitable habitat. Variables included in the model include forest fragmentation, slope, aspect and distance to waterbodies. Structures are placed in areas of high solar radiation and in close proximity to likely feeding areas and travel routes to allow for easy access to foraging and migration habitat.





Artificial Roosts
BCI-Certified
Nursery Box

ALLSTAR ECOLOGY LLC



What is a snag?

There are numerous management techniques to improve the quality of the forest. Traditional methods for timber stand improvement include the removal of unwanted trees to release growing space for desired tree species. The complete removal of unwanted tree species often has a detrimental effect to wildlife. Standing dead and dying trees, called "snags" or "wildlife trees," are important for wildlife in both natural and landscaped settings. Snags are natural occurring as a result of disease, lightning, fire, animal damage, too much shade, drought, root competition, as well as old age. Birds, small mammals, and other wildlife use snags for nests, nurseries, storage areas, foraging, roosting, and perching.

Snags can be created by killing a tree without removing it. Methods for snag creation vary and can determine the longevity and fate of the snag.

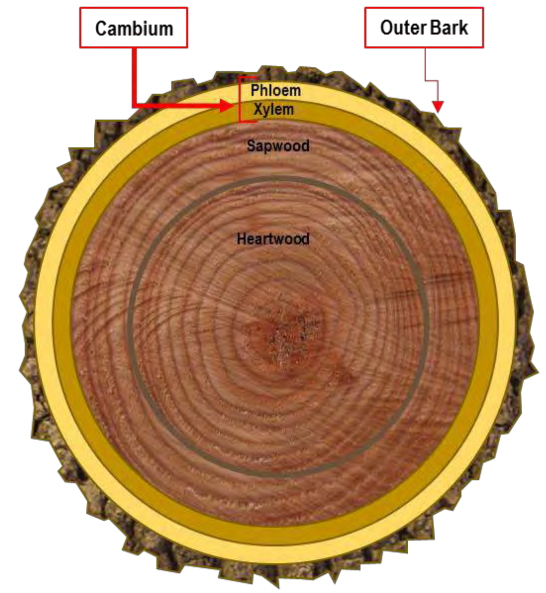
Girdling for snag tree creation

How Girdling Works

Girdling is the traditional method for killing a tree without felling. The outer rings of a tree house the phloem and xylem, both necessary for the transport of vital water and nutrients throughout the tree. Girdling severs the bark, cambium and sometimes the sapwood in a ring entirely around the trunk of the tree effectively halting the exchange of sugars, minerals and water between the roots and the rest of the tree.

Once the cambium is severed and the bark is removed, the transport of water and nutrients ceases and the tree will die over time. Decay will slowly create habitat and foraging areas. Bark will slowly fall off the tree creating roosting habitat for wildlife.

Cross Section of a Typical Tree



Improper Girdling

The Improper girdling of a tree can reduce the effectiveness of the snag:

- Ineffective girdling can fail to kill the tree.

- Cuts too far into the sapwood of the tree can reduce the integrity of the tree and create hazard trees and shorten the longevity of the wildlife snag.

- Timing is essential. Trees are most vulnerable early in the growing season just after rapid tissue growth has depleted carbohydrate reserves. Also the bark is "loose" in the spring and early summer when the cambium is active.

Tools for Girdling

There are many cutting devices that can be used to girdle a tree.

- Chainsaws
- Axes
- Handsaws
- Additional Tools include
- Wood Chisel or Sharp Wedge
    - For Bark and Cambium Removal
- Herbicide and Spray Bottle
    - Eye Protection, Safety Garments, PPE etc.
- Proper Safety Equipment
    - Eye Protection, Ear Protection, Safety Garments etc.

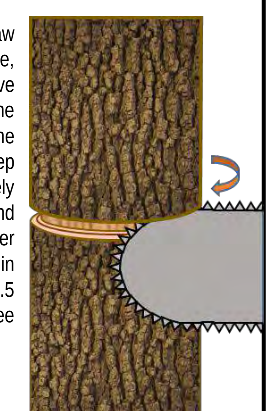
Chainsaw Method

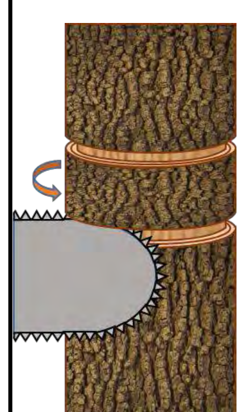
Chainsaws are efficient tools to use for girdling trees. Two cuts arte made and the bark and cambium between the two cuts are removed. Trees should be de-limbed beneath the cuts to inhibit regrowth and sprouting.

To create a successful wildlife snag, trees must be selected that have certain characteristics Hardwood species such as oak, maple, locust and hickory decay at a slower rate and as a result, are longer lasting. They also tend to retain their bark longer after the trees die, creating more roosting potential than species that decay at a faster rate. Additionally, Trees larger than 6 inches in diameter at breast height (DBH) are typically large enough to withstand high winds.

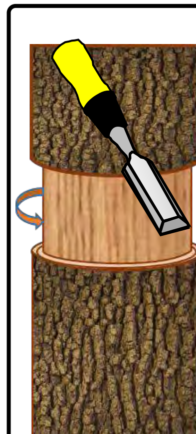
When using a chainsaw to girdle a selected tree, cut one grove completely around the tree at chest height. The groove must be deep enough to completely sever the phloem and cambium. For larger trees (greater than 10 in DBH) a groove cut 1.5 inches deep into the tree will be sufficient.

** REMEMBER**
Proper Chainsaw Safety





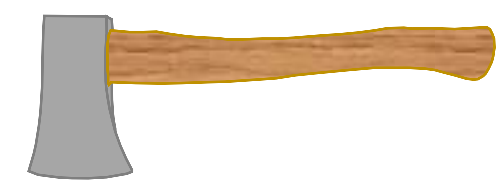
After the first grove, cut a second groove, completely around the tree, 2-3 inches below the first groove. The groove must be 1.5 inches deep.



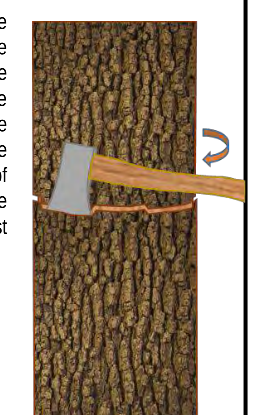
Once the two grooves are cut, the bark and the cambium between the two chainsaw cuts must be removed completely around the tree through the use of a wood chisel or sharp wedge. This removed area is called the kerf. A kerf, 2-3 inches wide should be sufficient to prevent the regrowth of the cambium and should successfully kill the tree.

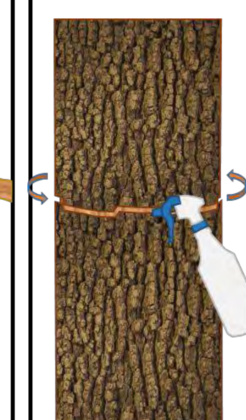
Hack'n'Squirt Method (Hand Ax)

Double Hacking with a hand ax involves the cutting of two lines at chest height, spaced approximately 3 inches apart, around the tree and removing the bark material between the two line



The most effective method of girdling a tree with an Ax involves the hacking of a line completely encircling the tree. The line can be created using a series of downward blows into the tree made at chest height.

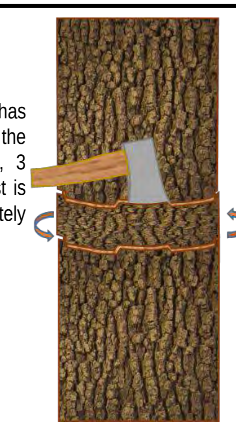


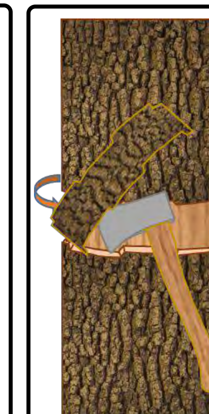


Applying systemic herbicide after a single line of ax cuts have been made completely around the tree is effective. This is known as the hack'n'squirt method.

Alternatively…

After the first line has been hacked around the tree, a second line, 3 inches above the first is made, also completely encircling the tree.



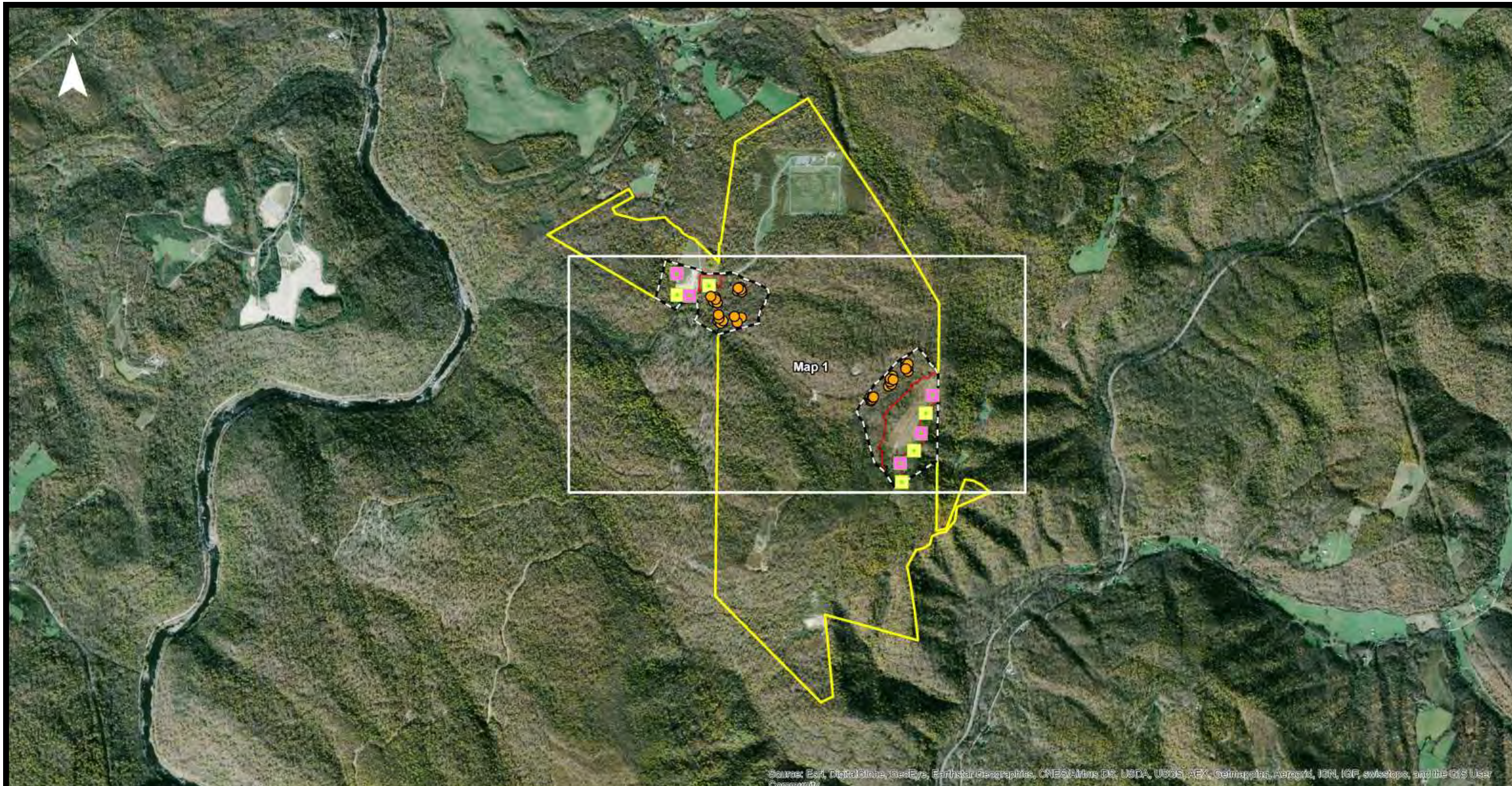


After the two lines have been hacked, the material between them must be pried out with the ax blade. Once the cambium is severed and the bark is removed, the transport of water and nutrients ceases and the tree will die over time.

Snag Creation for Habitat Improvement

ALLSTAR ECOLOGY LLC

Appendix C: Proposed Conservation Measures Installation Location Maps



PROPOSED MANAGEMENT AREAS
INDEX MAP

Camp Dawson
Briery Tract
Preston County, WV

2000' 1000' 0' 2000' 4000'

LEGEND

- Briery Tract
- Herb. Prescribed Fire Unit
- Proposed Management Area
- Girdled Tree
- 2-Chambered Rocket Box
- 4-Chambered Nursery Box

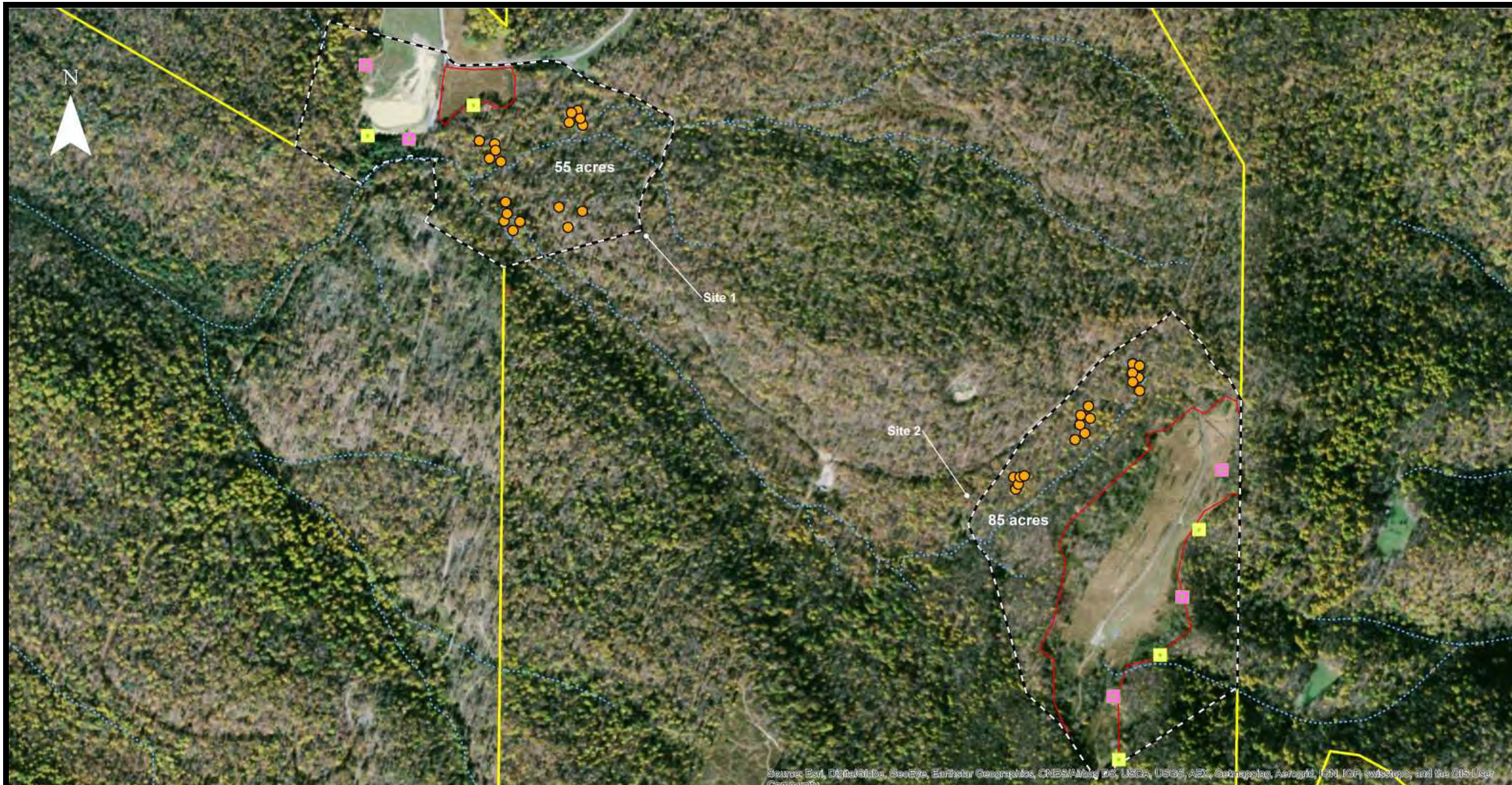
Prepared for:

WEST VIRGINIA NATIONAL GUARD

Prepared by:

ALLSTAR ECOLOGY
Natural Resource Specialists

Map Created: November 1, 2016



PROPOSED MANAGEMENT AREAS
MAP 1

Camp Dawson
Briery Tract
Preston County, WV

600' 300' 0' 600' 1200'

LEGEND

- Briery Tract
- Herb. Prescribed Fire Unit
- Proposed Management Area
- Girdled Tree
- 2-Chambered Rocket Box
- 4-Chambered Nursery Box
- SAMB Streams

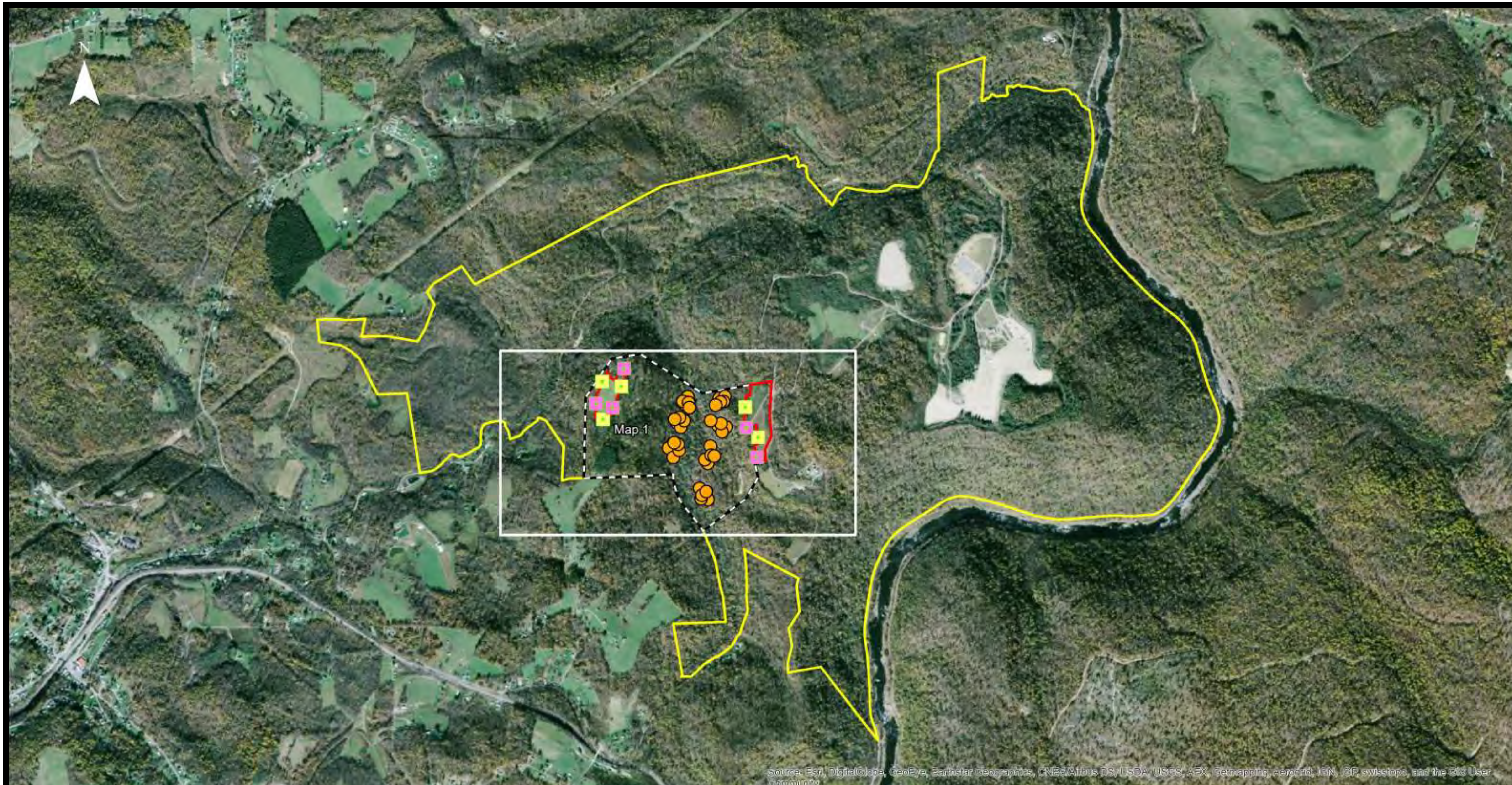
Prepared for:

West Virginia National Guard

Prepared by:

ALLSTAR ECOLOGY
Natural Resource Specialists

Map Created: November 1, 2016



PROPOSED MANAGEMENT AREA INDEX MAP

Camp Dawson
Pringle Tract
Preston County, WV

1500’ 750’ 0’ 1500’ 3000’

LEGEND

- Pringle Tract
- Herb. Prescribed Fire Unit
- Proposed Management Area
- Girdled Tree
- 2-Chambered Rocket Box
- 4-Chambered Nursery Box

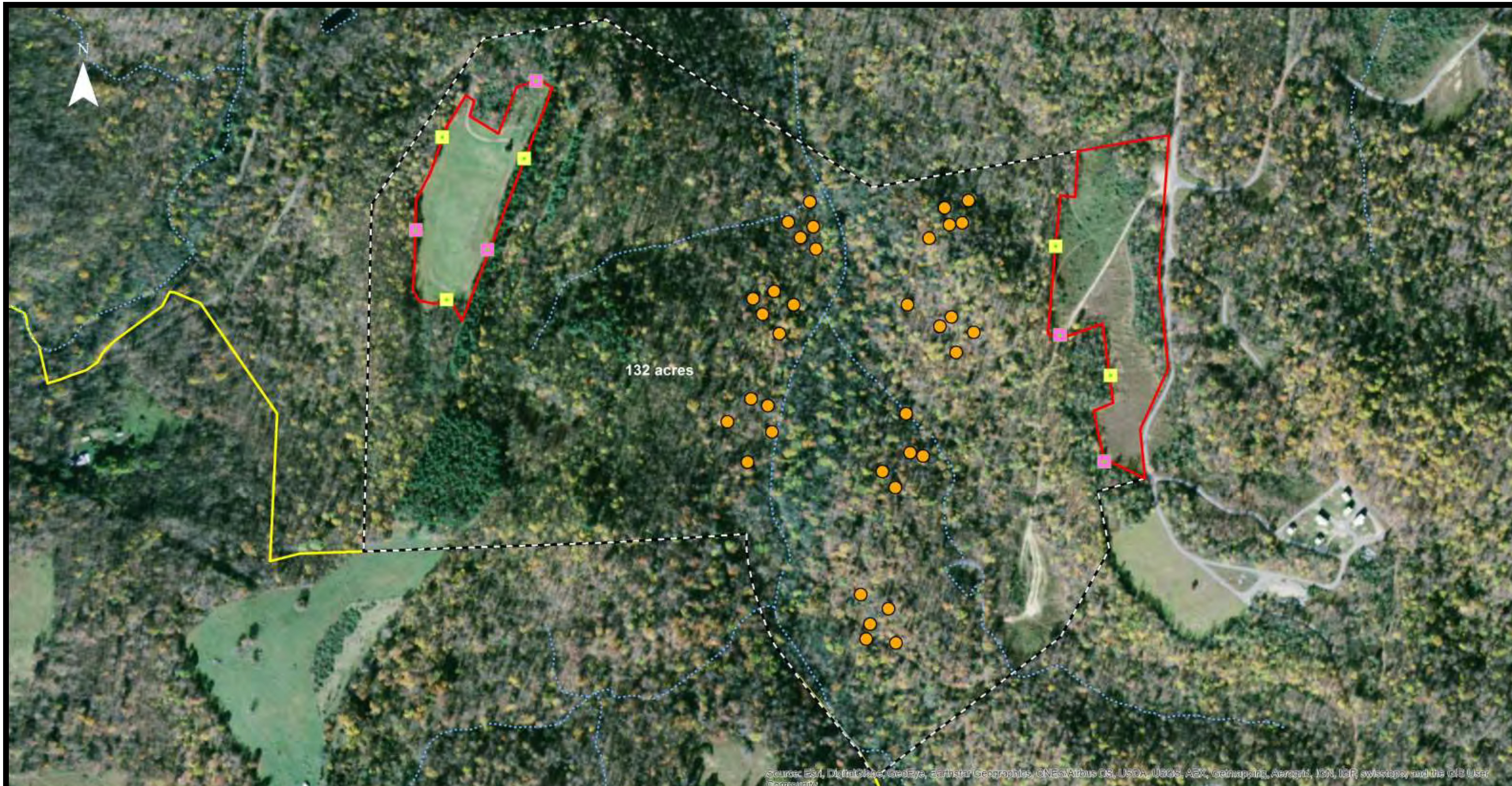
Prepared for:

West Virginia National Guard

Prepared by:

ALLSTAR ECOLOGY
Natural Resource Specialists

Map Created: November 1, 2016



PROPOSED MANAGEMENT AREA
MAP 1

Camp Dawson
Pringle Tract
Preston County, WV

350′ 175′ 0′ 350′ 700′

LEGEND

- Pringle Tract
- Herb. Prescribed Fire Unit
- Proposed Management Area
- Girdled Tree
- 2-Chambered Rocket Box
- 4-Chambered Nursery Box
- SAMB Streams

Prepared for:

West Virginia National Guard

Prepared by:

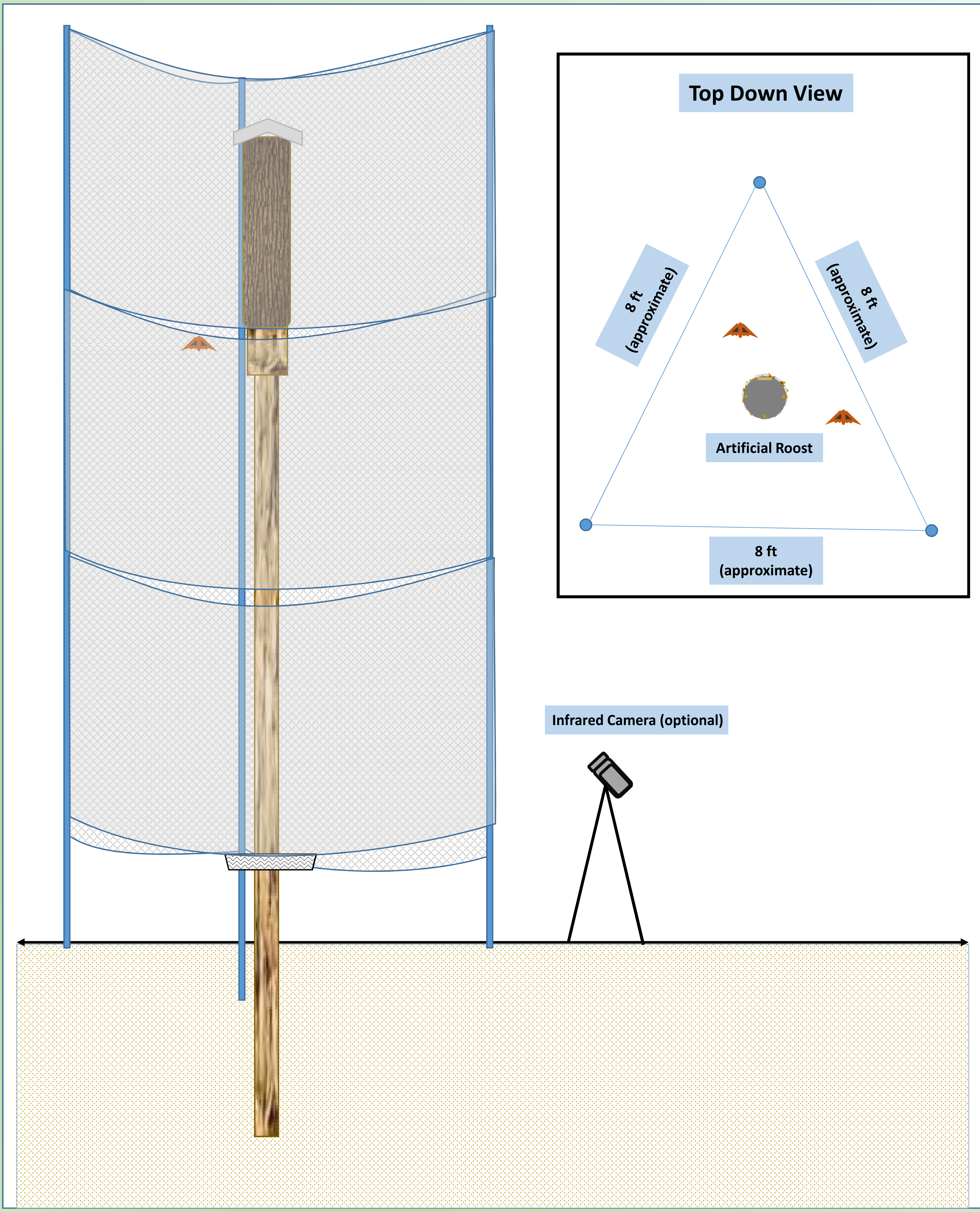
ALLSTAR ECOLOGY
Natural Resource Specialists

Map Created: November 1, 2016

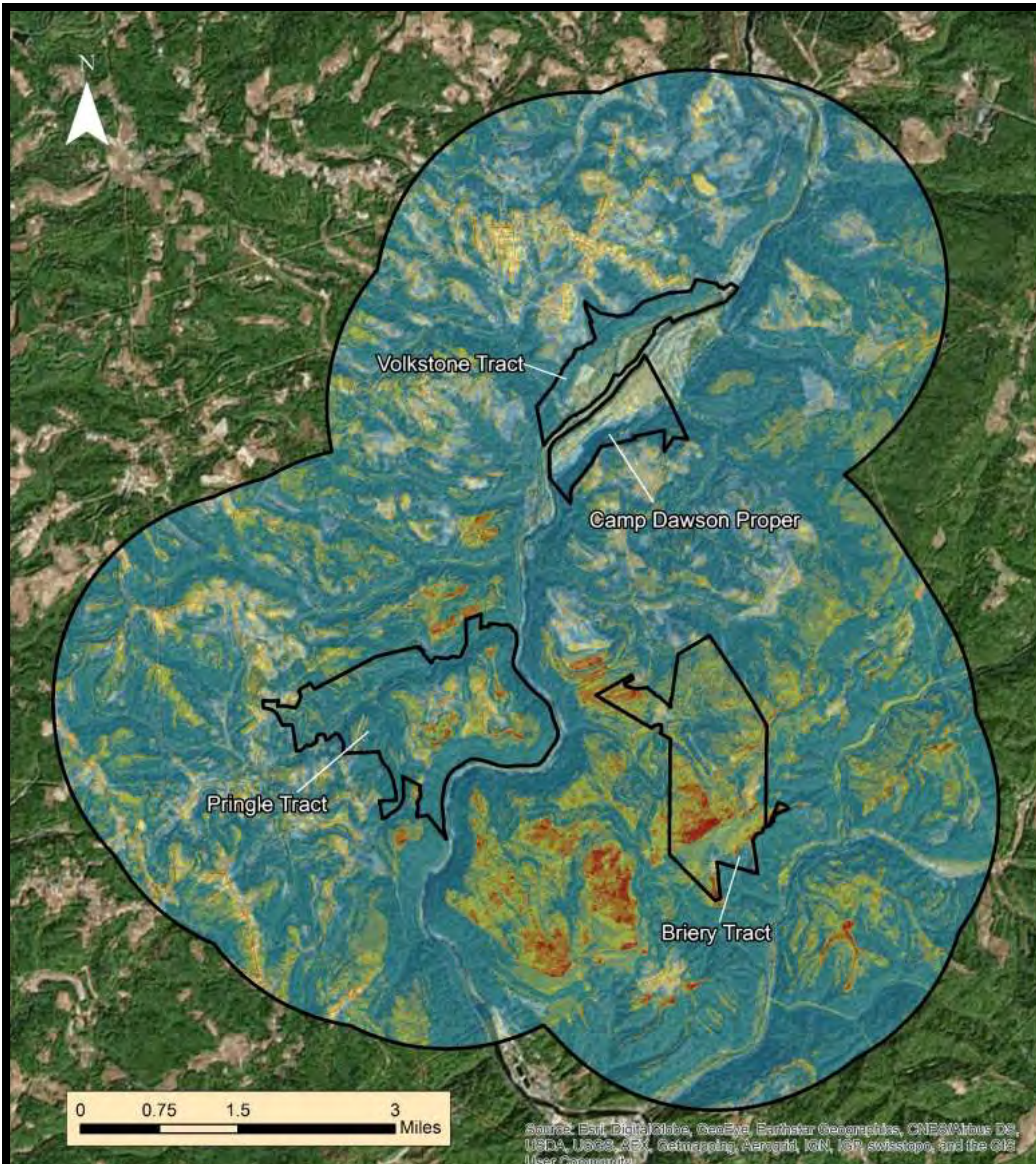
Appendix D: Emergence Capture

ALLSTAR ECOLOGY
Natural Resource Specialists

Emergence Sampling Diagram



Appendix E: MAXENT Map of Camp Dawson



MAXTENT
Indiana Bat Habitat Suitability Map

Camp Dawson
Preston County, WV

LEGEND

Poor	
Low	
Fair	
Good	
High	

Prepared by:

ALLSTAR ECOLOGY
Natural Resource Specialists

Prepared for:

WEST VIRGINIA NATIONAL GUARD

Appendix F: USFWS Indiana Bat Presence/Absence Concurrence Letter-Camp Dawson-2013

United States Department of the Interior

FISH AND WILDLIFE SERVICE

West Virginia Field Office
694 Beverly Pike
Elkins, West Virginia 26241

December 19, 2013

Mr. Jesse De La Cruz
AllStar Ecology, LLC
1582 Meadowdale Road
Fairmont, West Virginia 26554

Re: Camp Dawson Collective Training Area, Summer Acoustic and Mist Net Survey, Preston County, West Virginia

Dear Mr. De La Cruz:

The U.S. Fish and Wildlife Service (Service) has reviewed the report on the Indiana bat (*Myotis sodalis*) acoustic and mist net surveys conducted at Camp Dawson Collective Training Area (CDCTA), Preston County, West Virginia, and submitted on November 15, 2013. These comments are provided pursuant to the Endangered Species Act (ESA; 87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*). The survey followed the protocol outlined in the Draft Indiana Bat Recovery Plan and 2013 Revised Range-wide Indiana Bat Summer Survey Guidelines.

The acoustic survey was conducted from July 3 to August 8, 2013, and consisted of 42 acoustic detector sites. These sites produced 83 recorder nights of data. Fifteen of the 42 sites recorded potential Indiana bat calls. Of calls collected during the survey, a total of 152 and 85 potential Indiana bat calls were identified by Bat Call Identification, Inc. (BCID) and Kaleidoscope softwares, respectively. When these potential Indiana bat calls were visually assessed, 25 calls were visually confirmed to be likely Indiana bat calls. The likelihood of presence of Indiana bats presented in the visual assessment of calls triggered mist net surveys to be conducted.

The mist net survey was conducted from July 8 to August 8, 2013, and consisted of 11 mist net sites, which had a total of 32 nets placed over a 12 night period, producing 57 net nights. A total of 166 bats representing 6 species were captured during the survey. None of these was a federally listed species.

Based on the information provided to us from the acoustic surveys and mist netting as concluded on page 40 of your summer surveys report, the Service concurs that there is a high likelihood of presence of Indiana bats at the CDCTA.

The Service has evaluated the availability of suitable foraging and roosting habitat on the West Virginia landscape relative to the best estimate of the statewide population of Indiana bats. On that basis, we have determined that projects affecting 17 acres or less of suitable forest habitat and that occur more than 5 miles from hibernacula, 5 miles from summer capture sites with no known maternity roosts, and 2.5 miles from maternity roosts are very unlikely to result in direct or indirect impacts to the species. Please note that due to the likelihood of Indiana bat presence within the action area, as documented through acoustics surveys, this threshold does not apply. As a result, any future planned projects that may affect any amount of potential habitat for this listed species should be coordinated with the Service because of the high likelihood of presence of Indiana bats in this area.

Additionally, on October 2, 2013, in the *Federal Register* (78 FR 61045-61080) the Service proposed the northern long eared bat (*Myotis septentrionalis*) for listing under the ESA. During acoustic surveys, 50 and 305 calls were identified as potential northern long-eared bats by BCID and Kaleidoscope softwares, respectively. Visual examination confirmed 79 calls to be northern long-eared bats. Additionally, three northern long-eared bats were captured. If a decision is made to list this species, potential impacts from this project to this species may need to be addressed if this project is not completed by October 2, 2014. We encourage you to begin incorporating conservation measures to protect these species prior to any potential final listing decisions.

If you have any questions regarding this letter, please contact Liz Stout of my staff at (304) 636-6586, Ext. 15, or elizabeth_stout@fws.gov or at the letterhead address.

Sincerely,

John E. Schmidt,
Field Supervisor

Appendix G: Beneficial Forest Management Practices for WNS-Affected Bats

Beneficial Forest Management Practices for WNS-affected Bats

Voluntary Guidance for Land Managers and Woodland Owners in the Eastern United States

May 2018

Please cite this document as: Johnson, C.M. and R.A. King, eds. 2018. Beneficial Forest Management Practices for WNS-affected Bats: Voluntary Guidance for Land Managers and Woodland Owners in the Eastern United States. A product of the White-nose Syndrome Conservation and Recovery Working Group established by the White-nose Syndrome National Plan (www.whitenosesyndrome.org). 39 pp.

BACKGROUND

This document was prepared and reviewed by a diverse group of volunteers from universities, federal and state agencies, and non-governmental organizations functioning as a subgroup of the Conservation and Recovery Working Group (CRWG), which was established via A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats (a.k.a. the "National Plan"; USFWS 2011a (available at www.whitenosesyndrome.org). The need for beneficial forest management practices (BFMPs) for bats and forest management was identified by the CRWG and conceptualized during the 2013 White-Nose Syndrome Workshop held in Boise, Idaho.

This document contains detailed information, including a glossary of bat and forest management-related terms (defined terms are underlined and are linked to the glossary) and citations for pertinent scientific literature to help land managers and others interested in gaining a deeper understanding of the underlying science and related issues that were considered when developing the BFMPs. An abbreviated and condensed version of these BFMPs is being planned and will be available as a user-friendly brochure at https://www.whitenosesyndrome.org when completed.

ACKNOWLEDGEMENTS

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Contents

INTRODUCTION

The purpose of this document is to provide practicable Beneficial Forest Management Practices (BFMPs) that land managers and woodland owners can use to increase benefits to bats as part of their forest management activities while avoiding and reducing potential negative effects. This technical guidance was developed in collaboration with professional foresters and wildlife biologists representing state and federal agencies, academic institutions, private conservation organizations, and other interested groups and individuals in response to catastrophic population declines of many bat species due to white-nose syndrome (WNS). Although this guidance is largely focused on cave-hibernating bat species or "cave bats" impacted by WNS in the eastern United States (east of the Great Plains), general recommendations provided herein are likely to benefit other forest-dependent bat species (i.e., "tree bats"), regardless of their conservation status.

Several bat species have experienced precipitous population declines in eastern North America over the past decade, primarily as a result of WNS, an introduced fungal disease that killed more than six million bats from 2006-2012 (USFWS 2012) and continues to spread across the continent. Species currently affected by WNS include little brown bats (*Myotis lucifugus*), northern long-eared bats (*M. septentrionalis*), Indiana bats (*M. sodalis*), small-footed bats (*M. leibii*), gray bats (*M. grisescens*), big brown bats (*Eptesicus fuscus*), tri-colored bats (*Perimyotis subflavus*), Yuma myotis (*M. yumanensis*), southeastern bats (*M. austroriparius*), and cave bats (*M. velifer*). As WNS continues to move west, it is also likely to affect many western *Myotis* species such as the southwestern bat (*M. auriculus*), California bat (*M. californicus*), long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), and the long-legged myotis (*M. volans*). While WNS has emerged as the most significant threat to many hibernating bat populations, other environmental stressors and sources of mortality continue to exist and may further reduce the ability of WNS-affected species to persist or may slow their recovery.

Forests offer many essential resources to bats including a diverse assemblage of insects as prey and trees for roosts/shelter. Because forests provide year-round habitat for many bat species their management is crucial to maintaining high-quality habitat and healthy bat populations. The BFMPs presented here will help land managers to proactively conserve, restore, and enhance forested habitats for WNS-affected bat species and reduce the potential to inadvertently harass, harm, and/or kill bats. Following these general recommendations will also help managers provide diverse, high-quality habitats that will benefit other common and at-risk bat species.

This document is not regulatory in nature and is not intended to supersede guidance developed for federal- or state-listed species under various jurisdictions. Rather, this document is intended to supplement other available guidance and to encourage consideration of all WNS-affected bat species during forest management. In addition to these BFMPs, we highly recommend that land managers consult with a professional forester/silviculturalist and wildlife biologist when developing more detailed stand-specific management plans focused on timber production or other silvicultural goals and bat conservation efforts.

Important Life History Considerations for WNS-affected Species

Knowledge of the life history requirements of different bat species provides important insights into how they use habitat during different seasons (summer, wintering, and migration) and for different activities (e.g., foraging and roosting). Many bat species in eastern North America share life history traits (e.g., hibernation requirements and low reproductive rates) that make them particularly susceptible to disturbance or disease, reducing the ability of populations to recover from substantial losses. Understanding the general habitat needs of different bat species and timing of their most vulnerable periods is a fundamental requirement for developing conservation measures that effectively address actions that may affect bats and their habitat. The following overview of these important life history considerations is intended to provide additional context for conservation measures presented later in this document.

Summer

To date, all WNS-affected bat species use forests in the spring, summer, and fall, though some of these species also use non-forested areas for roosting and/or foraging (e.g., small-footed bat and little brown bat). However, these species use both forested and non-forested areas in ways that vary with their wing morphology (e.g., wing shape, size, wing tip) and echolocation call structure. Bat species with short broad wings are highly maneuverable, short-distance fliers that tend to forage in more cluttered habitats whereas bats with long narrow wings are less maneuverable, capable of flying long distances, and tend to forage in open habitats (Aldridge and Rautenbach 1987; Fenton 1990). A species' echolocation call is also uniquely adapted to its preferred foraging habitat. Species that forage in more cluttered environments have higher frequency broad-band calls allowing them to perceive their surroundings in greater detail (Schnitzler and Kalko 2001). Some examples include northern long-eared, Indiana, little brown, small-footed and tri-colored bats with short, broad wings and higher frequency calls more adapted for foraging in forest interior (Duchamp and Swihart 2008). Species that forage in more open environments have lower frequency calls allowing them to perceive objects at greater distances. For example, the big brown bat is one of the largest species affected by WNS and has long narrow wings and relatively broad band, low frequency echolocation calls (Duchamp and Swihart 2008).

During the summer, females of many species (e.g., Indiana bats, northern long-eared bats, little brown bats, and big brown bats) form maternity colonies, although some may roost singly. Males may also congregate in bachelor colonies. Female bats give birth to live pups, which are incapable of flying (i.e., non-volant) for several weeks; during this time, the females and pups are particularly vulnerable to disturbance. While females can and do move pups between roosts when disturbed, they are not always able to do so instantly, as may be needed in the case of a rapidly moving fire, when a tree is being felled, or when a structure is being demolished.

Because females of most WNS-affected bat species give birth to only one or two pups per year, their populations may take decades to recover from substantial losses.

Winter

In winter, WNS-affected species generally hibernate in caves and mines, although they may also hibernate in other landscape features or structures to varying degrees. Many of these species hibernate in large aggregations (e.g., Indiana bats, gray bats, and little brown bats) in caves and mines that provide appropriate temperature, humidity, and airflow. When individuals are geographically concentrated, single stochastic events, such as heavy rains that flood a hibernaculum can affect many individuals, and in some cases, may result in population-level level effects. Because of this, natural or anthropogenic modifications or disturbance to those hibernacula or disturbance to the bats themselves can result in a significant loss of the local population. The cool, moist conditions of most hibernacula also provide optimal conditions for the psychrophilic (cold-loving) fungus, *Pseudogymnoascus destructans* (Pd), which causes WNS. The large numbers and clustering behavior of many bat species in hibernacula makes them particularly susceptible to WNS during hibernation when their immune systems are suppressed, food and water are absent or scarce, and they must depend on finite fat reserves to survive the winter.

Migration

Because cave bats are considered the primary hosts and vectors of Pd (Blehert et al. 2009), understanding their seasonal movements can improve our understanding of the disease's spread (Rockey et al. 2013, Miller-Butterworth et. al 2014) and help inform management of important migratory habitat. For eastern migratory bat species, spring migration generally begins in March or April and extends through May or June and fall migration occurs between August and November, though timing varies by latitude, altitude, and annual weather patterns. None of the WNS-affected bat species in North America are considered long-distance migrants; however, several species make lengthy regional migratory movements. Northern long-eared bats have been documented migrating from 8-55 mi between summer and winter habitat, though some have moved up to 168 mi (USFWS 2014). Regional migrants, such as the little brown bat, gray bat, Indiana bat and tri-colored bat, migrate moderate distances (typically 60-300 mi) between summer and winter roosts (Fleming and Eby 2003). Indiana bats may migrate hundreds of miles between hibernacula and summer habitats (Winhold and Kurta 2006, USFWS 2007; Rockey et. al. 2013), and little brown bats frequently move 300 - 500 miles among swarming sites, summer roosts, and hibernacula (Humphrey and Cope 1976; Norquay et. al. 2013).

Unfortunately, migratory pathways and habitat needs of bats during migration are not well understood. For example, it remains unknown whether migratory bats tend to use specific, traditional migration routes or "corridors" or simply move in a dispersed fashion across the landscape. Similarly, relatively little is known regarding the use of migratory stopover sites by bats as compared to migratory birds (Cryan and Brown 2007, Buler and Dawson 2014). Where possible, species-specific management plans should account for known seasonal differences in bat behavior, such as the increased likelihood of daily torpor during spring and fall (especially during cold snaps), which could make them more vulnerable to prescribed fire at those times. Some seasonal habitat differences also have been identified for well-studied species, such as the Indiana bat, which may use a higher proportion of live trees in the fall than they do in summer (Brack 2006, Johnson et al. 2010), and more crevice roosts in spring (Gumbert and Roby 2011). However, until migratory patterns and habitat needs are better understood, our ability to develop detailed forest management recommendations for bats during migration remains fairly limited (Cryan and Veilleux 2007). In the interim, forest management practices that sustain and promote high-quality roosting and foraging habitats for bats during the summer are generally assumed to benefit bats during their spring and fall migrations.

Threats and Stressors

North American bats are among the most imperiled terrestrial species on the continent (Hammer et al. 2017). While the threats and stressors facing bat populations in eastern North America are varied, they affect bat populations through three primary mechanisms: (1) disease, (2) habitat alteration, and (3) disturbance or mortality of individuals/populations. A wide range of natural and anthropogenic factors and activities may affect individual bats or bat populations through each of these mechanisms.

Disease

At present, the primary cause of hibernating bat population declines in North America is WNS, which was first observed in New York in the winter of 2006-2007 (Blehert et. al. 2008, Castle and Cryan 2010). It killed over 6 million bats in the first 6 years after its initial discovery and continues to spread across eastern North America (USFWS 2012). WNS is caused by a non-native, invasive fungus, *Pseudogymnoascus destructans*, that thrives in the cool, moist conditions associated with bat hibernacula and is able to persist in the environment (e.g., in soil and other cave or mine substrates) when bats are absent, causing re-infection of bats each winter (Gargas et. al. 2009, Lorch et al. 2013). Bats infected with this fungus experience a physiological disruption that can eventually result in dehydration and starvation before spring emergence (Cryan et al. 2010, Cryan et al. 2013, Verant et al. 2014). Professionals generally agree that WNS is the greatest threat to cave- and mine-hibernating bat populations in eastern North America at this time.

Habitat loss and alteration

Most bat species show some degree of fidelity (i.e., loyalty) to summer and winter habitat. Substantial loss or alteration of habitat may force individuals or colonies to relocate, which may result in increased energy costs and potential impacts to reproductive, foraging, or hibernation success, depending on the quality of the new habitat and the timing. However, many bat species are capable of coping with a certain degree of habitat modification and even loss, especially those species adapted to ephemeral habitat features, such as snags, by using strategies like frequent roost-switching (see Carter et al. 2002 and Silvis et al. 2015). Individuals of many bat species also know of and visit multiple potential hibernation sites during fall swarming and migration (Fleming and Eby 2003).

Many activities can result in permanent habitat loss or alteration, such as land clearing for construction, development, energy development, or backfilling of abandoned mine entrances. Hibernacula can be made permanently unsuitable for bats when entrances are closed or altered (e.g., limiting access to bats or changing a hibernaculum's airflow, humidity, or temperature regimes), or if used to store chemicals or other contaminants. Vegetation management, such as timber harvest or prescribed fire, may alter summer habitat for years or decades, making it either more or less suitable for roosting or foraging bats. On a broader scale, climate change (Loeb and Winters 2013) and highly altered disturbance regimes (e.g., long-term fire suppression in otherwise fire-adapted ecosystems) may lead to vegetation shifts at landscape scales that could result in shifts in habitat and insect prey location and availability and affect the suitability of individual hibernacula.

Disturbance or mortality of individuals/populations

Numerous activities may cause direct or indirect harm or mortality to individuals or populations. Because local populations are concentrated during hibernation and in maternity colonies, bat populations are particularly vulnerable to disturbance at those sites. Human entry into caves and mines can disturb hibernating bats, depleting their finite energy reserves and inhibiting their ability to complete hibernation or survive WNS. Wind energy facilities have been documented as a major source of bat mortality in some locations (Johnson 2005; Arnett et al. 2008). Wind developments can kill individuals through several mechanisms, including both direct mortality (e.g., blunt force trauma and barotrauma; Baerwald et al. 2008) and indirect mortality (e.g., habitat loss and fragmentation), particularly if they occur near hibernacula or maternity colonies or in migratory pathways (Arnett et al. 2008). Felling of roost trees or removal or alteration of other roost structures can occur for many different purposes. If it occurs during the summer, individuals or groups of bats may be harmed or killed, particularly during the spring when bats may enter deeper torpor due to cool temperatures, and during the period after birth when pups are unable to fly (see Belwood 2002). Pesticide use and water contaminants may alter the availability of prey or result in bioaccumulation of contaminants in bats and their environment (Clark et al. 1978, Clark 2001, USFWS 2007). Blasting (e.g., for road construction or mining operations) is another potential disturbance, particularly when done near hibernacula or related underground karst features (Myers 1975).

General Habitat Needs of Bats

Bats have different seasonal habitat requirements, but most WNS-affected species use forest resources for roosting, foraging and drinking. Providing a diverse landscape including young and old forest stands, snags, open areas, and clean, accessible water should provide most of what bats require. Because bat species differ in their habitat preferences, no single type of forest management is best for all bats (Lacki et. al. 2007) or all game and non-game wildlife species (MacNeil et al. 2013), though providing forests with trees of varying age, a diverse understory and diversity of stand tree densities is important. Different forest types and stand characteristics may favor different bat species in different areas, but some general forest habitat features are beneficial for most WNS-affected species. The following sections describe many forest characteristics that are beneficial to bats and the types of forest management practices and other forest conservation measures that will help to provide quality habitat for those species.

DEVELOPMENT OF CONSERVATION MEASURES

The BFMPs outlined below are designed to be proactive and broadly applicable to bats and their habitats on forested lands in the eastern United States, providing a set of baseline considerations that are flexible and adaptable enough to be applied across the broad geographic range and diverse ecological communities that these species inhabit. Aside from a few endangered bat species with limited ranges or very specific habitat requirements, most bat species in eastern North America are widespread, occur across numerous ecological communities, and are adapted to various habitat types and disturbance regimes across their ranges.

While forest vegetation management has the potential to affect bats and bat habitat, these effects are temporary in most cases. Further, thoughtful planning that involves the application of BFMPs, such as those outlined below, can reduce the duration or magnitude of potential negative impacts while also providing beneficial effects and meeting management objectives. By managing for healthy and diverse forested landscapes, land managers can provide high-quality habitat that provides the full range of components needed in differing bat species' life history now and into the future. Bats inhabiting high-quality summer and fall swarming habitat are likely to enter hibernation in good health, improving their ability to survive WNS exposure and successfully reproduce. In many forested landscapes, management is necessary to maintain or restore ecosystems that experienced anthropogenic changes to historic disturbance regimes. In heavily forested areas, temporary adverse impacts of small-scale forest management activities to local bat populations often are balanced by maintenance and restoration of a diversity of high-quality habitats across the larger landscape.

Landscape Considerations

Bats require a suitable amount and arrangement of habitat to support all aspects of their life history, including foraging, roosting, reproduction, spring emergence, fall swarming, and hibernation (Fuentes-Montemayor et al. 2017). The size and characteristics of these habitat types vary depending on species and geographic location (e.g., see Silvis et al. 2016), but habitat features necessary for all essential life stages must be present to support a bat through its life cycle.

Bats are especially vulnerable during hibernation, in early spring (when bats may be recovering from effects of WNS), and when pregnant or rearing young. Therefore, caves, mines, and maternity roosts used during these critical periods should be a focus of conservation efforts. Conservation measures to protect hibernacula and maternity roosts are presented in other sections of this document. However, considering management of the larger supporting landscape around these key features also is important, because actions there also may affect the success of local bat colonies, even if a specific roost tree or hibernaculum is unaffected (Fuentes-Montemayor et al. 2017).

Many bats show some degree of site fidelity, both in summer and winter (e.g., Thompson 2006, Perry 2011) often returning each year to the same general area. Bats may move between nearby hibernacula in the winter, while females with young periodically move among nearby alternate tree roosts every 2-5 days during a single breeding season (e.g., Sasse and Pekins 1996, Foster and Kurta 1999, Menzel et al. 2002, Carter and Feldhamer 2005, Timpone et al. 2010). For many social tree-roosting species, colonies return to suitable forested habitat patches within and between years, but often switch roost trees within those areas. This roost-switching likely reflects maintenance of long-term social relationships between individuals from a colony, and social interactions among colony members may be important in identifying potential new roosts (Willis and Brigham 2004, Johnson et al. 2012, Silvis et al. 2014). As roost trees deteriorate, new ones must take their place or the area will ultimately lose its suitability. Colonies with access to larger areas of suitable roosting and foraging habitats may be more stable than those where individuals have to travel greater distances to obtain food or locate new primary roosts (Silvis et al. 2014). Thus, on a landscape scale, a mosaic of forest vegetation around hibernation and maternity sites generally is desirable, whether natural or managed through silviculture. Timber harvest can be used to create openings to provide more sunlight to potential roost trees or improve foraging habitat for some species. Harvest prescriptions that maintain more canopy cover can be desirable for other, more clutter-adapted species. Because of the diversity of bat species' foraging and roosting requirements, a staggered mix of silvicultural treatments and exclusion areas may be required within large timber production forests to sustain high levels of bat diversity on a landscape scale (Law et al. 2016). Prescribed fire and timber harvests also can be used to encourage the growth of new young trees, providing a source for future roost trees as existing roosts deteriorate and become unsuitable.

Landscape-scale Beneficial Management Practices:

- Bats have different temporal and spatial habitat needs and preferences. The scale at which bat species perceive their environment is influenced by variation in the distribution of resources, as well as by species-specific differences in ecological traits (Jachowski et al. 2016, Meyer et al. 2016, Silvis et al. 2016, Fuentes-Montemayor et al. 2017). Seasonal differences in habitat requirements were discussed above, but landscape-level planning also requires a consideration of different spatial scales. On a broad scale, a mosaic of forest types (including mature forest and other age classes) and non-forest habitats (e.g., grasslands, wetlands, scrub-shrub etc.) will produce a landscape conducive to multiple bat species. However, the size and juxtaposition of patches are also critical to meeting life history requirements of many species. At a local scale, the presence of high-quality maternity habitat for a given species within commuting distance of good foraging habitats and water sources can be key to maintaining populations. Likewise, productive foraging habitat, water sources, and suitable roosts near a hibernaculum provide quality fall swarming habitat, allowing bats to put on critical weight before hibernation, and can be essential for recovery of WNS-affected species upon emergence.

- For each known WNS-affected hibernaculum or maternity colony, determine the relative contribution of the site to the population. For sites deemed important to the success of the local population, a conservation zone should be established. The size of the zone may vary by bat species' biology and life history as well as the condition of the surrounding landscape. The shape of this zone may be irregular to accommodate fall swarming and spring staging areas, likely flight paths, local topography, alternate roosts, foraging habitat, surface water sources (e.g., streams, ponds, and wetlands) and hydrologically connected karst features/drainage basins (see Jones et al. 2003). For each conservation zone, develop a plan to manage suitable habitat, taking into consideration current conditions, desired future conditions, and future constraints and/or challenges. The plan may cover a range of formats depending on the situation; it may be formal or informal, be written as separate site-specific plans or address multiple areas at once, and provide broad or specific direction depending on how much is known about the site. Consider including input from interested federal, state, tribal groups, and non-governmental organizations (NGOs) and consider influence of both public and private ownerships within the conservation zone. Management actions within this conservation zone should be compatible with maintaining or restoring the structure, function, composition, and connectivity of forest ecosystems that support quality bat habitat. Identify desired future conditions to support WNS-affected bat species and, where feasible, manage towards these goals. Consider limiting activities that reduce habitat quality, permanently modify habitat or result in permanent habitat loss within each conservation zone.

Vegetation Management

Forest vegetation management can positively or negatively affect foraging habitat, maternity and day roosts, hibernacula, fall swarming and spring staging habitat at multiple spatial scales. Many WNS-affected bat species in North America roost in trees during summer, and vegetation management can play a key role in providing or enhancing day-roost and maternity-roosting habitat. While specific roost tree and landscape characteristics vary among bat species depending on geographic location and habitat availability, a few characteristics are common to most maternity colony habitats. For example, most bats prefer to roost in large-diameter trees and snags, which generally persist longer than smaller snags and can support more roosting bats

(Russo et al. 2004, Baker and Lacki 2006, Kalcounis-Rüppell et al. 2005, Lacki et al. 2012). Therefore, the identification and inclusion of such trees in residual patches during timber harvesting is important. In addition, tree roost-switching is common and retention of a network of suitable roost trees in close proximity is considered an important characteristic in selection of roost trees by reproductive females (Willis and Brigham 2004, O'Keefe 2009, Patriquin et al. 2010, Johnson et al. 2012, Silvis et al. 2014).

Conservation of forest cover and/or management of areas near hibernacula to provide additional snags can increase suitable habitat for tree-roosting bat species during swarming. Vegetation management and other habitat manipulation (e.g., the creation of water sources, particularly in areas lacking water, such as dry ridgetops; see Biebighauser 2003) also can be used to increase insect (prey) availability for bats during spring emergence and fall swarming. The availability of insect prey in the general vicinity of hibernacula can be critically important to bats affected by WNS as they emerge in spring and attempt to restore body fat and repair tissue damage from WNS infection and again while storing winter fat reserves during the fall swarming period (Lacki et al. 2015). In addition, vegetation management within a forested landscape can provide edge habitat that is frequently used by bats for commuting and foraging and can strongly influence both short- and long-term prey availability in a given area, which will result in a concurrent response from local bat populations (Hayes and Loeb 2007).

Potential Benefits and Impacts of Vegetation Management

The most direct influence of vegetation management on bat populations is the creation or destruction of roost trees. While tree harvest can result in the loss of potential roost trees, adverse effects can be avoided or minimized through a variety of management practices, including but not limited to: conserving riparian areas, leaving snags and live trees with known roost tree characteristics (e.g., exfoliating bark, large crevices, cracks, or cavities), maintaining a minimum basal area of potential roost trees, and seasonal restrictions where practicable. In areas of extensive intact forest, the likelihood that a given timber harvest will result in loss of a maternity colony is remote, although it cannot be ruled out. In many regions, harvesting timber during the hibernation period eliminates or significantly reduces the likelihood of direct fatality or injury to tree-roosting bats. Potential indirect impacts include disturbance and noise associated with harvest activities. If not carefully prescribed, some management activities (e.g., timber harvest and prescribed fire) could alter microclimates (e.g., humidity and temperature) in and around roost sites (whether tree roosts, rocky roost habitats, or structures), expose bats to greater temperature extremes, and thereby cause site abandonment or other adverse effects (Erdle and Hobson 2001).

Active forest management can result in the creation, enhancement, and conservation of bat habitat over broad areas. Vegetation management practices that sustain or enhance diversity of tree species, size-classes, and snag condition can be important tools in providing diverse habitat for bats, particularly when fire and other historical disturbance regimes have been suppressed or altered. Because of variable spatial and temporal habitat needs of bats (both within and across species), a heterogeneous landscape is advantageous even for forest interior (i.e., clutter-adapted) species if intact forest is the dominant cover type in a given area. In heavily forested landscapes, small patch cuts, variable-density thinning, and uneven-age management prescriptions (e.g., single-tree and group selection) can provide important habitat heterogeneity for bats, and may increase use relative to adjacent undisturbed forest (Hayes and Loeb 2007).

Potential beneficial effects of vegetation management to bats include, but are not limited to: the creation of snags, canopy gaps that increase sun exposure to existing and potential roost trees, travel corridors, a reduction in midstory clutter, and increased foraging opportunities (e.g., increased mobility, insect prey detection and likely foraging success). Silvicultural practices such as two-age harvests, shelterwood harvests, single-tree selection, and group-selection treatments likely are compatible with bat management, providing suitable habitat for closed canopy species, such as the northern long-eared bat, while also providing habitat for other species adapted to more open canopy conditions (Broders and Forbes 2004, O'Keefe 2009, Titchenell et al. 2011, Sheets et al. 2013). Under even-age vegetation management, reserve patches (e.g., 0.25 acres for every 10 acres harvested) may be retained to provide seed sources as well as roost sites, cavity trees and other wildlife habitat resources, protect seeps, and provide structural diversity (Leak et al. 2014). Such harvest units can provide valuable habitat for bats in an otherwise homogeneous forested landscape.

Retaining or creating large-diameter snags during regeneration harvests, and the creation of additional standing snags through mechanical (e.g., girdling) or chemical (e.g., "hack and squirt") means can provide roost trees, which might otherwise be in limited supply (Lacki and Schwierjohann 2001). Canopy gaps allow sunlight to warm roost trees and rocky habitats (for small-footed bats), providing warm microclimates that maximize growth rates of young bats (Johnson et al. 2009).

Vegetation management can affect foraging habitat for bats through both changes in the physical structure of foraging habitat and resultant changes in prey abundance, diversity, and availability. Providing a landscape containing forest stands with both high and low levels of clutter (e.g., through the use of both even- and uneven-aged silvicultural systems) can offer suitable foraging habitat for a variety of bat species. Effects of vegetation management on insect prey communities are varied and depend on many factors, including management actions, as well as landscape and climatic conditions that may vary both spatially and temporally. High diversity of invertebrate prey taxa, variation in responses to vegetation treatments, and temporal changes in invertebrate communities across differing habitats preclude broad-scale guidance regarding effects of vegetation management on prey populations. Some studies indicate that while the use of clearcutting results in a decrease in the abundance and diversity of Lepidoptera, the primary prey species for many bat species, the use of selective harvest (i.e., uneven-aged management practices) does not result in significant alteration of invertebrate prey communities (Summerville and Crist 2002, Dodd et al. 2012, Summerville and Marquis 2017). Even within previously clearcut areas, thinning of dense regrowth can enhance the revegetating forest as foraging habitat for both open- and clutter-adapted bats (Blakey et. al. 2016). While exceptions exist, studies in different geographic areas consistently have found an overall increase in bat activity in disturbed habitats (e.g., Brooks 2009, Loeb and O'Keefe 2011, Titchenell et al. 2011, Cox et al. 2016). This suggests that habitat structure that allows for more efficient foraging is more important than prey occurrence in determining spatial and temporal foraging patterns of forest bats (Morris et al. 2010, Dodd et al. 2012, Blakey et al. 2016).

Besides enhancing summer roosting and foraging habitat, vegetation management can affect spring staging and fall swarming habitat for bats in the immediate vicinity of hibernacula and associated karst features. The landscape surrounding hibernacula provides essential habitat for bats in fall as they mate and put on body fat reserves in preparation for hibernation. These areas also support bats emerging in the spring in need of nearby resources to restore body fat depleted during hibernation and repair tissue damage that may have occurred from WNS infection during hibernation (Raesly and Gates 1987). Maintaining the integrity of riparian habitats in forests also is critical to bat conservation as riparian zones frequently provide concentrated areas of roosting sites, water, and high-quality foraging habitats (Taylor 2006, O'Keefe et al. 2013).

The vegetation management recommendations provided below are based on aspects of bat ecology and are meant to be consistent with management of healthy forests and a sustainable supply of forest products while providing for long-term bat habitat conservation.

Beneficial Vegetation Management Practices

- During harvest activities, retain all snags except where public or worker safety concerns exist or where catastrophic weather events or disease/insect outbreaks in a stand constitute a threat to the health of the surrounding forest. Retain live leave-tree groups (reserve islands) around snags to provide partial shade during summer and to protect them from windthrow and being accidently knocked down during harvest operations.
- In even-aged management stands of $\geq$20 acres, where harvest reduces basal area to below 30 ft^2/acre, uncut patches totaling 5% of the harvested area should be retained. Leave-tree clumps should be variable in size (but a minimum of 0.25 acres) and located throughout the harvest unit, including all snags and one or more large live trees (>18 inches DBH, or as large as available) to provide for a continuous supply of roost trees. Locating leave-tree patches near or adjacent to riparian management zones, wetlands, and/or wildlife openings is encouraged; however, riparian buffers should not be used for all reserve islands, as snag and leave-tree patches also are important in upland forest treatments.
    - Exceptions to the recommended leave-tree patch size would occur when a stand is being managed for a specific vegetation type that has a basal area of < 30 ft^2/acre (e.g. savanna or grassland) or when recommended management for non-bat TES species conflicts with these guidelines.
- Uneven-aged management should maintain all snags, a minimum of basal area of 30 ft^2, and, where possible, retain at least 16 live trees $\geq$ 9" DBH per acre (with at least 6 trees/acre of the largest available trees of species favored by roosting bats, which will

vary by bat species and geographic location). Where insufficient large trees are available to meet silvicultural management needs while providing the number and size of trees noted above, a minimum basal area of 30 sf/acre should be maintained across the stand, including 16 of the largest trees available per acre, to provide adequate canopy cover and roost-tree availability.

- Application of herbicides and other pesticides should avoid or minimize direct and indirect effects to known hibernacula, maternity sites, and surface karst features. Aerial or broadcast spraying should not occur near these sites unless it can be demonstrated that they would have no adverse impact on bat populations or habitat. Refer to Non-Native Invasive Species (NNIS) section for more details regarding pesticide application issues. Such uses should be compatible with WNS-affected bat population maintenance or recovery.
- If an occupied bat roost tree(s) is discovered, avoid physical disturbance to it until it naturally falls to the ground or becomes unsuitable for bat use. Mark the roost tree and establish a buffer within which management activities that may disturb the bats would be restricted during the maternity season. Consider creating a new roost tree(s) nearby if an existing roost tree is not likely to remain suitable for much longer.
- Avoid disturbance around known maternity sites during the period when pregnant or lactating adults and non-volant young are present, except when necessary to address an immediate threat to public health and safety (see snag and hazard tree management section). Disturbance during this period should be avoided until the site no longer supports a maternity colony, as determined by a wildlife biologist. Also avoid disturbance around hibernacula during winter, spring emergence, and fall swarming periods. Contact your state wildlife agency or USFWS field office for time-of-year restrictions around maternity sites and hibernacula, as season dates vary by region and species.
- Provide artificial roosts such as bat boxes or artificial bark to supplement existing habitat or mitigate a loss of roosting habitat (Rueegger 2016).

Snag and Hazard Tree Management

Even though many are ephemeral, suitable roost sites are often considered the most important habitat component for cavity/crevice-roosting bats. Therefore, one of the most important actions forest managers can take to maintain local populations of these bats is to provide a continuous supply of suitable roost trees (Taylor 2006, Silvis et al. 2016) that provide shelter for bats and their pups. Snags are dead trees that provide important roosting structures for bats under loose bark and in cavities, crevices, and hollows (Taylor 2006). Leaving snags that provide roosting habitat on the landscape can provide essential habitat for a variety of bat species. As noted above, the creation, recruitment, and retention of large-diameter snags can provide important habitat for tree-roosting bats, particularly near high-quality foraging areas and areas with low snag densities. Sites with an abundance of quality roost trees are often used by maternity colonies of species such as the Indiana and northern long-eared bat. In addition to providing a place to raise young, such roosting sites provide protection from predators and the elements as well as a central location for social interactions and communications.

The creation and retention of snags is highly recommended as an integral part of forest management and bat conservation. However, at times, the goal of conserving bat habitat conflicts with the necessity of ensuring the safety of people, particularly when it comes to dead and dying trees, which may be considered hazardous. Human safety should always take top priority in emergency situations. However, to the extent prudent and practicable, land managers should remove safety threats posed by hazardous trees in a way that avoids and minimizes harm to bats that may be using these trees as roosting habitat. The actions outlined below are considered beneficial for the conservation of tree-roosting bats that may use trees that pose a safety hazard to humans but are not considered emergencies, and are intended for use with any forest activity, in any location, including along roads and trails through forested areas.

Beneficial Hazard Tree Management Practices

(Dates for seasons noted below may vary by latitude and elevation; check with the state wildlife agency or local USFWS field office)

- Once a hazard tree has been identified, a danger zone around it should be clearly delineated with caution tape until the tree can be safely felled. Appropriate federal and state policies and guidelines should be followed whenever hazard trees are removed. Only qualified individuals with sufficient knowledge, training, and experience should attempt to fell a hazard tree.
- Not all hazard trees are potential bat roost trees and vice versa. If a hazard tree does not provide potential bat roosting habitat (e.g., no loose/exfoliating bark, cracks, hollows or cavities), then it may be removed without further consideration to roosting bats.
- If a hazard tree appears to provide bat roosting habitat and does not pose an imminent danger to human safety or property, then felling should occur during winter (hibernation period). If a tree must be removed outside of the winter, and time allows (e.g., a non-emergency situation), determine whether the tree is occupied by bats before removal.
    - Bat occupancy of a tree typically can be made by conducting a single evening emergence survey during appropriate conditions (e.g., temperature ≥ 50 degrees F, no precipitation, no sustained winds > 9 miles/hour). If no bats are observed, then the hazard tree should be removed the following day; listen for roosting bats and look for guano at the base of the tree prior to felling the tree in case a maternity colony is present, but was not detected during the emergence survey. If one or more bats are observed or heard, then coordinate/consult with your local state wildlife agency or USFWS field office.
- All hazard trees that are known bat roosts and are not considered high-risk hazards should be removed during winter. If safety concerns or other circumstances dictate that felling of low- or medium-risk hazard trees cannot be postponed until the inactive season, avoid removing them during June and July when non-volant bat pups may be present.

- Assess whether a low-risk hazard tree that is occupied by bats could be left standing (short-term or long-term) and used as an educational outreach opportunity. For example, a roost tree within or near a campground might require the closure of a single campsite, but in turn could be the focus of a nightly bat count activity for campers (from a safe distance).
    - In cases where it is determined that a hazard tree needs to be removed, but the lower portion of the bole is considered sound and stable, consider felling the tree in a manner that leaves a tall (6-10 foot) stump, which addresses safety concerns, but leaves some roosting structure.
- Once felled, a downed tree(s) should be carefully inspected for bats. Report any dead or injured bats to your local state wildlife agency (or USFWS field office if it is known to be a federally listed TE species). If found, living non-volant and injured bats should be taken to a local bat rehabilitator.
- If snags must be removed, consider replacing them with artificial roosts, particularly in areas with limited natural roosting habitat or when bats are being excluded from structures. Proper design and placement of these structures are critical for success, and can vary by species and geographical region. Guides to bat house design and placement are available online (e.g., Bat Conservation International).

Prescribed Fire

Fire historically maintained a mosaic of forests, grasslands, savannas, and open woodlands throughout many portions of North America, including the eastern United States (Abrams 1992, Lorimer 2001, Perry 2012). Consequently, bats were exposed to frequent fire over many centuries, which likely caused adaptations to fire and the vegetation associated with frequent fire. During the 20th century, fire suppression caused many forests that were previously open and park-like to succeed to dense, closed-canopy forests (Lorimer 2001, Van Lear and Harlow 2002, Nowacki and Abrams 2008, Spetich et al. 2011), since fire-adapted forest ecosystems require fire to maintain the natural quality of the forest structure. Many plant and animal species are now endangered due to structural changes in forests associated with fire suppression (Wilcove et. al. 1998).

Land managers use prescribed fire to meet many forest-management objectives, including hazardous fuel reduction, preparing sites for seeding, improving wildlife habitat, controlling insects and disease, and ecological restoration (Waldrop and Goodrick 2012). These prescribed fires may affect bats directly through heat, smoke, and carbon monoxide, or indirectly through modifications in habitat and changes in their food base (Dickinson et al. 2009). Burning may have positive, negative, or no effect on bat ecology, and potential effects may vary among bat species, time of the year, fire frequency, ambient temperatures, and intensity of burns (Johnson et. al. 2010, Perry 2012, Ford et. al. 2016, Perry et. al. 2016).

Potential Benefits and Impacts of Prescribed Fire

Fire can have positive effects on forest structure for bats. For example, fire may reduce understory and midstory clutter and create small canopy openings that are used by many species of bats for foraging, and may increase insect production (Carter et al. 2002; Keyser and Ford 2006; Lacki et al. 2009; Perry 2012). In addition, burned areas may have lower tree densities, less structural clutter, more open canopy, and greater numbers of snags, which may provide favorable roosting sites for many species and may be especially important to female bats during summer (Perry 2012, Ford et al. 2016). Furthermore, planned prescribed burns often reduce the risk of unplanned wildfires, which can occur during any time of year, including the maternity season, and may result in both direct and indirect negative effects to bat communities.

Site preparation and developing infrastructure for prescribed fires may negatively affect bats. Disturbance from noise and felling of trees and snags during fire-line construction could cause direct mortality during the maternity season if non-volant bats are present in the burn area, or if ambient temperatures are low enough that adult bats in torpor are less able to mobilize and escape. Noise, smoke, and heat associated with prescribe fire also could disturb bats. Many bats roost high in tree canopies or boles; thus, low-intensity fires are less likely to cause injury than high-intensity fires (Rodrigue et. al. 2001, Dickinson et al. 2010). Fire intensities and other conditions that cause leaf scorch in overstory trees may be detrimental to bats if they are unable to escape approaching flames. Bats typically go into torpor during roosting, and the depth of torpor is dictated by the ambient temperature. When ambient temperatures are cold, but above freezing, bats are slow to arouse from torpor, which leads to increased response times when confronted with disturbances. Consequently, burning during cold periods may be detrimental to colonies of some species if individuals cannot escape smoke and heat from fires.

Beneficial Prescribed Fire Management Practices

- Burn plans should account for caves, mines, important rock features, bridges, and other artificial structures that are often occupied by roosting or hibernating bats.
  - The above sites should be considered smoke-sensitive areas and burn plans should be developed to avoid or minimize smoke influences on these sites by using wind direction and speed, mixing height, and transport winds;
  - Consider seasonal use of these features by bats and try to plan burns when bats may not be present;
  - Limit activities near cave entrances to avoid disturbances such as fire-line construction.
- Burn plans should consider potential presence of bats in the area.
  - Use low intensity burns when temperatures are $<50^{o}$ F to prevent heat injury to bats that cannot escape due to deep torpor.
  - If prescribed fire must be conducted during the maternity season (when non-volant young may be present in trees and snags) to meet management needs (e.g.,

habitat restoration in fire-adapted landscapes), then use only low-intensity burns during moderate winds (>5 mph) to reduce potential heat injury to roosting bats.

- While WNS-affected species do not typically roost in leaf litter, other bat species are known to roost and hibernate in litter. To avoid adverse effects to these species, dormant-season burns should occur on clear days when ambient temperatures are > 40°F and, when the previous night's temperatures fall below freezing. Ideally, fires should be ignited in late morning to afternoon. These actions allow litter to warm and increase the chances of escape by litter-hibernating species.

- Where practical, remove hazard trees and construct fire-lines during winter to reduce chances of removing occupied roost trees or disturbing maternity colonies.
- Known maternity roost trees and exceptionally high-quality potential roost trees (e.g., large snags or large-diameter live trees with lots of exfoliating bark; quality as determined by a wildlife biologist) should be protected from fire by removing fuels from around their base prior to ignition.

Creation and Management of Forest Openings

Forest openings are areas within forested landscapes with no or very sparse overstory canopies that often support early successional habitats and are usually created through disturbance (Greenberg et al. 2011). Forest openings range in size from a single treefall to hundreds of acres and result from numerous natural and anthropogenic disturbances. Natural disturbances include wind, ice, wildfire, tornados, hurricanes, pathogens, flooding, beaver activity, grazing, tree fall, and landslides (Rosell et al. 2005, White et al. 2011). Anthropogenic causes include forest harvesting, prescribed fire, and creation of wildlife openings, roads, and right-of-ways (Rankin and Herbert 2014). Natural openings include special ecosystems such as glades and high-mountain balds. The permanence of these openings varies depending on how and why they were created. For example, harvested areas on public and private lands usually are regenerated either naturally or through planting and only remain as early successional habitat for a relatively short time (e.g., <50 years), whereas wildlife openings and right-or-ways are typically maintained over long periods through active management.

Early successional habitats are components of ecosystems and need to be maintained as such within larger forested landscapes (Swanson et al. 2011). Many plants and animals depend on early successional habitats and the decline of early successional habitats over the latter part of the 20th century has resulted in the decline of these species (Hunter et al. 2001; Litvaitis 2001; Thompson and DeGraaf 2001; Warburton et al. 2011). Thus, several efforts are currently underway to restore early successional habitat throughout forests of the eastern and Midwestern U.S. (Rankin and Herbert 2014).

Potential Benefits and Impacts of Forest Openings

One of the most significant effects of creating openings through timber harvest is the loss of roost trees, particularly large-diameter snags (Hayes and Loeb 2007). Further, many of the live trees that are harvested represent potential future roosts. Wildfire and prescribed fire can also result in the loss of large snags, although small snags are often created (Bagne et al. 2008; Horton and Mannan 1988; Randall-Parker and Miller 2002; Stephens and Moghaddas 2005). Thus, if sufficient snags are not available throughout the rest of a particular area, then creating openings through harvest or fire may reduce roosting habitat. Creation of large openings can also cause fragmentation of forested areas used for roosting, foraging, and commuting. At the local scale, bats are often reluctant to cross large open areas (Henderson and Broders 2008; Murray and Kurta 2004; Swystun et al. 2001), but may use the edges of forest openings as foraging and travel corridors. There may also be effects at the landscape scale (e.g., see differing effects associated with non-forested habitats in Farrow and Broders 2011 and Ethier and Fahrig 2011).

Creating openings also may affect the insect prey base for bats. Some studies have found greater insect abundance in early successional habitats than in mature forest (Dodd et al. 2012; Lunde and Harestad 1986), whereas others found that insect abundance and diversity decline after harvesting (Burford et al. 1999; Dodd et al. 2008; Grindal and Brigham 1998, 1999; Morris et al. 2010).

Although creating openings in forested landscapes may have some negative effects on bats, openings are commonly used by WNS-affected bats for foraging and may represent important habitats for them (Loeb and O'Keefe 2011). For example, bats use openings for foraging and commuting much more than interior forests in a number of ecosystems (Ellis et al. 2002; Erickson and West 1996; Grindal and Brigham 1998, 1999; Krusic et al. 1996; Mehr et al. 2012; Sheets et al. 2013; Tibbels and Kurta 2003), although in more northern latitudes such as Alaska, openings appear to be avoided (Parker et al. 1996). Small openings and gaps are commonly used by species such as the little brown bat and tri-colored bat (Ford et al. 2005; Loeb and O'Keefe 2006; Schirmacher et al. 2007). Edges between openings and mature forest are particularly important foraging and commuting areas (Furlonger et al. 1987; Hein et al. 2009; Hogberg et al. 2002; Jantzen and Fenton 2013; Morris et al. 2010). Edges may be important habitats because they are often more protected from the wind and thus, increase foraging and commuting efficiency (Verboom and Spolestra 1999). Insect abundance is also greater along edges (Lewis 1970; Morris et al. 2010) and edges may serve as navigation aids (Furmankiewicz and Kucharska 2009; Verboom et al. 1999) and provide protection from predators (Clark et al. 1993; Verboom and Spolestra 1999; Walsh and Harris 1996). Thus, one of the most beneficial aspects of creating openings is the creation of edge habitat for bats.

Large openings are rarely used for roosting although some bats have been documented using snags, stumps, or small trees in clearcuts (O'Keefe et al. 2009; Vonhof and Barclay 1997; Johnson, unpublished data). However, bats often roost near or at the edge of openings (Callahan et al. 1997; Campbell et al. 1996; Carter and Feldhamer 2005). Bats may prefer to roost near forest edges to reduce thermoregulatory costs as roosts on forest edges likely receive more solar radiation (Barclay and Kurta 2007). Since many bats forage in open areas, they may also roost close to edges to reduce their commuting costs to these foraging areas (Kunz and Lumsden 2003; O'Keefe et al. 2009).

Factors Affecting Use of Openings by Bats

When creating forest openings, one of the first decisions managers must make is how large openings should be. Only a few studies have examined this question and results to date suggest opening size may be a factor for some bat species. For example, among small openings (0–525 feet in diameter) in the central Appalachians, opening size did not affect occupancy of northern long-eared bats, Indiana bats, or tri-colored bats, although big brown and little brown bats are more likely to be found in openings with larger dimensions (Ford et al. 2005). Similarly, big brown bats in the Coastal Plain of South Carolina were more active in 1.2-acre openings than 0.07-acre openings whereas tri-colored bats were more active in the 0.07-acre openings although the differences are not statistically significant (Menzel et al. 2002). For larger openings, Grindal and Brigham (1998) found that bat activity declined with increasing size openings in British Columbia, although the differences in activity among 1.2-acre, 2.5-acre, and 3.7-acre openings was not significantly different. Similarly, overall bat activity in the southern Appalachians was greater in small (0.5–4.9 acre) and large (15–45.7 acre) openings than in medium (4.9–14.8 acre) openings; however this difference was not statistically significant (Brooks et al. 2017).

The shape of an opening determines the amount of edge relative to its area. Given the importance of edge habitat for a number of species, shape may be an important characteristic to consider. However, the amount of edge necessary to sustain bats may vary with scale. For example, Bender et al. (2015) found that occupancy of managed stands by big brown bats decreased with increasing amount of edge in the landscape. A study by Morris et al. (2010) in a managed pine plantation indicated that edges were used extensively by several aerial-hunting bat species, including the big brown bat, but avoided by Myotis species. While Brooks et al. (2017) found no significant difference in bat activity between interiors and edges of openings in the Nantahala National Forest of North Carolina, higher levels of activity in elongated openings suggested that bats preferred openings with more edge relative to the opening area.

Few studies have addressed the relationship between position of openings on the landscape and bat use. One factor that may be important is proximity to water as riparian areas often are used more frequently than upland habitats (Brooks 2009; Ellis et al. 2002; Ellison et al. 2005; Grindal et al. 1999; Owen et al. 2004; Racey 1998; Walsh and Harris 1996). No studies have examined how use of openings varies with distance to water, but distance to water does not appear to be an important variable in models of forested stand use (Bender et al. 2015; Hein et al. 2009; Johnson et al. 2008; Loeb and O'Keefe 2006; Yates and Muzika 2006). Other landscape conditions that may be important, but require further study include the effect of patch interspersion and juxtaposition on bat activity and the effect of opening patch proximity to roosting habitat.

Beneficial Forest Opening Creation/Management Practices

- Where practicable, design forest openings that maximize the amount of edge relative to opening area (e.g., long and narrow openings, or those with sinuous edges), to provide a greater amount of foraging habitat and perhaps additional predator protection.
- Create relatively small openings (< 5 acres) as they may provide the best balance between maintaining foraging and roosting habitat across the landscape.
- Retain stumps and snags within openings, particularly along the edges to provide residual roosting sites for some species. Where natural roosting habitat is limited, consider creating additional snags (e.g., through topping, girdling or stem-injection herbicides) or, in rare circumstances, installing artificial roosts (e.g., bat boxes or artificial bark) to mitigate the loss of or complete lack of roosting habitat.
- If openings are created for forest regeneration, those stands should be thinned and/or burned during appropriate seral stages to create and maintain high-quality foraging habitat in the future (Humes et al. 1999; Loeb and Waldrop 2008; Smith and Gehrt 2010).

Non-Native Invasive Species (NNIS) Management

Non-native and Invasive Plants

Non-native and invasive plants often out-compete native vegetation and reduce native plant diversity with the potential to dramatically alter forest habitat. For example, some invasive plants such as Oriental bittersweet (*Celastrus orbiculatus*), Japanese honeysuckle (*Lonicera japonica*), Asian bush honeysuckles (*Lonicera* spp.) and Kudzu (*Pueraria lobate*) can choke out native trees. Invasive tree species, such as Russian olive (*Elaeagnus angustifolia*), may modify forest stand structure, resulting in decreased use of some riverine habitat by bats (Hendricks et. al. 2016). Non-native plants may also reduce insect biomass, disrupting terrestrial food webs by reducing the insect biomass available for insectivores in higher trophic levels (Tallamy 2004, Tallamy et al. 2010, McNeish et al. 2017). In addition, non-native species such as burdock (*Arctium* spp.) may pose a threat of entanglement and mortality for small flying vertebrates such as birds and bats (Norquay et. al. 2010). Thus, eradication and control of invasive plants often indirectly supports the maintenance of quality habitat for bats.

During invasive plant management, care needs to be taken to minimize disturbance to active bat maternity colonies and hibernacula, and to avoid removal of active maternity trees. Further, application of pesticides should avoid direct contact with bats, and locations of maternity colonies need to be considered when applying disturbance methods of invasive plant management such as prescribed fire (see prescribed fire section). Additionally, minimizing the use of pesticides as a management method will reduce risks of unintended consequences, such as food chain effects.

Pesticides vary in toxicity and persistence and this document will not attempt to review them. Pesticide additives, such as adjuvants and surfactants, while not the active ingredient of the pesticide, can be toxic as well. The ecological fate and effects of pesticides are complex and various ecological studies have found unexpected effects on biological systems. Control treatments vary depending on life history of the plant and level of problem. Management can include, but is not limited to: hand pulling, mechanical removal, covering with plastic, herbicide, fire, or any combination of the above. Control using herbicide in forest management typically consists of one or more of the following practices – a) foliar herbicide application, b) basal spray herbicide application, c) chainsaw girdling and herbicide application, or d) cut and spray herbicide application or herbicide injection. Minimizing the use of pesticides is a good practice that is consistent with the principles of Integrated Pest Management (IPM). When use is essential for meeting management objectives, applying in a way that reduces contact with non-targets is warranted.

Non-Native and Invasive Insects

Biological invasions are one of the most significant environmental threats to the maintenance of natural forest ecosystems in North America and elsewhere (Liebhold et al. 1995). Invasive forest insect pests (and fungal diseases) have the ability to cause massive mortality events across extensive forestlands. Apart from the staggering economic losses attributed to exotic insect pests such as the gypsy moth (*Lymantria dispar L*), emerald ash borer (*Agrilus planipennis*) and Asian long-horned beetle (*Anoplophora glabripennis*)(Wallner 1997, Aukema et al. 2011), these pests can have devastating adverse impacts on the health, productivity, species richness and overall biodiversity of eastern U.S. forests and the bat communities dependent on them. For example, the emerald ash borer has killed hundreds of millions of ash trees (an important roost tree for Indiana bats in Michigan and elsewhere) and gypsy moth larvae eat leaves of a large variety of trees, including ash, oak and maple, also important roost trees for a variety of tree-roosting bats. Hemlock wooly adelgid results in the loss of forest cover and change in forest composition, particularly in riparian areas, which could affect native insect prey resources for bats (Adkins and Rieske 2015).

Since bats are insectivores, they are at risk of accumulating pesticides and other toxins in the food supply (Clark et. al. 1978, Stahlschmidt and Bruhl 2012). Some have suggested that bats may be more susceptible to the effects of contaminants than other mammals due to their high metabolic rates, low reproductive rates, and annual hibernation cycles requiring significant fat deposition and the propensity for some contaminants to accumulate in fat reserves (Stahlschmidt and Bruhl 2012). In addition, their relatively long life spans can result in accumulation of toxins over many years until they finally reach toxic levels. Studies of pesticide residues in bats are not extensive. However, examples include a study of historical declines in Mexican free-tailed bats in Carlsbad Caverns that were linked to toxic concentrations of DDT (Clark 2001), and populations of little brown bats in New York and Kentucky that were found to have concentrations of persistent organochlorine, polybrominated and fluorine-based pollutants high enough to cause immunosuppression and endocrine disruption (Kannan et. al. 2010). Secord et al. (2015) also showed that some contaminants of emerging concern (CECs) are accumulating in the tissue of bats, and proposed that these CECs have the potential to affect physiological systems in bats, including hibernation, immune function, and their ability to respond to WNS. O'Shea and Clark (2002) provide an overview of contaminants and bats, with a focus on insecticides and the Indiana bat, and a more recent review of the issue of organic contaminants in bats is provided in Bayat et al. (2014).

Insects are more similar in structure and physiology to mammals than plants or fungi and consequently insecticides are often of greater toxicity to mammals than herbicides (Marrs 2012). Some insecticides are specific to the target organism and others are more broad-spectrum so they can potentially have greater impact to the food chain. Studies have shown that effects of chemical mixtures on ecological systems may be more than additive (Boone 2008).

The use of pesticides that are more target-specific than broad-spectrum may reduce contact with non-target organisms, and thus potential effects to bats. The use of more targeted pesticide application methods also can reduce unintended non-target effects, though even a targeted application may result in leaching of the pesticide into the food chain depending on the chemistry and persistence of the pesticide. An example might be imidacloprid, which is used to control hemlock woody adelgid (*Adelges tsugae*) with treatments that are applied either through soil or tree injections. The chemical is absorbed and transported through the tree's vascular system killing the feeding adelgids (Webb et al. 2003). Imidacloprid is in the family of neonictinoids, a relatively new class of pesticides related to nicotine that act on the nervous system of insects. Because it is water-soluble, it is readily absorbed in soil and into the entire plant. A study in the Netherlands found aquatic macroinvertebrate declines due to leaching of imidacloprid into waterways (Van Dijk et al. 2013). Since aquatic invertebrates often transform into terrestrial flying insects, they become a food source for foraging bats.

Beneficial Non-native Invasive Species Management Practices:

For pesticides, the concept of "less is best" should be kept in mind because the chemistry of pesticides is complex and unintended ecological consequences may occur. Further, Integrated Pest Management (IPM), using a combination of techniques for long-term pest control, is the best way to balance the needs of invasive management with the risks of pesticide use.

- Avoid NNIS activities around occupied bat roosts
- Apply principles of IPM when determining the treatment method
- Maximize buffer zones from water or wetlands when using pesticides to reduce contact with the aquatic food chain

- Use pesticide application methods that minimize pesticide contact with non-targets
- Minimize the need for treatment by minimizing the spread of invasives by:
  - Cleaning equipment before entering new sites and upon leaving sites
  - Minimizing ground disturbance as scarified ground provides for germination of many invasive plants.
  - Covering bare ground with non-invasive plants or weed-free material as soon as possible
  - Identifying and removing new invaders before they have the opportunity to become well established
- Use the most specific and least environmentally damaging pesticide product
- Use all pesticides according to the label as required by law (Federal Insecticide, Fungicide, and Rodenticide Act)
- When considering pesticide use, consider the potential environmental effects of both the active ingredient and other ingredients such as surfactants and adjuvants
- In areas where invasive plants are already well established, conduct one or more rounds of herbicide treatment (as needed) to reduce their vigor and abundance before conducting timber harvests or other soil-disturbing activities.

GLOSSARY OF TERMS (as they relate to this document)

Beneficial forest management practices (BFMPs): any existing or new practices adopted on a voluntary basis that provides an effective and practical means of reducing risks to WNS-affected bats or their habitats while achieving desired forest management goals. BFMPs describe the best ways of doing things in particular situations and at specific time periods to eliminate or minimize negative consequences for one or more environmental factors related to the conservation of bats or their habitats.
Clearcutting: A method of regenerating an even-aged stand in which a new age class develops in a fully exposed microclimate after removal, in a single cutting, of all trees in the previous stand.
Clutter-adapted: a species with a suite of characteristics that allow for use of physically cluttered environments (i.e., adapted to flying and foraging among dense or "cluttered" vegetation).
Conservation measures: actions that contribute to the conservation of WNS-affected bat species and include, but are not limited to, avoidance measures, minimization measures, mitigation measures, and proactive measures.
Conservation zone: a defined geographical space given special management consideration to support long-term conservation of bats. Conservation zones are typically established around important hibernacula and maternity roosts to prevent or limit human disturbance and ensure surrounding habitat is sustainably managed and/or is afforded some level of protection. The size, shape, and duration of a given zone may vary depending on available species-specific biological information and surrounding landscape conditions. While conservation zones are often circular and centered on important habitat features by default, irregularly shaped zones may be more effective when site-specific information such as swarming and staging areas, travel corridors, roosting and foraging areas, and other essential habitat features are known.
Early successional habitat: There is no concise definition of early successional habitats. However, all have a well-developed ground cover (e.g., grasses and forbs) or shrub and young tree component, lack a closed, mature tree canopy, and are created or maintained by intense or recurring disturbances. Examples of early successional habitats include weedy areas, grasslands, old fields or pastures, shrub thickets (e.g. dogwood or alder), and young forest.
Echolocation call: A series of ultrasonic pulses emitted as bats fly, which bounce off objects and return as echoes that enable them to orient and navigate through the environment. Many bats have species-specific call structures/characteristics (e.g., max. frequency, min. frequency, pulse length, and slope) that can be recorded with bat detectors and subsequently analyzed to identify them.
Emergence survey: A visual survey to count the number bats as they depart from a known or potential diurnal roost site. Surveys may be conducted by one or more observers and typically begin shortly before sunset and continue until it is too dark to see. Detailed emergence survey guidelines are available for some bat species including the federally endangered Indiana bat (https://www.fws.gov/midwest/Endangered/mammals/inba/inbasummersurveyguidance.html).
Fall swarming: an annual phenomenon in which numerous bats fly into and out of cave and mine entrances during late summer and fall (approximately August-November). Swarming activity varies by bat species and geographic location and typically is concentrated at hibernacula entrances at night. During the fall swarming period few, if any, of the bats roost within the hibernacula, but continue to use nearby trees as diurnal roosts instead.
Forest management: the practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the regeneration, management, utilization, and conservation of forests to meet specified goals and objectives while maintaining the productivity of

the forest. Forest management includes management for forest health, water, wilderness, wildlife, wood products, aesthetics, fish, recreation, urban values, and other forest resource values.
Hazard tree: any potential tree susceptible to failure due to a structural defect that may result in property damage, personal injury, or fatality. Tree hazards include dead or dying trees, dead parts of live trees, or unstable live trees (due to structural defects or other factors) that are within striking distance of people or property (a target).
Hibernaculum (plural **hibernacula**): a subterranean roost site, usually a cave or mine, where bats hibernate during the winter, including the surface entrance(s) and subterranean passages.
Hibernation season (winter): time of year when cave-dwelling bats are largely confined to hibernacula (approximately October-May, but varies by bat species and geographic location); synonym: hibernation period.
Integrated pest management (IPM): an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.
Leave-tree group (a.k.a. reserve islands)**:** A group of live trees purposely left in a stand during a timber harvest. Often these patches of trees surround important habitat features (e.g., a known roost tree) and function as a protective buffer from windthrow and incidental damage during harvest activities.es
Maternity colony: a group of reproductively active female bats and their young that occupy the same summer habitat, share communal roost sites, and interact to varying degrees.
Maternity habitat: suitable summer habitat used by juveniles and reproductive (pregnant, lactating, or post-lactating) females
Maternity roost: a summer roost, usually a tree but sometimes a man-made structure or bat box, used by reproductively active female bats and their young.
Maternity season (summer): time of year when reproductively active female bats and their young are present on the landscape (ranges from approximately April-September and varies by species of bat and geographic location).
Non-native invasive species (NNIS): A species that is not native (i.e., alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Non-volant: flightless, or lacking the ability to fly. Bat pups are non-volant for approximately the first 4 weeks after they are born.
Permanent habitat loss: the permanent removal/destruction of suitable bat habitat.
Permanent habitat modification: the permanent alteration of habitat in an area to the point where it diminishes the long-term suitability of the habitat for bat species and/or the introduction of new uses, activities, or infrastructure to an area that will produce enduring effects that diminish the long-term suitability of the habitat for bat species.
Prescribed fire: deliberate burning of wildland fuels in either their natural or their modified state and under specified environmental conditions, which allows the fire to be confined to a predetermined area and produces the fire intensity and rate of spread required to attain planned resource management objectives —synonyms: controlled burn, prescribed burn.
Potential roost tree: a live or dead standing tree exhibiting characteristics that make it potentially suitable for bat roosting, such as presence of cavities, hollows, cracks, crevices, or exfoliating bark.
Roost site: any location (trees, bat box, structure, bridge, rock outcrop, talus slope, etc.) where bats roost (rest) singly or in colonies.
Roost tree: a tree in which bats have been observed roosting singly or in colonies.
Season dates: the dates representative of the window of time that bats in a given area are considered

to be in a particular life history stage: e.g., maternity season; pup season; wintering (e.g., in hibernacula), etc.
Snag: a standing dead tree from which the leaves and most of the branches have fallen. Snags may provide important roosting habitat (i.e., **potential roost trees**) for bats under loose bark and in cavities, crevices, and hollows.
Spring staging: the departure of bats from hibernacula in the spring, including processes and behaviors that lead up to departure (ranges from approximately March-May and varies by species of bat and geographic location)
Stand: a contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable and manageable unit.
Stressor: a chemical or biological agent, environmental condition, external stimulus or an event /activity that causes stress to or triggers a stress response within an organism (e.g., disease, elevated sound levels, environmental contaminants).
Suitable habitat: spring, summer, fall and/or winter habitat with attributes considered suitable or otherwise appropriate for use by WNS-affected bat species; characteristics will vary based on bat species habitat needs and geographic area.
Summer habitat: roosting and/or foraging habitat used by bats during the summer.
Threat: the existence of or potential for an adverse effect (e.g., disease, injury/death, reproductive loss) to occur on living organisms and/or their environment by natural or man-made events, activities or conditions.
Uneven-aged harvest: Methods of regenerating a forest stand, and maintaining an uneven-aged structure, by removing some trees in all size classes either singly, in small groups, or in steps.
Vegetation management: The process and actions taken by land managers to control, alter or enhance the composition, structure, condition, health, and growth of forests, grasslands and other vegetative communities by the judicious use of mechanical equipment, chemicals, prescribed fire, or other means to achieve management goals.
White-nose syndrome (WNS): a devastating disease named for the white fungus, *Pseudogymnoascus destructans*, that infects skin of the muzzle, ears, and wings of hibernating bats. WNS has spread from the northeastern United States outward at an alarming rate, resulting in the deaths of millions of bats since the winter of 2007-2008. For more info see https://www.whitenosesyndrome.org/
Winter habitat: roosting habitat used by bats during the winter (also see **hibernaculum**).

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