Chapter 3
Environmental Setting

3.1 Introduction

This chapter provides general information about the environmental setting of the plan area with more detailed information provided for each of the states: Michigan, Minnesota, and Wisconsin. This discussion includes a description of the physical and biological setting with reference to the area's dominant physical attributes (e.g., proximity to the Great Lakes, climate, major watersheds, and geological features) as well as how these attributes affect the distribution of covered species throughout the year.

This chapter provides a regional overview of the following topics.

- Methods and data
- Environmental setting
- Ecosystems and vegetation types
- Forest trends
- Species status

This chapter also describes the following factors affecting the current environmental context of the plan area, or baseline.

- White-nose syndrome (WNS)
- Wind development
- Forest management programs

Lastly, the chapter provides state-specific information on forest type and species distribution.

3.2 Regional Overview

3.2.1 Methods and Data

The physical and ecological descriptions of the plan area were assembled using the following resources.

- Literature review
- Geographic information system (GIS) datasets
- U.S. Forest Service's Forest Inventory and Analysis (FIA) database (O'Connell et al. 2016)
- Professional knowledge of the region.

Land cover varies greatly across the plan area because of varying climate, soils, vegetation, and anthropogenic influences across the three states. As a result, GIS datasets were used to examine the diverse topography, geology, soils, hydrology, and land cover types across the plan area.

FIA data were used to tabulate land cover and acres of forest type. Because FIA data are not readily converted to a spatially explicit map, land cover maps were generated using the U.S. Department of Agriculture's National Land Cover Database (NLCD) (Homer et al. 2015). The NLCD land cover groupings were cross-walked to the FIA land cover and forest types to ensure that mapping of these data gave a reasonable depiction of the distribution of land cover across the plan area (Section 3.2.3.2, *Land Cover*).

The NLCD was developed for the conterminous United States using 2011 Landsat 30-meter imagery. The land cover classes focus on vegetation but also include human activities that modify land cover (e.g., agriculture, urban). Classification also uses calculations of percent impervious surface and percent tree canopy cover. The NLCD supports a variety of governmental and nongovernmental entities that use these data for a variety of applications such as ecosystem status and health, patterns of biodiversity, land management policy, and the effects of climate change (U.S. Geological Survey 2016). A more detailed description of the methods used to collect and crosswalk datasets is provided in Appendix C, *Land Cover Methods*.

The distribution of covered species in the plan area was described using data on bat occupancy provided by the Natural Heritage Program within the DNRs of all three states. These data were combined with information from peer-reviewed literature; the Bell Museum of Natural History; and input from species and technical experts from academia, industry, state and federal agencies within each of the three states, to create a distribution model for each of the four bat species for winter, summer, and fall/spring (Sections 3.4.2, 3.5.2, and 3.6.2, *Species Distribution*). In particular, species experts also provided input on the roosting value of each FIA land cover for bats. Additional detail on species distribution modeling can be found in Section 3.2.5, S*pecies Distribution*.

3.2.2 Environmental Setting

This section presents a broad overview of the physical and ecological attributes of the lands in the plan area (Michigan, Minnesota, and Wisconsin). In general, the interaction of an area's physical attributes (continental location, topography, geology and physiography, soils, climate, and hydrology) drives the ecosystems and vegetation types present in that area. These, in turn, influence the ranges of the four covered species of bats.

3.2.2.1 Location

The plan area is located in the Upper Midwest and is bounded by the Great Lakes to the north and east and the Great Plains to the West. The corn belt of Indiana, Illinois, and Iowa make up the southern border of the region. In addition to the Great Lakes, the plan area is notable as the origin of the Mississippi River.

3.2.2.2 Topography

Topography influences vegetation and climate, both of which may affect covered species in the plan area. Continental glaciers over the last million years are the primary topographical architects of the plan area. Compared to states bordering the east, south, and west, the topography of the plan area is relatively unvaried. The relatively flat nature of these states is the result of glaciers and precipitation

wearing down high points in the landscape while rivers and streams have deposited sediment in low-lying areas. Water moves slowly through this landscape and often collects in lakes, streams, and wetlands, which are abundant in the region. For example, the flat landscape of northwestern Minnesota once contained many wetlands and is itself a legacy of the southern lobe of glacial Lake Agassiz, a water body created by glacial melting that was larger than all the Great Lakes combined (Ojakangas and Matsch 1982). Ranges of low and high elevations are similar among the three states. The lowest elevations in Michigan, Minnesota, and Wisconsin are 571, 601, and 579 feet, respectively, and the highest elevations are 1,979, 2,302, and 1,951 feet, respectively. A few areas in the region are more rugged, including the Porcupine and Huron Mountains of Michigan's Upper Peninsula, the Sawtooth Mountains on the north shore of Lake Superior in Minnesota, and the Penokees of Wisconsin's Northern Highland Region. The Driftless Area along the border of Minnesota and Wisconsin, unglaciated in the last ice age, is also a rugged landscape where exposed bedrock is common.

3.2.2.3 Geology

Bat distributions are tied closely to physiography. First, geology influences vegetation, which influences bat distribution. In addition, bats use specific geological features in the landscape. A karst landscape, with its caves and cliffs, provides potential sites that may serve as bat hibernacula. Similarly, past volcanic activity deposited minerals that are removed by mining, which in turn creates hibernacula for bats. The following discussion provides an overview of the geology and physiography in the plan area, with a description of features relevant for the covered species, as appropriate.

As noted above, continental glaciations dominate the recent geological history and visible geology of the plan area. Glacial drift topographic features (e.g., outwash plains, eskers, ice contact ridges, kettle and kame moraines) form the landscape that is familiar to human eyes, and much of this landscape does not contain the caves (and later mines) that allow the covered bats to hibernate through winter.

In portions of the plan area, however, bedrock is the visible dominant feature. The Michigan Basin, consisting of layers from the Precambrian to Pennsylvanian, is centered on the Lower Peninsula of Michigan, and extends into the eastern Upper Peninsula on the north and west into eastern Wisconsin. It includes sandstones and carbonate rocks (limestones and dolostones). These geologic layers, formed during the Paleozoic, are visible in many locations along the Great Lakes shorelines (Dorr and Eschman 1970). Southeastern Minnesota and southwestern Wisconsin also contain areas of carbonate bedrock, exposed along the major rivers and elsewhere and forming what is termed a karst landscape of sinkholes and caves (Ojakangas and Matsch 1982). Figure 3-1 shows the major karst formations in the plan area.

Precambrian igneous and metamorphic rocks formed by ancient volcanic activity are visible in the northern portions of all three states. The Menominee River, which forms the northern border of Michigan and Wisconsin, flows along an ancient continental subduction zone that once produced volcanoes on the present day Wisconsin side as the Michigan side slid beneath it (Schneider et al. 2003). Northeastern and north-central Minnesota also have bedrock of igneous and metamorphic origin associated with the mid-continental rift system.

Distribution and abundance of bats in the Lake States is closely associated with mining activities. Mining of iron, copper, nickel, gold, silver, and other precious metals is associated with several areas

of ancient igneous and metamorphic bedrock (Figure 3-1). As a result, there are thousands of abandoned underground mines across these areas. Many of these sites provide habitat for hibernating bats. These included the largest hibernating populations of little brown bats and northern long-eared bats in all three states (see Sections 3.4.2, 3.5.2, and 3.6.2 below). It is likely that these mines made possible the relatively recent establishment of tri-colored bats in the Upper Peninsula of Michigan (Kurta and Smith 2014).

3.2.2.4 Physiography

Included in the plan area are two major physiographic regions designated by the U.S. Geological Survey (Fennemann and Johnson 1946). The first is the Laurentian Upland in northeast Minnesota, northern Wisconsin, and the western portion of Michigan's Upper Peninsula. This region is composed of Precambrian igneous, metamorphic, and sedimentary rock. The majority of this region is rolling to mountainous peneplain (an old landscape that has been extensively eroded) ranging from 800 to 1400 feet above sea level (Ojakangas and Matsch 1982). The rest of the plan area is mapped as Interior Plains, a region created when original portions of continents (cratons) collided and welded together. Much of this area was covered by extensive ancient seas that resulted in the formation of sedimentary bedrock from the sea bottom (e.g., sandstones, limestones, dolostones). Across the plan area, carbonate bedrock exposures are most evident in the karst-dominated Driftless Area of southwest Wisconsin and southeast Minnesota, and in areas associated with the Niagara Escarpment along Lake Michigan and Lake Huron shorelines (Figure 3-1).

As mentioned in Section 3.2.2.3, *Geology,* mining for metals has produced a large number of abandoned mines that are now used by hibernating bats. Prior to those mining efforts, the only known hibernacula in the Lake States were associated with the limestones and dolomites described in Section 3.2.2.4. Such caves were relatively few in number and did not contain the massive numbers of bats contained in some of the mines. Since settlement, anthropogenic activities within areas dominated by sedimentary bedrocks have also expanded hibernating opportunities for bats. Existing natural caves were expanded for a variety of purposes including tourism and underground storage (Kurta 2008). Finally, two of Wisconsin's large hibernacula are locations where sandstone is being mined to produce high-quality sand that is often used in hydraulic fracturing. Efforts to quarry limestone and dolomite have produced several small hibernacula (Slider and Kurta 2011). Two of Wisconsin's three large hibernacula are locations where underground sandstone is being mined with most current production being shipped out of state for use in hydraulic fracturing (WDNR 2016).

3.2.2.5 Soils

Soils exert a strong influence on the land cover and forest types of the plan area and consequently affect bat habitat distribution. In a post-settlement world, areas of limited value for agriculture or development are often allowed to revert to natural land covers, including forests. The dominant parent material of soils over much of the plan area is composed of glacial deposits (till) with some areas of loess deposits. In addition, northern Minnesota, northern Wisconsin, and the western end of Michigan's Upper Peninsula are dominated by glaciated metamorphic, igneous, and sedimentary bedrock in the highlands (Lucas et al. 2014), with relatively shallow soils deposited by glaciers.

The plan area comprises seven U.S. Department of Agriculture soil orders classified by several parameters, including parent material, moisture and temperature (U.S. Department of Agriculture Soil Survey Staff 2015). These are alfisols, entisols, histosols, incepticols, mollisols, spodosols, and

vertisols (Figure 3-2). Other patches occurring in smaller amounts are mapped as miscellaneous. All three states contain large areas, mainly in the south, mapped as *alfisols*. These soils, typically formed under broadleaf or conifer forests and are rich in nutrients. In the plan area, they correspond to cultivated and pastured agricultural lands on the landscape. *Entisols* are found in areas where erosion or deposition outpaces soil formation, such as uplands and floodplains. These soils are of relatively recent origin and thus the topsoil is very similar to the subsoil. One of the largest contiguous areas of this soil is found in central Wisconsin in association with Glacial Lake Wisconsin, which was impounded during the last glaciation. Other agricultural lands in the plan area are underlain by *mollisols*. These soils are typically found in areas with significant loess deposits where the original vegetation was native prairie, with large extents in the great plains of western Minnesota as well as scattered patches in southern Wisconsin and Michigan. *Spodosols*, acidic soils common under pine forests in the cold, moist north, often have a sandy parent material underlying them. They occupy significant portions of Michigan (northern Lower Peninsula and north edge and west end of the Upper Peninsula) as well as northern Wisconsin. These areas correspond with land uses of forest product production, with interspersed hay and pasture lands. *Histosols* are largely found in the eastern portion of Michigan's Upper Peninsula and in northern Minnesota. These soils exist under continuously saturated moisture regimes, usually with thick organic layers, such as those found in bogs and peatlands. *Inceptisols* are relatively young soils of moderate horizon (soil layer) development typically found on steep topography overlying erosion-resistant bedrock, such as the large area in northeastern Minnesota. Northwestern Minnesota includes areas of *vertisols*, clay-rich soils with little organic material that shrink and expand in response to a varied moisture regime. These were formed from clayey lake deposits in the Red River Valley.

3.2.2.6 Climate

Climate controls precipitation and temperature, which in turn affect bat prey type and abundance, timing of migration and overwintering, and even bat evolution. Overall, the weather of the plan area is dominated by a continental climate, influenced by the moderating effect of the Great Lakes in Michigan, northern and eastern Wisconsin, and northeastern Minnesota.

The Köppen Climate Classification is a widely used world climate system (Trewartha and Horn 1980). As modified by Peel et al. (2007), this system classifies the plan region into two major climate zones. The southern plan area has a hot-summer, humid, continental climate, with at least one month's average temperature over 72° F (22° C), four months averaging 50° F (10° C) and higher, and at least one month colder than 36° F (2.2° C). The northern plan area has a warm-summer, humid, continental climate, with no month averaging over 72° F (22° C), but four months above 50° F (10° C) on average, and the coldest month below 32° F (0° C). These climate zones are closely tied to vegetative patterns, which in turn are correlated with temperature and moisture regimes. This classification is used in climate change modeling to help predict vegetation changes in future decades (e.g., Mitchell and Keinholz 1997; Belda et al. 2014).

In the plan area, precipitation decreases from east to west with the wettest area in southwest Michigan and southern Wisconsin and the driest in northwest Minnesota (Kunkel et al. 2013) (Figure 3-3). The only exception to the trend is the northeast portion of Michigan's Lower Peninsula and small portions of the Upper Peninsula that experience less precipitation than the rest of the state.

Temperatures decrease from south to north with the coldest areas found in northern Minnesota and areas of Michigan's Upper Peninsula that do not border a Great Lake (Kunkel et al. 2013)

(Figure 3-4). The coldest temperature recorded in the plan area was a reading of -60°F (-51°C) recorded at Tower, Minnesota in February 1996. Michigan recorded a record low of -51°F (-46°C) at Vanderbilt in February 1934 and Wisconsin recorded -55°F (-48°C) at Couderay in February 1996.

3.2.2.7 Hydrology

Water resources can have a variety of direct and indirect effects on bats and their distributions. At the most simplistic level, bats need water to drink. In addition, aquatic insects are an important prey resource for all covered bat species. Riparian woodlands often play an important role in connecting landscapes dominated by agriculture, and/or human development. Very large water bodies, such as the Great Lakes, can serve as barriers to movement by bats, which in turn cause bats to make extensive use of shorelines during dispersal and migration. Finally, flowing water erodes landscapes, exposing the bedrock that may itself be soluble (leading to the formation of caves or exposing minerals that can then be mined).

The plan area falls within three continental watersheds: the Great Lakes, the Missouri-Mississippi Rivers, and the Red River of the North. Michigan lies almost entirely within the Great Lakes watershed, with waters reaching the Atlantic Ocean through the St. Lawrence River. The only exception is a tiny sliver of the headwaters of the Mississippi River in the western Upper Peninsula of Michigan at Lac Vieux Desert. In Michigan, the Menominee River constitutes the largest watershed of the Upper Peninsula. In addition, the Escanaba and the Manistique Rivers nearly cross the Upper Peninsula north to south, draining into Lake Michigan. Major watersheds of the Lower Peninsula include the Cheboygan, AuSable, Manistee, Muskegon, Saginaw, Grand, Kalamazoo, St. Joseph, Raisin, Clinton, and Huron Rivers (Figure 3-5). Minnesota contains four major river drainages. The St. Croix and Minnesota Rivers join the Mississippi River, which dominates drainage patterns in the majority of the state. Lands along the north shore of Lake Superior drain to Lake Superior in the Great Lakes basin. Lands in the northwest portion of the state, north of the Laurentian Divide (an area once occupied by Glacial Lake Agassiz) have their waters captured by the Red River, which flows north and eventually reaches Hudson's Bay. The Rock River in extreme southwest Minnesota drains toward the Missouri River. The portions of Wisconsin that lie in the Great Lakes Watershed are the northern shore along Lake Superior and the eastern two-thirds that drain to Lake Michigan. The remainder of Wisconsin drains into the Mississippi River and south to the Gulf of Mexico. Major rivers draining Wisconsin include the St. Croix, Chippewa, Black-Buffalo, Wisconsin, Rock, and Sugar-Pecatonica Rivers—all draining to the Mississippi River. On the east side, Wisconsin shares a border with Michigan along the Menominee River, which flows to Green Bay of Lake Michigan. The Wolf River flows into Lake Winnebago, and from there the Fox River flows to Green Bay.

It is an inescapable fact that the plan area's hydrology is dictated by its glacial legacy. The heterogeneity of glacial deposits influences the retention of water on the landscape, both as surface water and groundwater (Stephenson et al. 1988). As mentioned, large glacial features such as glacial lakes or outwash plains are not only drivers of hydrology but also of their associated vegetation. To illustrate, the poorly drained histosols and peatlands (both forms of organic, nonmineral soils) of Michigan's Upper Peninsula are legacies of the elevated levels of water bodies that preceded the Great Lakes and of the lacustrine depositions they left behind. In another example, sandy outwash plains that formed at the terminus of glacial moraines today are well drained and support pine and oak forests, although pockets of fine sediments remain as wetlands. In short, the hydrology of the plan area is complex in both form and function due to recent glaciations superimposed on underlying volcanic and sedimentary bedrock.

3.2.3 Ecosystems and Vegetation Types

3.2.3.1 Ecoregions

The land cover and forest types of the plan area are mapped at different geographic levels, called *ecoregions*. Ecoregions integrate multiple environmental factors to provide an ecological overview of the landscape. Because the distribution of forest types, bedrock, and other habitat elements is important for bats, an ecoregional framework provides a consistent approach for visualizing the distribution of those habitat factors over large areas. These ecoregions are defined by similar vegetation, wildlife, soils, geology, climate, hydrology, land use, and landforms.

The ecoregions used for this Plan were derived from the U.S. Environmental Protection Agency's *Ecoregions of the United States* (Wiken et al. 2011, Commission for Environmental Cooperation 2014). Ecoregions are mapped at four hierarchical levels of increasing detail and smaller geographical areas.

- Level I contains 12 broad ecoregions across the continental United States, with three of these covering the plan area: northern temperate forests in the northern portions of each state, eastern temperate forests in the midsections, and Great Plains on the western edge of Minnesota.
- Level II contains 25 ecoregions in the continental United States, nested within Level I.
- Level III contains 105 more finely delineated and smaller ecoregions that nest within Level II. These further differentiate soils, geology, climate, and vegetation. Level III is generally considered more useful for understanding ecological dynamics over space and time than the coarser levels.
- Level IV contains 967 detailed, descriptive ecoregions that nest within Level III. These are most appropriate for state-level or smaller, regional assessments.

Level III provides the appropriate detail to describe the different regions in the plan area that may be associated with variation in the distribution and abundance of bat species. As discussed, forests, other land cover, geology, and climate have a bearing on bat biology, and this information is described with relevant detail for bats at Level III. The plan area contains 12 Level III Ecoregions that are typically referred to by number and name, with associated descriptions (Wiken et al. 2011) (Figure 3-6 and Table 3-1).

Table 3-1. Level III Ecoregions by State

USEPA Ecoregions (Level III, with Ecoregion Code)	Michigan (Acres)	Michigan (Proportion of State)	Minnesota (Acres)	Minnesota (Proportion of State)	Wisconsin (Acres)	Wisconsin (Proportion of State)
Northern Glaciated Plains (46)			2,268,397	4.2%		
Western Corn Belt Plains (47)			10,387,156	19.2%	391,311	1.1%
Lake Agassiz Plain (48)			6,608,873	12.2%		
Northern Minnesota Wetlands (49)			5,640,718	10.4%		
Northern Lakes and Forests (50)	20,314,842	54.4%	15,897,779	29.4%	11,308,863	31.5%
North Central Hardwood Forests (51)	1,129,356	3.0%	10,613,862	19.7%	10,237,360	28.5%
Driftless Area (52)			2,590,038	4.8%	6,920,576	19.3%
Southeastern Wisconsin Till Plains (53)					6,906,936	19.2%
Central Corn Belt Plains (54)					155,325	0.4%
Eastern Corn Belt Plains (55)	779,448	2.1%				
Southern Michigan/Northern Indiana Drift Plains (56)	10,225,738	27.4%				
Huron/Erie Lake Plains (57)	4,875,064	13.1%				
Total	**37,324,448**		**54,006,823**		**35,920,370**	

Source: U.S. Environmental Protection Agency 2013

The 12 Level III ecoregions (with identifying number) are described below.

Northern Glaciated Plains (46)

Two lobes of the Northern Glaciated Plains (46) cross Minnesota's western border with the Dakotas. This flat to gently rolling landscape of glacial till once supported tall grass and mixed grass prairie. The largely treeless landscape supports abundant seasonal pothole wetlands, which are subject to great variation in precipitation, including severe, prolonged drought.

Western Corn Belt Plains (47)

The southern portion of Minnesota is characterized as Western Corn Belt Plains (47). A tiny lobe enters Wisconsin from Minnesota at the middle of the state's western edge. This region of glaciated till plains possesses fertile soils that are extensively farmed.

Lake Agassiz Plain (48)

The northwest corner of Minnesota is classified as Lake Agassiz Plain (48), and was created by a series of glacial lakes existing in this area since the beginning of the Pleistocene. The rich soils once supported tall grass prairie. Today the area supports row-crop agriculture.

Northern Minnesota Wetlands (49)

The northern-central portion of Minnesota is characterized by the Northern Minnesota Wetlands (49), a vast, flat former glacial lake bed now occupied by marshes, bogs and boreal forest.

Northern Lakes and Forests (50)

The Northern Lakes and Forests (50) consist of the entire Upper Peninsula and most of the northern third of the Lower Peninsula of Michigan, as well as northern Wisconsin and northeastern Minnesota. This ecoregion is characterized by nutrient-poor glacial soils that support conifer and hardwood forests on varied glacial topography. Agriculture is limited.

North Central Hardwood Forests (51)

In Michigan, the North Central Hardwood Forests is an area of wooded dunes and rich valley soils with a climate moderated by the Great Lakes. The topography is reflective of its recent glacial history and includes numerous lakes and wetlands. In Minnesota and Wisconsin, This ecoregion is part of the transition between the northern forests and the agricultural (once prairie and oak savanna) lands to the south. It encompasses the tension zone first described by Curtis (1959).

Driftless Area (52)

The southeast corner of Minnesota and western Wisconsin contains the Driftless Area (52), a loess-capped Paleozoic carbonaceous plateau deeply dissected by streams, with diverse agricultural operations in valleys and on flat ridgetops.

Southeastern Wisconsin Till Plains (53)

Southeastern Wisconsin Till Plains (53) is located in the southeastern area of Wisconsin. This ecoregion is a mosaic of vegetation types that are transitional between forest and savanna/prairie. Former prairie lands have been almost completely converted to forage crops.

Central Corn Belt (54)

A tiny lobe of the Central Corn Belt (54) reaches into extreme southeast Wisconsin. Once prairie and oak savanna, this ecoregion is today predominately agricultural.

Eastern Corn Belt (55)

A small lobe of the Eastern Corn Belt (55) extends into southeastern Michigan. The Eastern Corn Belt, once dominated by beech forests in presettlement times, today is predominately agricultural land growing corn and soybeans.

Southern Michigan/Northern Indiana Drift Plains (56)

Most of the southern two-thirds of the lower peninsula of Michigan are mapped as the Southern Michigan/Northern Indiana Drift Plains (56). This ecoregion constitutes a varied topography of landforms and soils, with agriculture occupying much of the area. Lakes, streams, and wetlands are abundant.

Huron/Erie Lake Plains (57)

The extensive lake plains associated with Michigan's "thumb" and extreme southeastern Michigan are designated as Huron/Erie Lake Plains (57). This ecoregion is a broad, fertile lake plain that has been cleared, drained and supports extensive agriculture.

3.2.3.2 Land Cover

The ecoregions described above provide context for how ecological systems are grouped in the plan area. Land cover provides additional context on where land cover types in general, and forest types in particular, are distributed on the landscape, which has bearing on where covered bats are typically found. This HCP uses the NLCD to define and map land cover type (Homer et al. 2015), which has an accuracy rate of 83-89% (Wickham et al. 2017). As described in Section 3.2.1, *Methods and Data*, FIA data were used to calculate acreages. However, FIA data cannot be mapped. In order to provide visual maps, the NLCD was used and crosswalked to the FIA forest types. As mentioned above, forest type has meaning for bats, with some types providing high-quality habitat and other types providing lower-quality habitat. Table 3-2 crosswalks the FIA and NLCD datasets and provides bat habitat quality for each FIA forest type. Finally, Table 3-2 provides typical stand age at harvest. Collectively, this information forms the foundation of the impact analysis developed in Chapter 4, *Potential Effects of Covered Activities.*

Table 3-2. Crosswalk of FIA and NLCD Systems, Bat Habitat Quality, and Typical Age of Harvest

NLCD Land Cover	FIA Forest Type Group & Land Cover Class	FIA Code	FIA Forest Type	Acres in Lake States (% of Lake States Acres)	Bat Habitat Quality		Typical Stand Age At Harvest (Years)[a]
					High	Low	
Forest and Shrub/Scrub							
Shrub/Scrub	Nonstocked	Forest Type Group 999	N.A.	523,698 (0.41)		X	N.A.
Evergreen Forest	Red/Jack Pine	Forest Type Group 100	Jack Pine, Red Pine	3,572,734 (2.81)		X	50
	White Pine/Hemlock	Forest Type Group 100	Eastern White Pine, Eastern White Pine/Hemlock, Eastern Hemlock	1,340,157 (1.05)		X	80
	Spruce/Fir (upland & lowland)	Forest Type Group 120	Balsam fir, White Spruce, Black Spruce, Tamarack, Northern White Cedar	8,055,510 (6.33)		X	50
	Other Eastern Softwoods	Forest Type Group 170	Eastern Red Cedar (not lowland)	49,657 (0.04)		X	50
	Exotic Softwoods Group	Forest Type Group 180	Scotch Pine, Norway Spruce	250,457 (0.20)		X	50
Deciduous/Mixed Forest	Oak/Pine	Forest Type Group 400	Eastern White Pine/Northern Red Oak/White Ash, Eastern Red Cedar/ Hardwood, Other Pine/Hardwood	1,437,695 (1.13)	X		80
	Oak/Hickory	Forest Type Group 500	White Oak/Red Oak/Hickory, White Oak, Northern Red Oak, Bur Oak, Scarlet Oak, Black Walnut, Elm/Ash/Black Locust, Red Maple/Oak	10,003,253 (7.86)	X		80
	Maple/Beech/ Birch	Forest Type Group 800	Sugar Maple/Beech/Yellow Birch, Black Cherry, Hard Maple/Basswood, Red Maple/Upland,	11,132,789 (8.75)	X		80
	Aspen/Birch	Forest Type Group 900	Aspen, Paper Birch, Balsam Poplar, Pin Cherry <9 in. dbh	5,362,908 (4.21)		X	25
			Aspen, Paper Birch, Balsam Poplar, Pine Cherry >9 in. dbh	6,969,267 (5.48)	X		50
	Other Hardwoods	Forest Type Group 960	Other Hardwoods	449,555 (0.35)	X		50

NLCD Land Cover	FIA Forest Type Group & Land Cover Class	FIA Code	FIA Forest Type	Acres in Lake States (% of Lake States Acres)	Bat Habitat Quality		Typical Stand Age At Harvest (Years)[a]
					High	Low	
Deciduous/Mixed Forest (continued)	Exotic Hardwoods group	Forest Type Group 990	Exotic Hardwoods	42,435 (0.03)		X	20
Woody Wetlands	Elm/Ash/ Cottonwood	Forest Type Group 700	Black Ash/American Elm/Red Maple, River Birch/Sycamore, Red Maple/Lowland, Cottonwood/Willow	5,563,585 (4.37)	X		80
Streams & Open Water							
Open Water	Water	N.A.	N.A.	5,542,206 (4.36)	N.A.	N.A.	N.A.
Open Land							
Barren Land	Barren	N.A.	N.A.	287,800 (0.23)	N.A.	N.A.	N.A.
Grassland/Pasture/ Cultivated	Grassland	N.A.	N.A.	50,337,443 (39.56)	N.A.	N.A.	N.A.
	Mixed Vegetation	N.A.	N.A.		N.A.	N.A.	N.A.
	Agricultural Vegetation	N.A.	N.A.		N.A.	N.A.	N.A.
Emergent Herbaceous Wetlands	Non-Vascular Vegetation (in part)	N.A.	N.A.	5,260,778 (4.13)	N.A.	N.A.	N.A.
	Grassland (in part)	N.A.	N.A.		N.A.	N.A.	N.A.
Developed Urban/Suburban							
Low/Medium Intensity Development	Developed, Vegetated	N.A.	N.A.	9,279,661 (7.29)	N.A.	N.A.	N.A.
High Intensity Development	Developed	N.A.	N.A.	412,306 (0.32)	N.A.	N.A.	N.A.

Source: Forest Inventory and Analysis Database: Database Description and User Guide for Phase 2 (ver. 6.1.1)

Appendix D (revision 09.2014) Forest Type Codes and Names

NLCD = National Land Cover Database; FIA = Forest Inventory Analysis

[a] The column "Typical Stand Age at Harvest" represents the stand age (in years) at which a given stand is typically harvested. For several forest types, however, harvest actually occurs within a range of years. The typical stand age at harvest is a simplifying assumption that allows the conversion of FIA data (in volume) to acres for a given forest type. The typical stand age at harvest was arrived at in consultation with foresters within the Lake States DNRs.

3.2.3.3 Forest and Shrub/Scrub

A large percent of the entire plan area (43.1%) is classified as Forest and Shrub/Scrub. As noted in in Section 3.2.3.1, *Ecoregions*, the majority of this area is found in the northern portions of all three states and in the Driftless Area.

Shrub/Scrub

In shrub/scrub areas, 20% or more of the vegetative cover consists of shrubs and trees less than 5 meters tall. Woody species may include true shrubs (multiple stems and height under 5 meters), young trees, and trees stunted from environmental conditions such as nutrient-poor soils, bedrock, or saturated soils. This land cover class includes such areas as young regenerating aspen or abandoned agricultural land grown in with shrubs and small trees. It may also include areas of oak savanna in the south or oak barrens in the north, particularly those with recent disturbance (e.g., logging, fire, or storm damage). Shrub/scrub also includes natural shrub ecosystems, such as open bogs and shrub swamps. In the entire plan area, it accounts for 0.4% of the total acreage across the Lake States. Shrub/scrub is considered low-quality habitat for bats due to the lack of suitable roosting habitat, although it may be used by foraging bats.

Evergreen Forest

Evergreen forests range in species composition from boreal assemblages in northeast Minnesota of white spruce, balsam fir, and white cedar, to forests with a mixture of pine species associated with sandy glacial soils. Despite extensive harvesting of evergreen forests since the late 1800s, such forests are still present in Northern & Central Wisconsin and the northern Lower Peninsula of Michigan. Before the large-scale pine logging at the end of the 19th century and beginning of the 20th century, the landscape percentages of evergreen forest were significantly larger. Naturally existing examples of this habitat type are reliant on disturbances to persist on the landscape. Conversely, the category also includes pine plantations which are entirely anthropogenic in their origin and maintenance. This class accounts for 4.5% of the project acreage, or 6.9% of the acreage in Michigan, 5.3% in Wisconsin, and 2.4% in Minnesota (mainly in the northeast).

Forest types in this class include red/jack pine, white pine/hemlock, upland spruce/fir, lowland spruce-fir and other softwoods. Nearly all the spruce-fir forest in the plan area is in lowlands, containing various mixtures of white cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), spruce (*Picea mariana, P. glauca*), and fir (*Abies balsamea*). Pine plantations in the Lake States are most typically composed of monotypic stands of Red (*Pinus resinosa*), Jack (*P. banksiana*), and occasionally eastern white (*P. strobus*) pines. All evergreen forests are considered low-quality bat habitat.

Deciduous/Mixed Forest

This class is found in the ecoregions of Northern Lakes and Forests, North Central Hardwood Forests, the Driftless Area, and portions of the Drift Plains in both Michigan and Wisconsin. Extensive blocks of this class are found in the northern portion of the plan area, corresponding to national forests and industrial forestlands. It varies in species composition throughout the plan area. In northern Michigan, for example, a deciduous/mixed forest might consist of maple-basswood-yellow birch (*Acer saccharum-Tilia americana-Betula allegheniensis*) with scattered hemlocks (*Tsuga canadensis*), spruce, and balsam fir. Areas in both the south and the north might consist of various

oak species (*Quercus rubra, Q. velutina, Q. ellipsoidalis* in the red oak group; *Q. alba, Q. macrocarpa, Q. bicolor, Q. muhlenbergii* in the white oak group) with a pine component (*Pinus resinosa*, *P. strobus*, *P. banksiana*) mixed in. At many locations in the southern plan area this forest does not have an evergreen component, but other hardwoods uncommon in the north occur, including hickories (*Carya* spp.) and black walnut (*Juglans nigra*). This class accounts for 27.8% of the entire plan area with the highest percentage of the state's land cover in Michigan (35.2%) and Wisconsin (33.1%) and the lowest in Minnesota (19.3%).

Forest types within this class include oak/pine, oak/hickory, maple/beech/birch, aspen/birch, and other hardwoods. Except for young aspen/birch forests where trees are not mature enough to develop structure and substrate for bat roosting, all deciduous/mixed forests are considered high quality bat habitat.

Woody Wetlands

Woody wetlands are areas where trees or shrubs account for more than 20% of the vegetative cover and the substrate is at least periodically saturated or inundated by water. They are found in many of the ecoregions of the plan area. They dominate the Northern Minnesota Wetlands ecoregion. In the north, alder (*Alnus incana, A. viridis*), Michigan holly (*Ilex verticillata*), viburnum (*Viburnum* spp.), and dogwoods (*Cornus* spp.) are likely to dominate the shrub layer, with black spruce, tamarack, and black ash (*Fraxinus nigra*) among the major tree species. Farther south, there is a greater diversity of shrubs and trees. More southerly floodplains, for example, support forests of silver and red maples (*Acer saccharinum, A. rubra*), elms (*Ulmus americana, U. rubra*), river birch (*Betula nigra*), hackberry (*Celtis occidentalis*), and cottonwood (*Populus deltoides*), with an equally diverse shrub understory that often includes dense stands of buttonbush (*Cephalanthus occidentalis*) and other shrubs and vines, such as alder, willows (*Salix* spp.), dogwood, river grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*). Michigan has the greatest percentage of state land cover in this class (11.9%), with Minnesota and Wisconsin possessing 10.2% and 8.6% respectively. This class accounts for about 10.3% of the entire plan area.

One forest type is within this class, elm/ash/cottonwood. Woody wetlands are considered high quality bat habitat, due to roosting opportunities presented by mature, dead, and dying large trees as well as the foraging and gleaning opportunities presented by a complex and diverse forest structure, often in association with water.

3.2.3.4 Streams and Open Water

Over the entire plan area land base, 4.4% is classified as Streams and Open Water. This percentage does not include the Great Lakes. In terms of bat habitat, these water features are important for the vegetative diversity they bring to the landscape. They are often bordered by mature forests that have a higher proportion of snags than intensively managed upland forests, thus providing bat roosting habitat (Carter 2006).

Rivers and Streams

The streams and rivers of the plan area encompass a wide range of stream orders, with many first and second order streams being a legacy of the area's glacial history. Rivers and streams were discussed in Section 3.2.2.6, *Hydrology*, and the larger rivers were mapped. Stream miles for the states are 47,845 miles in Michigan, 60,100 miles in Minnesota, and 53,375 miles in Wisconsin.

Open Water

Areas of open water are defined as water having less than 25% coverage of vegetation or soil. Minnesota has the largest percentage (6.1%) followed by Wisconsin (3.5%) and Michigan (2.6%).

3.2.3.5 Open Land

Open land occupies 43.9% of the plan area, nearly the same percentage as forested lands. This is a composite category of barren land, grassland/pasture/cultivated, and open herbaceous wetlands. Not surprisingly, Minnesota, with its western portion dominated by the Great Plains, has 53.9% of its surface covered by open land. Most of this is agricultural land. Wisconsin and Michigan, both agricultural states as well, possess 41.2% and 32.1% of open land, respectively.

Barren Land

Within the plan area, barren land includes areas of sand dunes, bedrock escarpments, and pavements as well as areas affected by past and present mining and quarrying. Vegetation accounts for less than 15% of the total cover in this category. Within the plan area, some areas of barren land correspond to the same metallic mining and karst areas described above, with a potential for bat hibernacula. With the exception of some large mining operations in northern Minnesota and Michigan, barren land rarely occurs over extensive areas. The plan area as a whole is 0.5% covered by this land cover class.

Grassland/Pasture/Cultivated

This composite classification lumps together open, upland vegetated lands regardless of the type of vegetation. It represents 39.6% of the total plan area, typical for states that are so heavily agricultural. Minnesota has the highest percentage at 47.2% and Michigan the lowest at 29.8%. Wisconsin weighs in at 38.2%. Native grassland (restored or remnants) are only a tiny fragment of this total acreage. Agricultural lands range from pasture and hay lands to crop lands growing mainly corn and soybeans on a large scale, as well as other crops (vegetables, fruit) in smaller patches of land.

Emergent Herbaceous Wetlands

Open herbaceous wetlands are areas permanently or periodically saturated or inundated with water, and where perennial herbaceous vegetation accounts for more than 80% of the vegetative cover. These may be emergent or wet meadow wetlands. Native species may include native wetland grasses and forbs, native cattails, rushes, and sedges. Some wetlands in this category are dominated by alien invasive species such as narrow-leaved cattail (*Typha angustifolia*), hybrid cattail (*Typha x glauca*), reed canary grass (*Phalaris arundinacea*), or the invasive form of giant reed (*Phragmites australis)*, particularly along the Lake Michigan shoreline. This class accounts for 4.1% of the total plan area with Minnesota possessing the highest percentage (6.5%) and Michigan the lowest (1.8%). Wisconsin herbaceous wetlands account for 3.0% of the state. Emergent herbaceous wetlands have been reduced through conversion to agriculture) in the southern portions of the plan area and in western Minnesota by 80 to 90% over the past 150 years.

3.2.3.6 Developed Urban/Suburban

In the plan area, 7.6% of the landscape is classified as developed/urban. These are lands where a human-constructed footprint dominates to varying degrees. The most highly developed areas in city and town centers provide limited habitat for bat species. Low to medium development may provide some habitat depending on the landscape context, style of development, and inclusion of green space. Developed open space included here presents the greatest opportunities for bats among these developed land cover types.

Low/Medium Intensity Development

Low to medium intensity development areas typically contain a greater mixture of constructed materials and vegetation with single family housing being the main form of development. Impervious surfaces account for 20 to 49% of low intensity development areas and 50 to 79% of medium development areas. Such areas account for 7.3% of the entire plan area. Michigan's area contains 10.0% of this class, with Wisconsin and Minnesota following at 7.2% and 5.5% respectively.

High Intensity Development

High intensity development areas are those where large populations reside. These are the largest urban areas where only limited and fragmented natural habitat remains. Impervious surfaces (buildings and pavement) account for 80 to 100% of the total cover. High intensity development also occurs in small patches within suburban and rural landscapes. This class accounts for 0.3% of the plan area, with Michigan having the highest percentage at 0.6%.

3.2.4 Forest Trends

Forest conditions in the plan area have always changed with varying climate and disturbance regimes, but significant changes in the last 200 years occurred over a shorter period than in the preceding centuries (Cole et al. 1998). Change continues, but the outcomes may be unpredictable due to interacting environmental factors, such as climate, and legacies in the soil and vegetation (e.g., Johnstone et al. 2016).

Several studies compared presettlement vegetation (ascertained from land survey records of the early to mid-1800s) to the modern forest cover and composition (Frelich and Lorimer 1991, Frelich 1995, Snetsinger and Ventura 2000). Although pre-1800 vegetation was managed to varying degrees by indigenous people for game and food crops, most notably with fire, it was not until European settlement in the early to mid-1800s that forest modification began in earnest. An era of cropland grubbing, clear-cutting, and uncontrolled wildfire, extending into the early 20th century, dramatically altered forest cover and composition across the Lake States. With agricultural clearing, primarily in southern Michigan and Wisconsin and in eastern Minnesota, the forested area declined by over 40%. Today on average, 41% (± 19%) of the ecoregions in the northern plan area is nonforested, compared to 12% (± 9%) before European settlement (Shulte et al. 2007). Beginning in the mid-20th century, however, forest cover across the plan area began increasing due to farmland abandonment, forest succession on hay meadows and pastures, and fire suppression. (Basic forest types classified by land cover are summarized in Section 3.2.3, *Ecosystems and Vegetation Types*.) Maps of presettlement and modern forests nevertheless show a dramatic change in forest extent,

type, and patch size (Michigan Department of Natural Resources and Environment 1995, Rhumtulla et al. 2009, Minnesota Department of Natural Resources 1994) (Figures 3-7 and 3-8).

During the forest clearing period, some 21% of presettlement forests (particularly red and white pine forests) were converted to early successional forests of aspen and birch, the only forest type to increase in total acreage in this time. The average size of patches of different vegetation types also changed substantially. The average size of contiguous patches of all vegetation types except aspen-birch forest and nonforested lands decreased. The decrease in forest patch size continues to the present day due to land development practices and parcelization of lands. Parcelization divides large forest ownerships into many small ownership parcels, which contributes to smaller forest patch size as more owners implement uncoordinated forest management practices and land conversions (Mundell et al. 2007). These factors all contribute to fragmentation of the forest, which, in turn, affects the distribution and population viability of many forest wildlife species. The southern portion of the plan area experienced the most dramatic change as forests were cultivated, pastured, or developed, shifting the landscape to an open condition. In most agricultural areas in the southern plan area, forests were reduced to woodlot fragments. Parcelization of ownership complicates efforts to manage forests as habitat for bats and other species.

The structure and composition of the 44% of the plan area that is forested has also changed since settlement and continues to change, with fewer tree species and vegetation layers resulting from land use practices and changes in disturbance, such as that due to fire suppression. Shulte et al. (2007) concluded that the forest "shows a distinct and rapid trajectory of vegetation change toward historically unprecedented and simplified conditions." They further maintain that

> ". . . current forests are marked by lower species diversity, functional diversity, and structural complexity compared to pre-Euro-American forests. Today's forest is marked by dominance of broadleaf deciduous species…ecoregions that comprise the region exhibit a lower relative dominance of conifers in comparison to the pre-Euro-American period (Stearns and Likens 2002). Aspen (*Populus grandidentata* and *P. tremuloides*) and maple (*Acer saccharum* and *A. rubrum*) species comprise the primary deciduous species that have replaced conifers."

Unsustainable harvest practices prior to the establishment of professional forestry practices in the region also locally removed tree seed sources, especially conifers such as hemlock, red and white pine, and white cedar (Stearns and Likens 2002). Disease has altered and continues to simplify forest composition. Dutch elm disease removed American elm from forests in the second half of the 20th century. Presently, forest managers face the specter of multiple species of ash being affected by the emerald ash borer. Herbivory by high white-tailed deer populations favors species such as red maple which are less palatable to or more tolerant of browsing, resulting in decreases in less tolerant or palatable species (Palik and Pregitzer 1992). Age structure has likewise been simplified both on the landscape as well as at the stand level.

On the other hand, recent forest growth trends suggest that forestland acreage and the size and age of trees on average are gradually and slowly increasing, with deciduous trees other than aspen and birch contributing the most to those trends (Miles and VanderSchaff 2015, Perry 2015, Pugh 2015). Snag abundance, which contributes to the quality of bat habitat, has been noted to peak when a Great Lakes forest stand is in the 90- to 150-year range. Thus, with a shift toward younger forests in the earlier historical period, a decline in snag abundance likely occurred. More recent trends, however, suggest snag abundance is increasing due to the growing number of older trees. At the same time, the more simplified, fragmented forests of the present, in comparison to forests of 150 years ago and before, are expected to exhibit less resilience in the face of climate change and greater

vulnerability to disease and pests, leading arguably to the acceleration of change and simplification unless counter-measures, such as active forest management, are implemented (Kling et al. 2003).

To summarize, the forests of the plan area were drastically altered beginning in the early 1800s, but recovery of some characteristics, such as structure, of the pre-1800 forest ecosystem has occurred since. Some negative changes continued until the recent past, perhaps accelerated by changes in ownership and management, disease and pests, climate change, and legacies inherited from the past 200 years of land use (Shulte et al. 2007). Given the variability in the FIA data by which these recent trends were detected, and the relatively short duration of those trends, it is premature to be confident in future predictions of forest change.

Given the anticipated regional changes in temperature and precipitation patterns, further forest parcelization and land use changes, and management which fails to prevent forest species simplification, it is unlikely that the composition, structure, and distribution of forests in the plan area will return to the landscape and stand level diversity of the early 1800s or even perhaps to remain as they are today. For example, Frelich and Reich (2009) describe multiple factors acting on the forest ecosystems of northern Minnesota which are anticipated to interact with climate change, potentially reducing or even eliminating over a dozen species of trees in the northern half of the plan area, and even diminishing the density of forest canopies by the late 21st century. Moreover, they predict a potential northeastward shift in the boundary between southern and northern forest types of up to several hundred kilometers by the end of the 21st century. In modeled simulations of forest composition with climate change in Minnesota and Michigan, Duveneck et al. (2014) learned that more diverse tree composition in forest stands in the northern plan area may increase the resistance and resilience of forests in the face of climate change. The legacy conditions of forests in the Lake States, however, combined with climate change and disturbances, make it difficult to reliably predict the future composition and structure of the plan area's forests (Johnstone et al. 2016). The dilemma foresters find themselves in is to manage for multiple forest benefits in the face of unknown future influences, while responding with appropriate forest management practices to reduce undesirable outcomes, such declines in tree species diversity and forest productivity.

3.2.5 Species Distribution

3.2.5.1 Overview

This Lake States HCP covers four species of small bats (5 to 11 grams) that exclusively feed on insects. The life histories of these species can be identified in four components (Table 3-3), which are broadly similar among the four species (hibernation in winter, fall/spring migration between winter and summer habitats, reproduction in summer, and staging/swarming at the hibernacula). Prior to settlement, all four covered species relied on caves for hibernation and spent most of the summer roosting in trees. As such, each of these species migrates between winter and summer habitats and may occur in a wide variety of habitats at that time. All four species also engage in behaviors known as autumn swarming, when large numbers of bats fly in, out, and around the entrances of potential hibernacula. Upon exiting a hibernaculum in the spring, some bats mass near the hibernaculum as they recover from hibernation and prepare for migration—a behavior known as spring staging. Swarming and staging are associated with mating and feeding to prepare for and recover from the rigors of hibernation. A summary of seasonal distribution for covered bats is provided in Table 3-3 and a detailed account of all species in their respective sections (Sections

3.2.5.2, *Indiana Bat*, 3.2.5.3, *Northern Long-Eared Bat*, 3.2.5.4, *Little Brown Bat*, and 3.2.5.5, *Tricolored Bat*).

Table 3-3. Seasonal Habitat Definitions for Covered Bats

Season	Dates	Distribution	Rationale
Hibernation	October 16 through April 14	Bats are restricted to within 0.25 mile of entrances to hibernacula.	• Eliminates or reduces disturbance associated with vibration and noise. • Addresses the reality that locations of hibernacula are often poorly mapped. • Consistent with FWS guidance on hibernacula buffers (e.g., northern long-eared bat 4(d) rule.
Fall/Spring	April 15 t through May 14, August 16 through October 15	Bat distributions are centered near entrances to hibernacula with bats occurring within: • 5 miles for most hibernacula (up to 10,000 bats). • 10 miles for very large hibernacula (could include >10,000 bats, pre-WNS).	• Bats concentrate near hibernacula in fall/spring for swarming and staging. • Distances based on recommendations developed for the wind industry (USFWS 2011) and on published data.
Summer	May 15 through August 15	Bats are distributed in forested habitat throughout the Lake States. • Bats are more likely to be found in forest types that have larger trees and so more potential roosts. Forests communities that have higher potential to be used by roosting bats identified in Table 3-2. • Bats are 10-times as common in high-quality bat habitat than in low quality habitat.*	• Bats are widely dispersed on the landscape during summer. • Bats are most dense in forest types identified as being high quality bat habitat in Table 3.2.
Nonvolant Pups	June 1 through July 31	See Summer, above	Nonvolant juveniles are present in maternity roosts—we assume a doubling of the female population.

WNS = white-nose syndrome

* Based on solicited expert opinion.

All covered species make extensive use of forest for roosting and foraging; however, the intensity of use varies among forest types (Table 3-2). Furthermore, bats use forests in different ways at different times of year. To understand the distribution of bats across the landscape, forest type and associated habitat quality from Table 3-2 are intersected with seasonal distribution from Table 3-3 (Figure 3-9) to provide a distribution and density matrix for each species. This process is repeated for each of the four covered species for the four seasonal components of the annual life cycle. Following is a discussion of how each of the seasons affects estimates of bat distribution.

Winter Use Habitat

All four covered species make use of caves, mines, and similar sites for hibernation during winter. During these periods, the bats are sensitive to a variety of disturbances. In the Lake States, mining has created many hibernacula in areas where few previously occurred. Details on how winter use habitat was modeled for each species can be found in their respective sections.

Fall/Spring Use Habitat

All four species spend part of the active (i.e., nonhibernation) season massed near hibernacula entrances. During this time, they fly in and out of the entrance of the hibernacula and may roost in trees near the entrance—a behavior that puts them at risk of being affected by forestry operations. During fall, this behavior is termed swarming and is thought to be driven primarily by mating, but also includes a component of bats preparing for hibernation. Fall swarms can be highly intense activities. Prior to the arrival of WNS, it was not unusual to observe hundreds or thousands of bats of multiple species engaged in this activity from September through October. Spring staging is less intense as bats begin to forage and prepare for migration, although some mating also occurs at this time.

During most of the swarming and staging periods these bats stay within five miles of hibernacula entrances. At large hibernacula (i.e., those containing more than 10,000 bats), however, bats may use larger areas. Details on how fall/spring habitat was estimated can be found in the species-specific sections that follow. Forest types that have an abundance of potential roosts are identified as high quality habitat, whereas forest types with few such roosting opportunities are deemed low quality habitat (see Table 3-2).

Migratory Habitat

Before swarming and after staging, bats migrate from and to their summer ranges. Little is known about any distinctive behaviors at this time, although it is currently a topic of intense interest to biologists as this is the time when bats are most at risk of colliding with wind turbines. Migration habitat is not specifically modeled or addressed by this plan. Further, it is notable that migration occurs within the summer range which is considered occupied through 15 August, a time at which most bats have begun to arrive at the swarming range. As such, although migration habitat is not modeled separately, it is included in other habitat types.

Summer Use Habitat

In summer, bats spread out from hibernacula and can be found throughout the Lake States. All four species roost in trees and manmade structures. Use of manmade structures varies among the four

species. Little brown bats (*Myotis lucifugus*) make extensive use of such habitats, whereas Indiana bats only rarely do so; northern long eared and tricolored bats are intermediate in their use of such structures. In forested areas, the three *Myotis* make extensive use of dead, dying, or damaged trees by roosting under exfoliating bark and in cavities and crevices, which are most likely to occur in larger, older trees. Tricolored bats roost primarily in clusters of dead and live leaves, but preferentially select larger trees. Forest types that have an abundance of such potential roosts are thus identified as high quality habitat, whereas forest types with few such roosting opportunities are deemed low quality habitat (see Table 3-2).

The presence of hibernacula can have a dramatic effect on the abundance of these species in spring and fall and, for some species, in the summer as well, although this pattern is not as strong in Wisconsin as for Michigan and Minnesota. A description of how summer distribution was estimated can be found in each of the species–specific sections that follow.

3.2.5.2 Indiana Bat (*Myotis sodalis*)

Species Description

The Indiana bat is distinguished from the little brown bat and northern long-eared bat by differences in morphology of the feet and ankles. Indiana bats have a distinctly keeled calcar (cartilage that extends from the ankle to support the tail membrane), smaller feet, and relatively sparse and short hairs on the toe. The fur is dull and dark, but upon close inspection weakly tricolored.

The species was amongst the first species to be listed as endangered under a precursor of the modern Endangered Species Act (ESA). It is also listed as endangered under the Michigan endangered species statute; it is not known to occur in Minnesota or Wisconsin.

Habitat Preferences

Although broadly distributed in forested habitats throughout the eastern United States, the Indiana bat is rarely encountered in the Lake States (Figure 3-10). The species has not been recorded in Wisconsin for over half a century (Ainslie 1983) and no records exist for Minnesota. In Michigan, the species occupies the southern-most three tiers of counties in the Lower Peninsula during summer and hibernates at Tippy Dam in Manistee County. Most summer residents in Michigan migrate into the karst regions of Indiana, Ohio, and Kentucky during winter.

Summer colonies of Indiana bats in Michigan begin forming in late April or early May and the bats leave again by late September or early October. Most (≈89%) of the adult Indiana bats in Michigan are reproductive females who typically form maternity colonies of 15 to 30 adults. These colonies focus their roosting and foraging behaviors on forested wetlands. Every colony uses multiple trees during the summer, with individual bats moving amongst trees every 1 to 3 days. Trees that are used by most of the bats on most of the days are termed primary roosts. They tend to be very large snags with exfoliating bark or vertical cracks and substantial solar exposure. Roosts used by smaller numbers of bats are termed alternate roosts, and often are smaller, have lower solar exposure, and may include live trees. Most roost trees in Michigan are wetland-adapted species and include elms (*Ulmus*), maples (*Acer*), and ashes (*Fraxinus*), although other trees are used if they have the appropriate structure.

Foraging Indiana bats focus on patches of forest especially those that are connected to each other by fencerows and forested streams (Murray and Kurta 2004). In other states, forest edge and open habitats are also regularly used (Sparks et al. 2004).

The only known active hibernaculum of Indiana bats in the Lake States is Tippy Dam, which has previously housed approximately 20 Indiana bats (USFWS 2015). A male tagged during Kurta's 1995 study of bats swarming at the site roosted in forested wetlands within 2.5 miles of the spillway where the bats hibernate.

Distribution and Population Estimates

The distribution and population estimates that follow are made for pre-WNS populations of the species. Estimates will be adjusted to account for WNS over time as part of the effects analysis. Current population estimates, when available, are included.

Winter

The only known active hibernaculum for the Indiana bat in the plan area is the spillway of Tippy Dam. A historic record of a hibernating Indiana bat is known from Wisconsin, but this appears to have been a transient individual. Approximately 20 bats hibernated in Tippy Dam prior to the arrival of WNS. Winter habitat for this species is modeled as occurring within a 0.25-mile radius around Tippy Dam. Kurta and Smith (2017) noted that Indiana bats still occur in Tippy Dam, and that populations of all bats at that site remain high. As such, the winter population is still best estimated at 20 individuals.

Fall/Spring

While some bats may range 20 miles or more from the entrance of the hibernaculum (ESI 2005, Chenger 2007), swarming activity is typically restricted to an area within 5 miles of the entrance (Gumbert et al. 2002, Rommé et al. 2002, Chenger 2007). The only Indiana bat tagged in the Lake States during swarming was an adult male at Tippy Dam, which roosted approximately 2.5 miles from the hibernaculum. The quality of forest habitat within 5 miles of Tippy dam was assigned to high- or low-quality categories based on forest type as described in Table 3-2.

Migration

Details about migration in this species are limited to band returns and mortality of bats at wind energy sites. As such, migration habitat is assumed to occur anywhere between summer and winter habitat. Most Indiana bats that summer in Michigan are summer migrants from hibernacula in Indiana, Kentucky, Ohio, and Illinois. Thus, migration in the Lake States occurs within the area identified as the summer range (described below) and along the shore of Lake Michigan, which connects the summer range to Tippy Dam.

Summer

Indiana bats roost almost exclusively in forested areas, although scattered trees in other land cover types may be used for foraging and other behaviors. The species makes extensive use of larger, dead, and dying trees. Accordingly, high- and low-quality forested habitat for the species is assigned in Table 3-2.

Indiana bats in the summer are assumed restricted to portions of the Lower Peninsula of Michigan within the average migratory distance (429 kilometers or 266 miles) of hibernacula in Kentucky, Ohio, and Indiana (Rockey et al. 2013).

Approximately 20 Indiana bats hibernate in Tippy Dam in Manistee County, Michigan. The summer range of bats from this hibernaculum are unknown, but according to band returns (Kurta et al. 1993, Kurta et al. 1996, Kurta et al. 1997, Foster and Kurta 1999, Kurta and Murray 2002, Kurta and Rice 2002, Kurta 2005, Winhold 2007, Kurta 2008, Kurta 2010, Rockey et al. 2013, Kurta and Smith 2014, Auteri and Kurta 2015) they most likely migrate south along the shore of Lake Michigan, where they mingle with other bats migrating northward from hibernacula in Ohio, Kentucky, Indiana, Illinois, and possibly other states. Band returns (Foster and Kurta 1999, Winhold and Kurta 2006, Rockey et al. 2013, Auteri and Kurta 2015) have helped establish both the hibernacula used by Indiana bats that summer in Michigan and the maximum flight range of these bats. The summer range, illustrated in Figure 3-10 was modeled by buffering Priority 1 and 2 hibernacula (those with a history of containing more than 1000 Indiana bats) in Indiana, Ohio, and Kentucky, with the maximum reported migration distance for the species.

The U.S. Fish and Wildlife Service (USFWS) (U.S. Fish and Wildlife Service 2007) noted the presence of 11 known maternity colonies in Michigan, at the northern edge of the range of the species. One additional colony was located in 2016 (J. A. Wong pers. comm.). Based on the maximum size of a typical colony in Michigan f (30 bats) about 360 adult females occurred in Michigan during the summer pre-WNS. Kurta (2008) also notes that 11% of the bats captured in Michigan are male, yielding an estimate of 40 adult males and 400 adults present in the state. Bats that summer in Michigan are tied to hibernacula where populations have declined by approximately 10% since 2011 (USFWS 2015) yielding a current population estimate of 300 individuals.

3.2.5.3 Northern Long-Eared Bat (*Myotis septentrionalis*)

Species Description

Northern long-eared bats closely resemble Indiana and little brown bats. The most obvious difference is the much larger ears that, when laid flat, extend well beyond the tip of the nose. The tragus, a small projection of the ear, is also much longer and more pointed than in the other two species. The feet are moderately sized with a few scattered hairs, and the calcar can be lightly keeled. Before the arrival of WNS, the species was widely distributed in the Lake States. In response to population declines caused by WNS, the northern long-eared bat is now listed as a species of special concern in Michigan and Minnesota and as threatened in Wisconsin. The species was also listed as threatened under the ESA on April 15, 2015.

Habitat Preferences

Northern long-eared bats occur throughout the Lake States. The species is presumed to be evenly distributed across the forested landscape although it may be more abundant in areas of higher-quality forest, especially when those habitats occur near suitable hibernacula known to include caves, mines, the spillway at Tippy Dam, and potentially a variety of rock crevices.

Available data indicate that northern long-eared bats begin to form summer colonies with large numbers grouped together in May and early June before the birth of a single pup per female in late June or early July. This species uses a much wider variety of trees and conditions of trees as roosts during summer compared to Indiana bats and a wide variety of woodlands. The species readily

makes use of smaller trees (3 inches dbh or smaller), live trees, roosts with low solar exposure, and hollows within trees. However, within this pattern, it is important to note that large trees (especially snags and hollow trees) remain an important resource. In more southern portions of the Lake States, there is an apparent preference for ashes, maples, oaks, and elms, but species such as quaking aspen (*Populus tremuloides*) are important in more northern areas (Catton 2014, Swingen et al. 2016). The species makes use of bat boxes when available (Whitaker et al. 2006) and other artificial roosts such as bridges and culverts. Like Indiana bats, northern long eared bats move between roosts every few days.

Unlike most other bats in the region, northern long-eared bats readily forage in interior forests with much vegetation. Forest management practices in the partial harvest group (commercial thinning, the regeneration harvest of shelter woods, and single-tree selection) were found to create preferred foraging and roosting habitat for this species (Pauli 2014, Silvis et al. 2016) indicating the species can benefit from low-intensity disturbance.

Like the other species covered by the Lake States HCP, northern long-eared bats begin returning to staging areas around caves and mines to hibernate in late August and early September. In caves and mines, individual bats are often found hidden within cracks and crevices, making them very difficult to locate. Several closely related species in the western United States, including the long-eared bat (*Myotis evotis*), and Keen's bat (*Myotis keenii*), use rocky outcrops and slopes covered with loose rock (talus) as roosts at multiple times of the year (Rouse and Willson 2002, Boland et al. 2009, O'Shea et al. 2011, Snider et al. 2013). Northern long-eared bats also make use of such sites when caves and mines are rare (Lemen et al 2016). As such, the northern long-eared bat may also hibernate in such sites. Two of the known hibernacula (Gnomen, and Hole-in the-Head) are caves associated with the rocky shore lines of Lake Superior in Minnesota, and it is likely that many other northern long-eared bats hibernate within this area as well.

Distribution and Population Estimates

The distribution and population estimates that follow are made for pre-WNS populations of the species. Estimates will be adjusted to account for WNS over time as part of the effects analysis.

Winter

Northern long-eared bats are known or thought to hibernate in at least 110 sites throughout the Lake States, including 29 sites in Michigan, 60 sites in Wisconsin, and 21 sites in Minnesota. Potential hibernacula in this list include rocky cliffs along Minnesota's portion of the Lake Superior shoreline and two mines in Michigan. Northern long-eared bats have not been positively identified in the Millie Mine in the Upper Peninsula of Michigan, but most bats at this site are too far away to positively identify. Similarly, Tilden Mine in the Upper Peninsula is unsafe to enter but is suspected of containing large numbers of bats including little brown, tricolored, and northern long-eared bats. Winter habitat for this species is described as a 0.25-mile radius around the entrances to these hibernacula which is intended to identify area where limited winter activities (by bats) are occurring as well as protecting the hibernacula from disturbance and deal with inaccurate locations typical of hibernacula.

Because the species secrets itself within cryptic over-wintering locations, hibernacula counts are an ineffective way to estimate the population. As a simplifying assumption, the winter population in each state is assumed to be the same as the summer population with higher numbers of bats associated with larger hibernacula.

Fall/Spring

Northern long-eared bats return to the hibernacula in the fall, initiate swarming activities, and begin hibernation. Lowe (2012) found that once northern long eared bats began swarming, roosts were regularly located within 4.5 miles of the hibernacula. These data were used by USFWS to support the 5-mile protective buffer currently used around known hibernacula (U.S. Fish and Wildlife Service 2014). In terms of forested habitat, high- and low-quality habitat is assigned in Table 3-2 and is consistent with known foraging and roosting behaviors of the species (Kunz 1973, Brack and Whitaker 2001, Whitaker et al. 2004, Amelon and Burhans 2006).

To estimate distribution in the plan area, a 10-mile buffer is used to model fall/spring habitat for northern long-eared bat around the 14 hibernacula that historically have contained more than 10,000 hibernating bats regardless of species. A 5-mile buffer is used for the smaller, known hibernacula.

Because the number of winter bats is unknown, the fall/spring population is assumed to be the same as the summer population. Bats are spread among hibernacula based on the proportions reported from large and small hibernacula and then evenly spread within hibernacula class.

Migration

Details about migration in this species are limited to band returns and mortality of bats at wind energy sites. During migration, the species could occur anywhere in the Lake States.

Summer

Northern long-eared bats are locally abundant, and can be found throughout the Lake States (Figure 3-11). Table 3-2 contains a list of forest types and rates those forest types as to their suitability for bats.

Because the species hibernates in cryptic locations, winter counts in hibernacula provide more of an index than a population estimate. However, based on abundance ratios (between summer populations of northern long-eared bats and little brown bats) provided by the state bat experts (White pers. comm.) and available literature (Kurta and Tibbels 2000, Winhold et al. 2008, Catton 2014, Swingen et al. 2016), it is estimated that 724,971 northern long-eared bats occur in the Lake States. If the decline of 95% noted by Kurta and Smith (2017) is generalized across the region, the current population is approximately 36,249 adult bats. While northern long-eared bats likely move between the Lake States and surrounding states, the number within the Lake States is assumed the same across seasons.

Northern long-eared bats are presumed to be distributed in accordance with Tables 3-2 and 3-3 during summer as opposed to being clustered near hibernacula.

3.2.5.4 Little Brown Bat (*Myotis lucifugus*)

Species Description

The little brown bat is most easily confused with the Indiana bat, from which it is separated by its brownish/brassy coloration, a medium-sized foot with many long hairs, and an unkeeled calcar. The ears are smaller than the northern long-eared bat, and do not extend past the tip of the nose when laid down. Little brown bats are widely but unevenly distributed across North America from central

Alaska to central Mexico (Harvey et al. 1999), and can be found throughout the Lake States especially near known hibernacula (Figure 3-12). Before the arrival of WNS, the species was abundant across much of the region, but the species is now listed as a species of special concern in Minnesota and threatened in Wisconsin in response to the arrival of WNS. Following the arrival of WNS in North America, declines of more than 90% have occurred and the species is now under consideration for federal listing in the year 2023 (Tinsley 2016).

Habitat Preferences

Unlike other species addressed under the Lake States HCP, the little brown bat makes extensive use of buildings as roosts and thus has been able to reduce its reliance on forested habitats, a trait that makes it widely distributed within the Lake States (Figure 3-12). For the purposes of the Lake States HCP, it is assumed that half the little brown population summers in buildings based on data provided by bat biologists active in the region. Known hibernacula are scattered throughout the region and include natural caves, mines, surge tunnels, and the spillway at Tippy Dam (Kurta 2008, Slider and Kurta 2011).

Seasonality of summer colonies for little brown bats is similar to the other covered species with the exception that the use of buildings may allow this species to arrive a little earlier and leave a little later. These bats use a variety of anthropogenic structures such as attics, barns, and bridges as roosts, with a typical Michigan colony containing 100-300 with some colonies containing 1,000 bats (Kurta 2008) although numbers are likely decreasing due to WNS. Bats move around within a roosting structure, but most bats remain in the same structure. It is likely that some of these bats still use trees as roosts, and (based on data from other areas) primary roosts would be large, dead or dying trees with exfoliating bark or cavities similar in structure to those used by Indiana bats. Trees used by nonreproductive individuals and males tend to be smaller, but still consist of exfoliating bark, cavities and/or crevices.

Little brown bats make extensive use of aquatic resources, especially emergent wetlands for foraging (Belwood and Fenton 1976, Anthony and Kunz 1977, Fenton and Bell 1979, Kunz and Reichard 2010, Bergeson 2012, Bergeson et al. 2013). Within forested landscapes, the species makes extensive use of edge habitats and corridors for foraging and commuting, although it is also capable of using unbroken forest in areas with limited clutter (Lacki et al. 2007, Sheets et al. 2013, U.S. Fish and Wildlife Service 2013).

Little brown bats throughout the eastern U.S. make extensive use of caves, mines and other suitable underground environments (e.g., tunnels, sewers, basements, bear dens, etc.) for hibernation with swarming occurring at the entrances in September and October. Little brown bats can occupy a wide variety of conditions within the hibernacula, using temperatures ranging from 37 to 46°F.

Distribution and Population Estimates

The distribution and population estimates that follow are made for pre-WNS populations of the species. Estimates will be adjusted to account for WNS over time as part of the effects analysis.

Winter

In the Lake States, the largest hibernaculum for this species in each of the three states is an abandoned mine. Little brown bats are known to hibernate in at least 121 sites throughout the Lake States, including 28 sites in Michigan, 52 sites in Wisconsin, and 41 sites in Minnesota. Eleven of

these sites (seven in Michigan, one in Minnesota, and three in Wisconsin) contain more than 10,000 little brown bats. Most accessible mines and caves in Minnesota and Wisconsin have been surveyed. However, the Upper Peninsula of Michigan is riddled with unexplored mines that are expected to contain bats, including at least one (Tilden Mine) that likely housed a population of 10,000 or more bats. Tilden Mine in the Upper Peninsula is unsafe to enter but is suspected of containing large numbers of bats including little brown, tricolored, and northern long eared bats. Winter habitat for this species is modeled as a 0.25-mile radius around these hibernacula.

As such, it is likely that many of Michigan's bats have not been counted. Based on data produced during hibernacula surveys (and an estimate of those in un-surveyed sites), the hibernating populations of Michigan (500,000 bats), Minnesota (25,000 bats), and Wisconsin (330,000 bats) was estimated with local bat experts and yielded a region-wide population estimate of 855,000 hibernating little brown bats. Based on the 78% decline reported for little brown bats in hibernacula in Michigan (Kurta and Smith 2017), the current hibernating populations of the three states are approximately Michigan (110,000 bats), Minnesota (5,500 bats), and Wisconsin (72,600 bats) for a grand total of 188,100.

Little brown bats are known to move between the Lake States and surrounding states. However it is assumed the same number of bats remain in the Lake States at all times of years. Most bats are associated with large hibernacula that contained 10,000 or more bats prior to the arrival of WNS.

Fall/Spring

Little brown bats return to the hibernacula in the fall and initiate swarming activities. A recently completed Master's thesis (Lowe 2012) included studies of little brown bats near the hibernacula. Once bats were involved in swarming, more than 80% of roosts were located within 2 miles of the hibernacula and the furthest any bat traveled was 8.1 miles. At very large hibernacula (or complexes of hibernacula) bats may need to travel further to find resources, and thus a buffer of 10 miles was applied to those mines with 10,000 or more bats. A 5-mile buffer is used for smaller, known hibernacula.

High- and low-quality habitats were assigned to forest types (Table 3-2) and are consistent with described forest associations for foraging and roosting (Belwood and Fenton 1976, Anthony and Kunz 1977, Fenton and Bell 1979, Barclay 1991, Barclay and Brigham 1991, Kunz and Reichard 2010, Bergeson 2012, Bergeson et al. 2013).

Migration

Details about migration in this species are limited to band returns and mortality of bats at wind energy sites. It is known that bats from the Lake States migrate outside the region to other states and Canada Indeed, most large hibernacula occur on or near a state border. Thus migrating little brown bats can be found anywhere within the Lake States.

Summer

As a simplifying assumption, it is assumed that the same number of bats summer in the Lake States as hibernate in the Lake States in winter, but these bats include many bats that migrate in from other regions. Effectively this is an assumption that bats that migrate out of the Lake States are replaced by bats migrating into the Lake States. Further, it is assumed based on consultation with regional bat biologists, it is assumed that at least half the population (427,500 bats) is located in anthropogenic structures including buildings, bridges, and bat houses, and thus does not occupy

forested habitat. The remaining bats (427,500) are again broken in two halves with 213,750 bats being residing in areas of high density near those hibernacula that contained 10,000 or more little brown bats prior to WNS. Based on banding data contained in Humphrey and Cope (1976), these high density areas are considered to be all lands within 100 km of the large hibernacula as well as a band across southern Wisconsin that connects the three major hibernacula in the state (Figure 3-12). This high-density band is supported by data provided by the J. Paul White who leads Wisconsin's bat program. The remaining 213,750 bats were distributed across the larger landscape. This approach recognizes that little browns occupy both trees and anthropogenic roosts, that the species is most dense in areas with large hibernacula, and that some bats are found at great distances from hibernacula.

Summer habitat is mapped in Figure 3-12, with areas of high and low suitability following the descriptions in Table 3-2.

3.2.5.5 Tricolored Bat (*Perimyotis subflavus*)

Species Description

The tricolored bat (or eastern pipistrelle) is the smallest species addressed under the Lake States HCP, and is usually recognized by the reddish skin along the forearm and fingers that contrast strongly with the nearly black flight membranes and a pelage that is golden to reddish brown. Adhering to its common name, the bat's guard hairs have a tricolored appearance—dark at the base, yellow in the middle and dark at the top. The species is distributed sporadically across the Lake States (Figure 3-13), and was absent from most glaciated areas before settlement (Brack and Mumford 1984). Because the species is relatively rare in the region and is severely affected by WNS, the species is now listed as special concern in Michigan, special concern in Minnesota, and threatened in Wisconsin. USFWS is currently reviewing a petition for listing under the ESA.

Habitat Preferences

Tricolored bats occur sporadically in the Lake States, especially along the edge of Lake Michigan and typically summer within 85 miles of usable hibernacula. Density of the species declines rapidly with increasing distance from potential hibernacula which are known to include caves, mines, surge tunnels, and the spillway at Tippy Dam.

Tricolored bats move from the caves to summer habitat in spring, and may make use of migration roosts including open areas of buildings such as shaded porches or bridges (Whitaker 1998). Some of these sites are used throughout summer. Most bats then move to roosts in trees, most of which are located in clusters of dead and live leaves, although they have also been seen to roost in lichen and pine needles accumulated in tree splits (Veilleux et al. 2003, Perry and Thill 2007, Wisconsin Department of Natural Resources 2013). In areas with extensive forest, they tend to roost in forested areas that have dense understory vegetation. However, in developed areas, the species occasionally roosts in isolated trees within a variety of landscape types. Males roost alone, and females roost in small colonies of less than 30 adult bats.

Tricolored bats forage in a variety of habitat types located within 2.5 miles of their roost trees (Veilleux et al. 2003, Helms 2010). They forage in and along the edges of woodlands and areas of scrub/shrub. While they avoid areas of intense development, they routinely forage right up to the edges of such habitats.

Tricolored bats typically roost alone in the hibernacula (as opposed to clustering) and thus it is not unusual for this species to be the only bat using a relatively small underground void such as a short mine shaft or even hand-dug wells.

Distribution and Population Estimates

The distribution and population estimates that follow are made for pre-WNS populations of the species. Estimates will be adjusted to account for WNS over time as part of the effects analysis.

Winter

Tricolored bats are known to hibernate in at least 129 sites throughout the Lake States, including 16 sites in Michigan, 70 sites in Wisconsin, and 43 sites in Minnesota. The species hibernates in caves, mines, and similar underground structures. Tilden Mine in the Upper Peninsula is unsafe to enter, but is suspected of containing large numbers of bats including little brown, tricolored, and northern long-eared bats—it is included as a hibernaculum.

Based hibernacula surveys and an estimate of tri-colored bats in un-surveyed sites, the hibernating populations of Michigan (100 bats), Minnesota (1,000 bats), and Wisconsin (2,300 bats) produce a region-wide population estimate of 3,400. Generalizing the 92% decline of this species noted by Kurta and Smith (2017) the current hibernating populations of Michigan (8 bats), Minnesota (80 bats), and Wisconsin (184 bats) for a region-wide population estimate of 272 hibernating tricolored bats.

The number of bats in the Lake States is presumed to be the same at all times despite the fact individual bats may move in and out of the region. Winter habitat for this species is modeled as a 0.25-mile radius around these hibernacula.

Fall/Spring

No telemetry studies have been completed for tricolored bats engaged in swarming or staging, but the species is a weaker flyer than the other covered species. Therefore, we assume that a 5-mile buffer around all known hibernacula is appropriate for modeling fall/spring habitat. Table 3-2 assigns high- and low-quality habitat by forest type, and the 3,400 bats are assumed to be evenly distributed in fall/spring habitat.

Migration

Details about migration in this species are limited to mortality of bats at wind energy sites and the locations of summer and winter populations. As such, no calculation of take has been completed and migration habitat is assumed to occur anywhere between summer and winter habitat.

Summer

Tricolored bats occur sporadically within the plan area, although they are most abundant in the southern portions of the Lake States. The species is rare/absent across most of the Lower Peninsula of Michigan, outside the karst region of Wisconsin, and in western Minnesota. Summer habitat is mapped in Figure 3-13, with areas of high and low suitability following the descriptions in Table 3-2.

3.3 Baseline

3.3.1 White-Nose Syndrome

The discovery of white fungus on the noses of bats hibernating in a cave near Albany, New York, in 2006 was the first sign of an emerging infectious disease. The WNS fungus, *Pseudogymnoascus destructans*, thrives in cold and humid conditions characteristic of the caves and mines used by hibernating bats, including the covered species (Gargas et al. 2009), and readily invades the tissue of hibernating bats. When the bats are using the caves and mines during hibernation, they have a reduced immune response, making them susceptible to infection (Carey et al. 2003). The disease now occupies a range from the Atlantic Coast to the edge of the Great Plains (Figure 3-14). (whitenosesyndrome.org 2017) and in March 2016, a little brown bat with signs of WNS was collected in Washington State and subsequently tested positive for WNS. A silver-haired bat (*Lasionycteris noctivagans*) collected at the same site tested positive for the fungus, but shows no symptoms of disease (U.S. Geological Survey 2016).

Following the arrival of WNS at a hibernaculum, populations of most cave hibernating bats decline rapidly, but the level of mortality varies with physical conditions at the site and species-specific responses to infection (Langwig et al. 2012, Langwig et al. 2016). Emerging data (Frick et al. 2017) provide evidence that in the decade since WNS first arrived in the Northeast, the Indiana bat has suffered significant population declines, but those declines are less severe than other similar species and populations are no longer declining. Similarly, populations of little brown and tricolored bats were severely affected but now are no longer rapidly declining. Unfortunately, population declines for northern-long-eared bat continue without signs of slowing.

Federal, state, local, and private entities are investing significant time and funding into research aimed at reducing effects from WNS (Michigan Department of Natural Resources and Environment 2010, Minnesota Department of Natural Resources 2013, Wisconsin Department of Natural Resources 2011), but efforts at treatment or prevention remain experimental. The fungus is initially transmitted primarily through bat-to-bat contact, but once it is present in a hibernaculum it can persist for long periods within the cave system (Lorch et al. 2013, Zukal et al. 2014). Decontamination protocols are available from USFWS to prevent spread of the disease by researchers (whitenosesyndrome.org 2017). Cave management and preservation organizations are limiting or not allowing access to caves and are requiring that clothing and equipment be disinfected in an effort to prevent the spread of the WNS fungus.

Within the plan area, the first evidence of WNS was the detection of the fungus in samples collected from bats in winter 2011/2012 at Minnesota's largest hibernacula (Minnesota Department of Natural Resources 2013). Diseased bats were found at several Michigan hibernacula in spring 2014 (Kurta and Smith 2014), and bat mortalities related to WNS were recorded in Keweenaw County in January 2015 (Michigan Department of Health and Human Services 2017). Hibernacula surveys in Michigan during early 2017 have documented widespread population declines consistent with observations in other WNS-affected states (Kurta pers. comm.). Bat mortalities related to WNS were confirmed at Soudan Underground Mine in January 2016 (Minnesota Department of Natural Resources 2016). Winter surveillance of 75 bat hibernacula in Wisconsin during 2014 and 2015 found 14 sites in eight counties that contained either *P. destructans* or WNS, including Grant, Crawford, Richland, Door, Dane, Iowa, Dodge, and Lafayette Counties (Wisconsin Department of Natural Resources 2015). The site in Grant County, the original point of infection in Wisconsin, saw a

70% population decrease from pre-WNS estimates (Wisconsin Department of Natural Resources 2015). Finally, Indiana bats migrate to the covered lands from surrounding states, including Indiana, Kentucky, and Ohio, where WNS has also reduced numbers of this species (USFWS 2015). Thus, this plan is being developed at a time when WNS is rapidly reducing the population of the covered species in the region.

3.3.2 Wind Energy Development

The Lake States HCP is located in a region where land-based wind energy is a rapidly developing industry. The operation of commercial wind energy facilities results in the accidental mortality of both birds and bats, including all four species addressed by the Lake States HCP. On behalf of the industry, the American Wind Energy Association has championed the development of the Midwest Wind Energy Habitat Conservation Plan (Wind Energy Plan) to address the potential effects of this industry on three of the species covered by the Lake States HCP. The Wind Energy Plan does not address effects on the tricolored bat, but those are addressed in the associated environmental impact statement.

To calculate effects, the Wind Energy Plan made use of a proportional mortality model. This model works by combining data obtained when biologists survey operating wind turbines for dead birds and bats (i.e., carcass searches). To obtain an accurate estimate of mortality, biologists must not only count the number of carcasses they find but also account for those carcasses that are taken by scavengers before they are found, overlooked by biologists, or fall outside of designated search areas. When these mortality estimates are combined across multiple studies, it is possible to estimate the number of bats killed per tower, (standardized to the size of the towers in megawatts, and the proportion of those mortalities that are assignable to a particular species.

Based on studies throughout the Midwest (defined as Ohio, Indiana, Illinois, Iowa, Michigan, Minnesota, Missouri, and Wisconsin), the number and size of operating turbines, and the number and size of turbines expected to be built in the region during the next 45 years, it was possible to estimate the number bats that will be killed at these sites. Thus, the Wind Energy Plan estimates that over the next 45 years, wind energy in the Midwest will take 16,822 Indiana bats, 9,753 northern long-eared bats, and 440,830 little brown bats.

The model used to estimate mortality of Indiana bats was recreated for a variety of other species, including the tricolored bat, in order to estimate the impacts of the Wind Energy Plan on these nontarget species. That model predicted the mortality of 51,389 tricolored bats.

These numbers are based on summer 2016 population estimates and are expected to decline as WNS reduces the population of bats throughout the region. These numbers also do not reflect conservation measures included in the Wind Energy Plan that are designed to achieve the following goals.

- Reduce mortality of all bat species by at least 50%
- Prevent wind energy sites from being built in highly sensitive areas
- Create and manage habitat to mitigate for impacts to the three species covered in the Wind Energy Plan (little brown, Indiana, and northern long-eared bats)

As noted in the associated environmental impact statement, such steps are also likely to benefit other species, including the tricolored bat.

3.3.3 Forest Management Programs

3.3.3.1 Forest Management on DNR and County Lands

Each state's DNR manages extensive forested areas using widely accepted practices described in silvicultural guidelines or handbooks specific to each state. Those practices are similar among states and described in detail in Chapter 2. County land management staff also use practices similar to those employed by state DNRs.

Management on DNR and county lands usually occurs as a timber sale to a private firm. DNR or county staff specify the type of management to be performed in a specified area, called a stand, and firms compete to purchase this stumpage[1] on public lands. Thinning and similar timber stand improvement cuts, which are less profitable, may be undertaken by DNR or/county staff and temporary employees, or a private firm may be hired to complete the project.

Over the last few decades, the Lake States DNRs have established standards for forest management that include protection of water quality and soil integrity, provision for endangered and threatened species habitat, and wildlife habitat enhancement, such as leaving standing dead trees and snags. Third-party certification documents the attainment of such standards for implementing these and other forest management practices. See Section 3.3.3.3, *Federal-State Joint and Third-Party Programs*.

3.3.3.2 Voluntary Best Management Practices

Each state has loggers and landowners outside the known federal, state, and third-party management planning programs. Protecting water quality in streams, wetlands, and lakes is a primary objective of forestry best management practices. Although these forestry best management practices are voluntary and not all of them are tied to certification, tax incentives, or other incentives, they can result in improvements to forest management activities, such as road building, and harvesting in riparian areas. These state efforts include extension and outreach, training workshops, publications, and continuing education credits. They may be implemented in cooperation with other agencies, such as Michigan's Department of Environmental Quality.

3.3.3.3 Federal-State Joint and Third-Party Programs

Each state participates in two federal-state joint programs, the Forest Stewardship Program and the U.S. Forest Service's Forest Legacy Program (Table 3-4). Hundreds of thousands of private acres have been formally enrolled in these programs. Involvement in these programs results in cost-share, payments for easements and technical assistance. Some acres may be required to be open to public hunting.

Another forest management initiative, third-party certification, leads to commercial benefits, such as the ability of a landowner to sell forest products under a certification label. Certification standardizes and documents the attainment of best forest management practices. The programs all require that a forest management plan, written by or reviewed by natural resource professionals, be completed for each enrolled land parcel. As natural resource issues are identified or emerge, such as

[1] Stumpage is the price on standing timber and the right to harvest it, reckoned as a unit value per stump.

WNS and the decline of cave-hibernating bat species or new listing of a species, the expectations for these plans changes and new best practices are incorporated into the management plans. In this regard, all these lands have or will over time very likely incorporate protections for cave-dwelling bats.

Table 3-4. Involvement in the Forest Stewardship, Forest Legacy, and Forest Certification Programs by Ownership Type and Percent of all Forestland between States

Program	Forest Stewardship Program		Forest Legacy Program		Forest Certification Programs			
					Sustainable Forestry Initiative		Forest Stewardship Council	
Ownership Type	**Acres**	**%[a]**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Michigan								
DNR Lands	N/A	0	4,170	0.1	3,900,000[b]	92.7	3,900,000[b]	92.7
County and Municipal	23,688	5.4	N/A	0	N/A	0	N/A	0
Private	923,840	7.3	150,479	1.2	1,516,323	12.0	279,753	2.2
Minnesota								
DNR Lands	N/A	0	N/A	0	4,900,000[b]	127	4,825,839[b]	125
County and Municipal	340	<.1	8,664[d]	0.3	1,627,667[c]	63.2	1,594,814[c]	61.9
Private	715,120	8.8	343,664[d]	4.2	704,316	8.6	267,650	3.3
Wisconsin								
DNR Lands	N/A	0	N/A	0	1,551,440[b]	130	1,551,440[b]	130
County and Municipal	N/A	0	N/A	0	2,383,488[c]	101	2,383,488[c]	101
Private	3,445,017	29	259,436	2.2	139,007	1.2	547,055	4.6
Grand Total	**5,108,005**		**766,413**		**16,722,241**		**15,350,039**	

[a] % refers to percent of enrolled acres relative to all forestland in the state under that ownership.

[b] DNR State Forest Lands are dual-enrolled in SFI and FSC. An additional 81,481 acres in MN are SFI certified only.

[c] County Forest Lands are enrolled in one or both certification programs. 699,640 acres on MN county lands and 1,483,893 acres on WI county land are dual-certified.

[d] All County lands and 206,000 acres of private lands are enrolled in the state-equivalent "Minnesota Forests for the Future" program.

DNR = Department of Natural Resources

Forest Stewardship Program

The Forest Stewardship Program is a partnership between the U.S. Forest Service, a state DNR or similar agency, and private sector foresters who offer professional planning and technical assistance to private forestland owners. The purpose of the program is to encourage long-term stewardship of family forestland by developing and implementing a Forest Stewardship Plan that produces both economic and ecological benefits. In order to be eligible, a landowner must own 20 acres with at least 50% of that forested. Enrollees must also commit to 10 years of management actions. Each Forest Stewardship Plan is customized and describes the landowner's personal goals, unique forest resources, and suggested management activities. A landowner may use their Forest Stewardship Plan to enroll in the Commercial Forest Program (Michigan) or the Qualified Forest Program (Michigan). Although participation in the Forest Stewardship Program is voluntary, these referenced tax programs require landowners to comply with their forest management plan in exchange for a

reduced property tax. The Natural Resources Conservation Service also accepts Forest Stewardship Plans when a landowner applies for financial assistance to implement conservation practices recommended in their plan. Landowners might also use a Forest Stewardship Plan to enroll in the American Tree Farm System to certify the sustainable management of their forestland. Plans have been established for several thousand landowners covering nearly 924,000 acres in all 83 counties in Michigan (Table 3-4). Most of these properties were from 40 to 80 acres. In Minnesota, approximately 715,000 acres of forestland have a Forest Stewardship Plan. In Wisconsin [waiting for data]. Although Forest Stewardship enrollments represents less than 10% of private forestland acres in each state, it is the most effective program to implement professional forest management on private lands.

Forest Legacy Program

The Forest Legacy Program seeks to protect privately owned and environmentally significant forestland from being converted to nonforest uses. The program is voluntary and provides funds to acquire land in fee ownership or development rights through a conservation easement. The Forest Legacy Program encourages partnerships with local governments and land trusts, recognizing the important contributions that private landowners, local communities, and environmental organizations make to forest conservation efforts. Michigan has enrolled 155,000 acres of primarily private land (Table 3-4). Minnesota has enrolled more than 352,000 acres of public and private lands. Minnesota also implemented its own forest conservation easement program, the Minnesota Forests for the Future Program, in tandem with Forest Legacy. Wisconsin has enrolled more than 259,000 acres in this program. Forest Legacy easements cover less than 5% of the total private forestland acres in each state, but because it targets productive timberlands and seeks to prevent parcelization, it is an effective method to maintain forest cover and avoid habitat fragmentation due to development.

American Tree Farm System

The American Tree Farm System provides tools and information to help tree farmers and woodland owners keep forests healthy and productive. In Minnesota, for example, more than 2,400 private landowners representing approximately 1 million acres participate in the tree farm program. In early 2015, several updates to the certification standards were instituted. One enhancement provides clarifying language that identifies clear obligations for protection of occupied threatened and endangered species habitats and communities on enrollee lands.

Forest Certification Programs

Forest certification is widely seen as the most important initiative in recent decades for promoting sustainable forest management. Forest certification is a voluntary process based on independent, third-party audits of a landowner's management program, practices, policies, and on-the-ground forest activities. Each of these elements is measured against specific management standards that address environmental, social, and economic parameters. Certification provides an objective and quantitative means for recognizing well-managed forestland. For instance, the Sustainable Forestry Initiative (SFI©) and Forest Stewardship Council (FSC©) standards prohibit conversion of one forest cover type to another type except in justified circumstances, such as dealing with disease. SFI© and FSC© also limit (minimize to avoid) pesticide use and require that pesticides be properly vetted and/or government-approved.

Certification represents a significant investment of time and money. A decision to pursue and maintain forest certification is usually made by the landowner. Provisions also exist for landowners to join a group seeking certification. Private landowners sometimes pursue group certification, as do some municipal and county entities. Certified forests support certain markets for timber (local through global) as many forest products manufacturing facilities need certified wood to satisfy customer demands.

All landowner groups in all Lake States participate in the most common and recognized forest certification programs: SFI© and FSC©. Nearly 32 million acres of forestland are certified under one or both of these programs (Table 3-4). Specifically, Michigan has 5.70 million certified acres (state lands are dual-certified in both programs) (Table 3-4). Minnesota has 7.26 million certified acres and approximately 88% of the certified acreage is in public ownership. All of Minnesota's state-owned lands are dual certified to SFI© and FSC© (five counties in northern Minnesota have a group certificate). Even though public forestlands make up the bulk of the certified acres, nearly 972,000 acres of certified private forestland in Minnesota are enrolled in one of these programs. These include family forests, industrial forests, and conservation lands owned by entities such as The Nature Conservancy. Wisconsin has 4.62 million certified acres and 27 of Wisconsin's County Forests are third-party certified to either SFI© or FSC© (17 counties are dual certified). State DNR lands in Wisconsin are dual certified. Private lands in Wisconsin are certified under one program or the other.

The percent of certified acres in an ownership type approaches or exceeds that reported in FIA data for that ownership type. This is because certified tracts of land include nonforested lands.

3.3.3.4 State-Specific Forestry Programs

Each state has a forestry program that incentivizes landowners to manage their forest resources primarily to ensure a supply of good timber for commercial use but also to prevent the conversion of forestland to nonforested land. Landowners enrolled in these programs receive a tax benefit. Participants must complete a forest management plan. Such a plan could include provisions to protect certain key natural resources. At a minimum, enrollees are required to not damage legally protected resources.

The following discussion highlights forest management programs that are unique to individual states. These programs offer potential connections with foresters while providing incentives for landowners to manage their lands under the guidelines established by the Lake States HCP.

Michigan Forestry Programs

Commercial Forest Program

The Commercial Forest Program in Michigan provides a significant property tax reduction to private landowners as an incentive to retain and manage their forestland for long-term timber production in support of the state's forest products industry. Landowners do not pay *ad valorem* taxes, which are based on a property's assessed value, but pay a specific tax of $1.25 per acre per year for land enrolled in the program. Additionally, the State of Michigan makes an annual payment (from the general fund) of $1.25 per acre to each county with commercial forestland, to help offset the lost local tax revenue. It is estimated that approximately 2.2 million acres of private forestland owned by 1,800 landowners are enrolled in the program (Table 3-5). Commercial forest landowners range

from large, industrial timber producers to small, nonindustrial businesses, private individuals, civic groups, and trusts. Program participants assume the following responsibilities.

- Managing the property for commercial timber production.
- Having a written forest management plan.
- Certifying that the forest management plan is in effect.
- Allowing public access (foot) for hunting and fishing.

Prohibited activities include agriculture, grazing, and industrial, residential, resort, or commercial activities. The penalty for withdrawing a property is complicated, but generally costs approximately $100 per acre.

Qualified Forest Property Program

The purpose of the Qualified Forest Program is to encourage private forestland owners to manage their land in an economically viable and environmentally sustainable manner. Landowners receive an exemption from local school operating taxes and/or exemptions from the uncapping of the taxable value of their property in the event of a change in ownership. Enrolled properties must have a forest management plan that is prepared by a qualified forester. Enrollees must also agree to manage their forest in accordance with the forest management plan. Enrollees must report to the Michigan Department of Agriculture and Rural Development when a forest practice or timber harvest has occurred on a qualified property. If a landowner does not accomplish forest practices and harvests within three years of the time specified in the current forest management plan, the property will revert to its former tax status and be subject to a recapture tax.

To enroll in the program, the parcel must be at least 20 acres. For parcels of fewer than 40 acres, at least 80% must be stocked with productive forest (producing at least 20 cubic feet of wood per acre per year). For parcels of 40 or more acres, at least 50% must be stocked with productive forest. A maximum of 640 acres per property owner may be enrolled in a tax-collecting unit of government.

Since its inception, approximately 368,000 acres have been enrolled in the program, which is only a fraction of the approximately 12.6 million acres of private forestland in Michigan (Table 3-5). Unlike the Commercial Forest Program, public access for hunting and fishing is not required for enrolled property.

Table 3-5. Involvement in State Forest Management Programs by Ownership Type in Michigan [a]

	Commercial Forest Program		Qualified Forest Property Program	
Ownership Type	**Acres**	**%**	**Acres**	**%**
Private	2,218,358	17.6	367,593	2.9

[a] % refers to percent of enrolled acres relative to all forestland in the state.

Minnesota Forestry Programs

Sustainable Forest Incentive Act

The Sustainable Forest Incentive Act is one of the more popular programs available to private forestland owners in Minnesota. Established in 2001, the program is administered by the Minnesota

Department of Revenue in coordination with the Minnesota DNR. The program functions as an incentive payment rather than a tax rebate or credit. Upon meeting the eligibility criteria, the landowner pays full property taxes and in turn gets a subsequent payment from the state. Eligibility requires a minimum of 20 contiguous forested acres. Owners must adhere to a covenant, with a mandated minimum 8-year commitment. Enrollees are required to develop a forest management plan that is usually satisfied by a forest stewardship plan (described below). Non-motorized public access is required for landowners who enroll more than 1,920 acres.

Recently, the annual payment was codified in statute at $7.00 per acre. In the first year of the program, 320 landowners enrolled with a corresponding 531,508 acres. Enrollment peaked in 2010 with 2,048 landowners having enrolled over 917,000 acres. Starting in 2010, payments were capped at $100,000 per landowner. This action had significant economic implications for some of the state's largest forestland owners who ultimately opted out. In 2016, more than 836,000 acres remained enrolled (Table 3-6).

Table 3-6. Involvement in State Forest Management Programs by Ownership Type in Minnesota[a]

	Sustainable Forest Incentive Act		2c Managed Forest Classification		Rural Preserve Program	
Ownership Type	**Acres**	**%[a]**	**Acres**	**%**	**Acres**	**%**
Private	836,400	10.3	Waiting for info		Waiting for info	

[a] % refers to percent of enrolled acres relative to all forestland in the state.

2C Managed Forest Classification

Unlike the Sustainable Forestry Incentive Act program, the 2C tax classification-managed forestland designation is a standard property tax rate deduction. The 2C classification lowers the class rate of eligible properties from 1.00 to 0.65%. Similar to the Sustainable Forestry Incentive Act program, eligibility requirements include a minimum of 20 acres as well as a written management plan. There is no stipulation for public access and the classification has a maximum enrollment cap of 1,920 acres per landowner. From 2008 (first year) to 2012, the number of enrolled acres increased nearly fivefold from 47,162 to 226,713 acres.

Rural Preserve Program

The Rural Preserve Program was launched in 2011 to accommodate changes made to the Green Acres tax program. The program requires a minimum of 10 acres of rural vacant land, which may or may not be forested. The program does not require a conservation plan or public access. The land is taxed at the current use value as opposed to the estimated market value.

Wisconsin Forestry Programs

Managed Forest Law Program

Wisconsin's Managed Forest Law is a private landowner property tax incentive program that requires enrollees to practice sustainable forestry. Management plans contain recommendations related to forestry, wildlife management, water quality, endangered resources, and aesthetics. Roughly 3.35 million acres of private forestland are enrolled in the program (Table 3-7). Lands enrolled into the program can also qualify for voluntary membership in the Managed Forest Law

Certified Group (American Tree Farm System and FSC©). Landowners can opt in or out of the group at any time.

Table 3-7. Involvement in State Forest Management Programs by Ownership Type in Wisconsin[a]

	Managed Forest Law Program		Forest Crop Law Program	
Ownership Type	**Acres**	**%**	**Acres**	**%**
Private	3,348,666	28.2	113,865	0.3

[a] % refers to percent of enrolled acres relative to all forestland in the state.

Managed Forest Law enrollees pay an acreage share tax instead of the regular (*ad valorem*) property tax. Wisconsin has an average statewide tax for productive timberlands of $42.70 per acre, and provides a 95% reduction in property taxes if public access is allowed. The average net tax under the program is $2.14 per acre if enrolled after 2004, and $0.79 per acre if enrolled between 1987 and 2004. If public access is prohibited, the tax rate increases to $10.68 per acre for lands enrolled after 2004 and $1.87 per acre for lands enrolled earlier.

To qualify and comply with the Managed Forest Law, lands must be restricted from other industries or land uses such as agriculture, grazing, commercial storage facilities, game farms, cell towers, mines, quarries, and campgrounds. To participate in the program, landowners designate property as *Open* or *Closed* to public access for recreation, and commit to a 25- or 50-year sustainable forest management plan. The plan sets the schedule for specific forestry practices, which landowners must complete. In return, participants make a small annual payment in lieu of regular property taxes plus a yield tax when trees are harvested. Yield taxes go to the local municipality to help offset the annual property taxes that are deferred while properties are enrolled in the Managed Forest Law.

In order to qualify for Managed Forest Law designation, a forested parcel must meet the following criteria.

- Contain at least 10 contiguous acres under the same ownership.
- Be at least 80% covered by forest dedicated to growing commercial timber products and able to grow at least 20 cubic feet of wood per acre per year. Up to 20% of each forest parcel may be deemed unsuitable for growing timber or is characterized by an unmanaged vegetation type to include forested no-cut zones.
- Be unencumbered concerning recreational leases. Landowners may not receive consideration (cash, goods, or services) for the use of Managed Forest Law lands for a recreational activity that is exclusive.

Mandatory forest management practices such as the following must be carried out during the Managed Forest Law entry period.

- Harvesting timber according to sound forestry standards.
- Thinning plantations and natural stands for merchantable products.
- Releasing trees from competing vegetation.
- Tree planting to maintain necessary forest density.
- Treating before and after harvest to ensure adequate forest regeneration.

- Controlling soil erosion.

A noncompliance fee of $250 may be assessed on a landowner who fails to complete each mandatory practice according to the established schedule. Failure to follow the management plan can result in the loss of Managed Forest Law designation and an assessment of withdrawal taxes and fees.

Forest Crop Law Program

The Forest Crop Law Program was retired in 1986 and is in the process of being phased out. It is considered a legacy program for previously enrolled acreages. All new enrollments and changes of ownership are directed to the Managed Forest Law Program. Almost 114,000 acres of private land remain enrolled under the Forest Crop Law Program (Table 3-7).

3.4 Michigan Covered Lands

Covered lands in Michigan include state, private, municipal, and county lands. In the Lower Peninsula, state lands are scattered and relatively sparse due to human development. Some state landholdings can be found in the Allegan pine plains, the morainal region north of Detroit, and along major rivers (Figure 3-15). In the northern Lower Peninsula large blocks of state lands separate two units of the Huron-Manistee National Forest. Private ownership comprises the majority of forestland in the southern Lower Peninsula. The eastern Upper Peninsula is predominantly state lands, with two units of the Hiawatha National Forest on either side of the state lands. The Seney National Wildlife Refuge, a vast wetland mosaic with scattered old forest patches, lies between these two units. A large block of state lands occurs in the western Upper Peninsula, with smaller blocks in the Huron Mountains, the Keweenaw Peninsula, and along Green Bay. Private and county forestlands lie between public forestlands in the northern Lower and Upper Peninsulas (Figure 3-15).

3.4.1 Forest Type Distribution

Forestland in Michigan is found throughout the state, but in the southern two-thirds of the Lower Peninsula it is a small proportion of land cover because of extensive agriculture and urban/suburban development. In the northern Lower and entire Upper Peninsulas, forest is the dominant land cover.

In the southern Lower Peninsula, maple/beech/birch and oak/hickory are the predominant forest types. In the northern Lower Peninsula and eastern Upper Peninsula aspen/birch and smaller areas of white/red/jack pine forest predominate. The eastern Upper Peninsula's forestland consists of a complex mosaic of types: aspen/birch, white/red/jack pine, and in lowlands, spruce/fir. In the western Upper Peninsula, maple/beech/birch predominates, with large expanses of aspen-birch. There remain but few remnants of old growth, long-lived conifer stands like those that once dominated the northern portion of the state. Table 3.8 shows other land cover classes within the state. Table 3.9 shows the forested land cover classes addressed by this Plan (i.e., State DNR, county and municipal, and private lands). Figure 3-16 displays the land cover classes, including forestlands, within the state.

Table 3-8. Michigan Other Land Cover

Land Cover Class	Acres	%
Forested	(see above using FIA data)	54.7
Rivers & streams (miles)	N.A.	N.A.
Open water	978,215	2.6
Barren land	171,835	0.5
Emergent herbaceous wetlands	686,992	1.8
Grassland/pasture/cultivated	11,124,993	29.8
Low/medium-intensity development	3,717,082	10.0
High-intensity development	211,680	0.6
Total	**16,890,797**	**100**

Source: NLCD 2017
Note that NLCD acres and FIA acres do not match exactly and are not interchangeable across tables

Table 3-9. Michigan Covered Forestland by Ownership Type

	Total		State DNR		County and Municipal		Private	
Land Cover Class	Acres	% of Forest Types	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland
Forest and shrub/scrub	**17,261,220**	**N.A.**	**4,208,397**	**24.4%**	**434,749**	**2.5%**	**12,618,074**	**73.1%**
Shrub/scrub	130,451	0.8%	30,493	0.2%	3,853	0.0%	96,105	0.6%
Evergreen forest	3,827,446	22.2%	1,411,579	8.2%	73,770	0.4%	2,342,097	13.6%
Deciduous/mixed forest	11,316,477	65.6%	2,524,216	14.6%	298,077	1.7%	8,494,184	49.2%
Woody wetlands	1,986,846	11.5%	242,109	1.4%	59,049	0.3%	1,685,688	9.8%

Source: FIA Data 2017

3.4.2 Species Distribution

The following section discusses the expected distribution of the covered species on covered lands in Michigan. Table 3-10 shows the seasonal distribution of covered bats by habitat quality.

3.4.2.1 Indiana Bat

The only known active hibernaculum for the Indiana bat in Michigan is the spillway of Tippy Dam. During fall and spring, the species may be found within 5 miles of this hibernaculum in any of the land classes outlined except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. Indiana bats in the summer are assumed restricted to portions of the Lower Peninsula of Michigan within the average migratory distance (429 kilometers or 267 miles) of hibernacula in Kentucky, Ohio, and Indiana (Rockey et al. 2013). The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-2 and 3-3.

3.4.2.2 Northern Long-Eared Bat

Northern long-eared bats are known to hibernate at 29 sites in Michigan, including mines, caves, and the spillway at Tippy Dam. During fall and spring, it is likely the species occurs within 5 miles of these hibernacula in any of the land cover classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, it is likely that the species is found throughout the state in land cover classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. The distribution of bats that roost in forested habitat (i.e. those at risk of take) is outlined in Tables 3-2 and 3-3.

3.4.2.3 Little Brown Bat

Little brown bats are known to hibernate at 28 sites in Michigan, which include natural caves, mines, surge tunnels, and the spillway at Tippy Dam. Seven of these sites, mostly abandoned mines in the Upper Peninsula, can contain 10,000 or more little brown bats during winter. Little brown bats are may occur in all land classes, except Developed High Intensity, within 10 miles of these large hibernacula during fall and spring. At smaller sites, little brown bats are expected to occur within the same land cover classes within 5 miles of the hibernaculum. During summer, little brown bats may use anthropogenic structures as roosts in addition to forested habitats. This species is expected to be found in structures as well as on the land cover classes outlined in Table 3-10, with the exception of Developed High Intensity and Developed Medium Intensity. The model for little brown bat summer habitat is described in Section 3.2.5.4, *Little Brown Bat* under *Summer*. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-2 and 3-3.

3.4.2.4 Tri-colored Bat

The tricolored bat is known to hibernate at 16 sites in Michigan, including caves, mines, and the spillway at Tippy Dam. During fall and spring, it is likely the species may occur within 5 miles of these hibernacula in any land classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, the species occurs sporadically, concentrated in the lower portion of the state, along Lake Michigan, and within 85 miles of suitable hibernacula. It is assumed to occur in all land classes within this area, except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-2 and 3-3.

Table 3-10. Seasonal Distribution of Covered Bats in Michigan by Habitat Quality

Area Occupied	Acres of All Land Classes within Area Occupied (% State)	Total Number of Bats	Acres of Forested Habitat by Quality (% State)		Bats Per Acre	
			High	Low	High	Low
Winter Habitat						
≤0.25 mile	287,716 (1%)	20 Indiana bats	26 (51%)	25 (49%)	.069	.007
		500,000 Little brown bats	139,179 (77%)	40,826.27 (23%)	3.49	0.35
		580,000 Northern long-eared bats	197,010(78%)	55,151 (22%)	1.79	0.18
		100 Tricolored bats	4118 (79%)	1115 (21%)	0.02	<0.01
> 0.25 mile	37,036,675 (99%)	NA	-	-	-	-
Fall/Spring						
≤5 miles except for hibernacula with >10,000 bats[a] (Iron Mountain Mine, Calledonia Mine Complex, Carp Lake Mine, Copper Creek Mine, Millie Mine, Norway Mine, Tilden Mine, and Tippy Dam)	1,972,148 (5%)	20 Indiana bats	31,956 (75%)	10,784 (25%)	<0.01	<0.01
		425,000 Little brown bats (large hibernacula)	695,870(78%)	192,663 (22%)	0.59	0.06
		75,000 Little brown bats (small hibernacula)	626,935 (79%)	165,463 (21%)	0.12	0.01
		307,563 Northern long-eared bats (large hibernacula)	695,870(78%)	165,583 (22%)	0.43	0.04
		54,276 Northern long-eared bats (small hibernacula)	669,293 (80%)	165,593 (20%)	0.08	0.01
		100 Tricolored bats	318,615 (78%)	90,527(22%)	<0.01	<0.01
All other lands	35,352,243 (95%)	NA	-	-	-	-

Early Summer						
All forested lands	20,432,942 (55%)	366 Indiana bats	3,780,278 (89%)	485,046 (11%)	<0.01	<0.01
		75,519 Little brown bats (near large hibernacula)	7,326,831 (78%)	2,010,343 (22%)	0.23	0.02
		80,446 Little brown bats (broader landscape)	8,844,172 (80%)	2,251,597 (20%)	0.07	0.01
		361,839 Northern long-eared bats	16,171,003 (79%)	4,261,939.60 (21%)	0.02	<0.01
		100 Tricolored bats	10,065,794 (81%)	2,396,194 (19%)	<0.01	<0.01
Nonvolant Pups						
All forested lands	20,432,942 (55%)	330 Indiana bats	3,780,278 (89%)	485,046 (11%)	<0.01	<0.01
		37,760 Little brown bats (near large hibernacula)	7,326,831 (78%)	2,010,343 (22%)	0.04	<0.01
		40,223 Little brown bats (broader landscape)	8,844,172 (80%)	2,251,597 (20%)	0.04	<0.01
		180,920 Northern long-eared bats	16,171,003 (79%)	4,261,939.60 (21%)	0.01	<0.01
		50 Tricolored bats	10,065,794 (81%)	2,396,194 (19%)	<0.01	<0.01
Once Pups are Flying						
All forested lands	20,432,942 (55%)	696 Indiana bats	3,780,278 (89%)	485,046 (11%)	<0.01	<0.01
		113,279 Little brown bats (near large hibernacula)	7.326.831 (78%)	2.010.343 (22%)	0.12	0.01
		120,669 Little brown bats (broader landscape)	16,171,003 (79%)	4,261,939.60 (21%)	0.03	<0.01
		542,759 Northern long-eared bats	16,171,003 (79%)	4,261,940 (21%)	0.05	0.01
		150 Tricolored bats	10,065,794 (81%)	2,396,194 (19%)	<0.01	<0.01

[a] All bat numbers are pre-WNS.

3.5 Minnesota Covered Lands

Covered lands in Minnesota include state, private, municipal, and county lands. State lands are most common in the northeastern forested part of the state, with large blocks from the Nemadji State Forest at the Wisconsin line, north and northwestward to Rainy Lake and Lake of the Woods (Figure 3-17). State lands are also distributed in small parcels across the rest of the state. Much of this state land is managed by county governments. These large blocks under state ownership are interspersed with federal forestland in the Chippewa and Superior National Forests. The latter is the location of the (federally owned) Boundary Waters Canoe Area Wilderness, with Voyageurs National Park lying just to the west. Private forestland is much more extensive than public forestland in the Driftless Area, but is interspersed with the extensive public holdings in the other forested regions of the state.

3.5.1 Forest Type Distribution

Forestland in Minnesota is distributed statewide. Historically, forestland was largely limited to areas along major rivers in the prairies of the west to southwest third of the state. That pattern largely holds today. Although forest has encroached significantly into the prairie region, the most extensive and best-developed forests today are in the Driftless Area, along large rivers, and in the northeastern third of Minnesota.

In the southeastern Driftless Area, oak/hickory prevails, with elm/ash/cottonwood in river bottoms and the maple/beech/birch type (with basswood but absent beech, which does not occur in the state) on northerly-facing slopes (Figure 3-18). The forest along the transition zone, angling from the northwest to the southeast is predominantly maple/beech/birch and aspen/birch. In the northern to northeastern third of the state, aspen/birch is the dominant forest type, with extensive spruce/fir forest in peatlands and lowland settings. White/red/jack pine forests are present but not extensive. At the southern edge of the northern coniferous-deciduous forest region are found oak/pine forests.

Current forests are different from historical forests that existed before large-scale logging between 1850 and the early 1900s. The dramatic changes in this period resulted in some elements of the forest becoming rarer than before, despite their previous persistence in the landscape. Rarer elements of Minnesota's forestland than in the early 1800s are long-lived conifer species (white pine, white cedar) and old-growth stands. Extensive forested areas were always rare in the southern to northwestern third of the state, but in the third of the state between the prairie region and northeastern state, extensive forests are restricted to wet, steep, or sandy areas where land was difficult to farm. Table 3-11 shows other land covers in Minnesota while Table 3-12 shows forestland by ownership type.

Table 3-11. Minnesota Other Land Cover

Land Cover Class	Acres	%
Forestland (including woody wetlands, scrub/shrub)	(see above using FIA data)	34.4
Rivers & streams (miles)	N.A.	N.A.
Open water	3,294,278	6.1
Barren land	80,760	0.1
Emergent herbaceous wetlands	3,505,114	6.5
Grassland/pasture/cultivated	25,505,176	47.2
Low/medium-intensity development	2,981,808	5.5
High-intensity development	104,757	0.2
Total	**35,471,893**	**100**

Source: NLCD 2017
Note that NLCD acres and FIA acres do not match exactly and are not interchangeable across tables

Table 3-12. Minnesota Covered Forestland by Ownership Type

	Total		State DNR		County and Municipal		Private	
Land Cover Class	Acres	% of Forest Types	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland
Forest and shrub/scrub	**14,573,330**	**N.A.**	**3,848,586**	**26.4%**	**2,574,362**	**17.7%**	**8,150,382**	**55.9%**
Shrub/scrub	174,739	1.0%	53,592	0.4%	32,778	0.2%	88,369	0.6%
Evergreen forest	3,987,644	23.1%	1,892,571	13.0%	735,769	5.0%	1,359,304	9.3%
Deciduous/mixed forest	8,893,259	51.5%	1,642,313	11.3%	1,580,947	10.8%	5,669,999	38.9%
Woody wetlands	1,517,688	8.8%	260,110	1.8%	224,868	1.5%	1,032,710	7.1%

Source: FIA 2017

3.5.2 Species Distribution

The following discusses the expected distribution of the covered species on covered lands in Minnesota. As noted in Chapter 1, *Introduction*, the Indiana bat is not known to occur in Minnesota. Table 3-13 shows the seasonal distribution of covered bats by habitat quality.

3.5.2.1 Northern Long-Eared Bat

The northern long-eared bat is known to hibernate at 18 sites in Minnesota, including caves and mines. It is likely that during fall and spring, the species occurs within 5 miles of these hibernacula, in all land classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, the species likely occupies these same land classes regardless of hibernacula location. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-1 and 3-2.

3.5.2.2 Little Brown Bat

Little brown bats are known to hibernate in 35 or more sites throughout the eastern half of the state. One hibernaculum, Soudan Mine, houses more than 10,000 little brown bats. In the fall and spring little brown bats are expected to occur within 10 miles of this hibernaculum in all land cover classes except Developed High Intensity. During summer, the species may use anthropogenic structures as roosts in addition to forested habitats. It is likely that little brown bats occupy all land classes except Developed High Intensity and Developed Medium Intensity. The model for little brown bat summer habitat is described in more detail in Section 3.2.5.4, *Little Brown Bat* under *Summer*. The distribution of bats that roost in forested habitat (i.e. those at risk of take) is outlined in Tables 3-1 and 3-2.

3.5.2.3 Tricolored Bat

Tricolored bats are known to hibernate in 41 sites in Minnesota, often in small numbers at caves, mines, and similar underground structures within the state. During fall and spring, the species is expected occur within 5 miles of these hibernacula in all land cover classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, the species occurs sporadically in the southern portion of the state and within 85 miles of suitable hibernacula. Within this 85-mile area, tricolored bat is likely to occur in all land classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. The distribution of bats that roost in forested habitat (i.e. those at risk of take) is outlined in Tables 3-1 and 3-2.

Table 3-13. Seasonal Distribution of Covered Bats in Minnesota by Habitat Quality

Area Occupied	Acres of All Land Classes within Area Occupied (% State)	Total Number of Bats	Acres of Forested Habitat by Quality (% State)		Bats Per Acre	
			High	Low	High	Low
Winter Habitat						
≤0.25 mile	14,942 (<1%)	25,000 Little brown bats	1,149 (68%)	534 (32%)	20.79	2.08
		292,700 Northern long-eared bats	7,952 (53%)	6,990 (47%)	33.83	3.38
		1,000 Tricolored bats	1221 (72%)	469 (28%)	0.79	0.08
> 0.25 mile	53,991,794 (>99%)	NA	-	-	-	-
Fall/Spring						
≤5 miles except for hibernacula with >10,000 bats[a] (Soudan Mine)	554,839 (1%)	21,250 Little brown bats (large hibernacula)	122,816 (66%)	62,787 (34%)	0.16	0.02
		3,750 Little brown bats (small hibernacula)	161,312 (71%)	64,777 (29%)	0.02	<0.01
		248,795 Northern long-eared bats (large hibernacula)	122,816 (66%)	62,787 (34%)	1.93	0.19
		43,905 Northern long-eared bats (small hibernacula)	343,891 (62%)	210,948 (38%)	0.12	0.01
		1,000 Tricolored bats	267,387 (69%)	120,122 (31%)	<0.01	<0.01
All other lands	53,544,045 (99%)	NA	-	-	-	-
Early Summer						
All forested lands	18,533,937 (34%)	44,631 Little brown bats (near large hibernacula)	4,256,531 (69%)	1,924,070 (31%)	0.07	0.01
		86,038 Little brown bats (broader landscape)	9,404,956 (76%)	2,948,380 (24%)	0.07	0.01
		292,700 Northern long-eared bats	13,661,487 (74%)	4,872,450 (26%)	0.02	<0.01
		1,000 Tricolored bats	8,375,277 (71%)	3,364,529 (29%)	<0.01	<0.01

Area Occupied	Acres of All Land Classes within Area Occupied (% State)	Total Number of Bats	Acres of Forested Habitat by Quality (% State)		Bats Per Acre	
			High	Low	High	Low
Nonvolant Pups						
All forested lands	18,533,937 (34%)	22,316 Little brown bats (near large hibernacula)	4,256,531 (69%)	1,924,070 (31%)	0.04	<0.01
		43,019 Little brown bats (broader landscape)	9,404,956 (76%)	2,948,380 (24%)	0.03	<0.01
		146,350 Northern long-eared bats	13,661,487 (74%)	4,872,450 (26%)	0.01	<0.01
		500 Tricolored bats	8,375,277 (71%)	3,364,529 (29%)	<0.01	<0.01
Once Pups are Flying						
All forested lands	18,533,937 (34%)	66,947 Little brown bats (near large hibernacula)	4,256,531 (69%)	1,924,070 (31%)	0.11	0.01
		129,057 Little brown bats (broader landscape)	9,404,956 (76%)	2,948,380 (24%)	0.10	0.01
		439,050 Northern long-eared bats	13,661,487 (74%)	4,872,450 (26%)	0.03	<0.01
		1,500 Tricolored bats	8.375.277 (71%)	3.364.529 (29%)	<0.01	<0.01

[a] All population numbers are pre-WNS

3.6 Wisconsin Covered Lands

Covered lands in Wisconsin include state, private, municipal, and county lands. These lands are most common in the northern third of the state (Figure 3-19). State lands are predominantly located between the Chequamegon and Nicolet units of the National Forest but are found in smaller areas elsewhere in northern Wisconsin. County forestlands are distributed across the northern third of the state. In Wisconsin's southern two-thirds, state, county, and federal ownership is concentrated at discrete locations, often incorporating unusual landscape features, such as the Kettle Moraine, or wildlife concentration areas, such as Horicon Marsh.

3.6.1 Forest Type Distribution

Forestland in Wisconsin is distributed across the state. In the state's southern two-thirds, it is a small fraction of the total land area due to agriculture and urban/suburban development (Figure 3-20).

In the southwestern Driftless Area, oak/hickory prevails, with elm/ash/cottonwood in river bottoms and maple/beech/birch on northerly-facing slopes (although beech is limited in Wisconsin to a band near Lake Michigan, it is included in the name of the forest type) (Carpenter 1974). The forest in the state's southeast quarter is highly fragmented and consists primarily of oak/hickory with areas of maple/beech/birch and elm/ash/cottonwood along rivers. Maple/beech/birch and aspen/birch dominant the northern third of the state up to the Michigan border, with large inclusions of white/red/jack pine forest. Spruce/fir in peatlands and lowlands are present as well in this area. South of here, up to the Driftless Area, forest cover consists of small stands, except in the extensive central Wisconsin sand plains between Black River Falls and Baraboo, where oak/pine forest predominates.

Current forests are different from historical forests that existed before large-scale logging between 1850 and 1950. The dramatic changes in this period resulted in some elements of the forest becoming rarer than before. Rare elements of Wisconsin's forestland are long-lived conifer species (hemlock, white pine, white cedar) and old-growth stands. Extensive forested areas are rare in the southern two-thirds of the state, except in the Driftless Areas and on the central Wisconsin sand plain. Table 3-14 shows other land covers in Wisconsin while Table 3-15 shows forestland by ownership type.

Table 3-14. Wisconsin Other Land Cover

Land Cover Class	Acres	%
Forest and shrub/scrub	(see above using FIA data)	47.7
Rivers & streams (miles)	N.A.	N.A.
Open water	1,269,713	3.5
Barren land	35,205	0.1
Emergent herbaceous wetlands	1,068,672	3.0
Grassland/pasture/cultivated	13,707,274	38.2
Low/medium-intensity development	2,580,771	7.2
High-intensity development	95,870	0.3
Total	**18,853,375**	**100**

Source: NLCD 2017
Note that NLCD acres and FIA acres do not match exactly and are not interchangeable across tables

Table 3-15. Wisconsin Covered Forestland by Ownership Type

	Total		State DNR		County and Municipal		Private	
Land Cover Class	Acres	% of Forest Types	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland	Acres	% All Non-Federal Forestland
Forest and shrub/scrub	**15,436,807**	**N.A.**	**1,192,782**	**7.7%**	**2,358,966**	**15.3%**	**11,885,059**	**77.0%**
Shrub/scrub	161,615	0.9%	24,953	0.2%	7,459	0.0%	129,203	0.8%
Evergreen forest	2,778,877	16.1%	290,984	1.9%	549,667	3.6%	1,938,226	12.6%
Deciduous/mixed forest	10,783,977	62.5%	691,836	4.5%	1,599,061	10.4%	8,493,080	55.0%
Woody wetlands	1,712,338	9.9%	185,009	1.2%	202,779	1.3%	1,324,550	8.6%

3.6.2 Species Distribution

The following section discusses the expected distribution of the covered species on covered lands within Wisconsin. Table 3-16 shows the seasonal distribution of covered bats by habitat quality.

3.6.2.1 Indiana Bat

A single historical record of a hibernating Indiana bat is known from Wisconsin, but this appears to have been a transient individual. The Indiana bat is not expected to occur in Wisconsin at any point in the year, and is not expected to occupy any land classes in this state. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-1 and 3-2.

3.6.2.2 Northern Long-Eared Bat

The northern long-eared bat is known to hibernate in at least 60 sites in Wisconsin, including caves and mines, and at other suitable hibernacula. The species is expected to occur within 5 miles of these hibernacula, except in Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, the species is expected to occur in all land classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-1 and 3-2.

3.6.2.3 Little Brown Bat

Little brown bats are known to hibernate in at least 52 sites in Wisconsin. Three of these sites contain 10,000 or more little brown bats during winter. The species is expected to occur within 10 miles of these hibernacula during fall and spring, except in the Developed High Intensity land cover class. At smaller hibernacula, little brown bats are expected to occur in the same land cover classes but within 5 miles of the hibernacula entrances. During summer, little brown bats may use anthropogenic structures in addition to forested habitats. The species is expected to occur throughout the plan area, except in the following land cover classes: Developed High Intensity and Developed Medium Intensity. The model for little brown bat summer habitat is described in more detail in Section 3.2.5.4, *Little Brown Bat* under *Summer*. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-1 and 3-2.

3.6.2.4 Tricolored Bat

Tricolored bats are known to hibernate in at least 70 sites in Wisconsin, including caves, mines, and other similar underground structures. During fall and spring, the species is expected to occur within 5 miles of all known hibernacula, in all land cover classes except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. During summer, the species occurs sporadically in the southern portion of the state within 85 miles of suitable hibernacula. Tricolored bats are expected to occupy all land classes in this range, except Open Water, Cultivated Crops, Developed High Intensity, and Developed Medium Intensity. The distribution of bats that roost in forested habitat (i.e., those at risk of take) is outlined in Tables 3-1 and 3-2.

Table 3-16. Seasonal Distribution of Covered Bats in Wisconsin by Habitat Quality

Area Occupied	Acres of All Land Classes within Area Occupied (% State)	Total Number of Bats	Acres of Forested Habitat by Quality (% State)		Bats Per Acre	
			High	Low	High	Low
Winter Habitat						
≤0.25 mile	59,149 (<1%)	330,000 Little brown bats	35,342 (85%)	6,092 (15%)	9.18	0.92
		70,433 Northern long-eared bats	32,510 (88%)	4,335 (12%)	2.14	0.21
		2,300 Tricolored bats	24,273 (84%)	4498 (16%)	0.09	0.01
> 0.25 mile	35,861,166 (>99%)	NA	-	-	-	-
Fall/Spring						
≤5 miles except for hibernacula with > 10,000 bats[a] (Neda Mine, Bay City Mine, Maiden Rock Mine)	1,281,377 (4%)	313,500 Little brown bats (large hibernacula)	166,814 (88%)	22,101 (12%)	1.85	0.19
		16,500 Little brown bats (small hibernacula)	670,431 (87%)	104,195 (13%)	0.02	0.19
		66,911 Northern long-eared bats (large hibernacula)	166,814 (88%)	22,101(12%)	0.40	0.04
		3,522 Northern long-eared bats (small hibernacula)	774,039 (86%)	125,642 (14%)	<0.01	<0.01
		2,300 Tricolored bats	267,387 (85%)	120,122 (15%)	<0.01	<0.01
All other lands	34,638,938 Acres (96%)	NA	-	-	-	-
Early Summer						
All forested lands	17,162,773 Acres (48%)	93,599 Little brown bats (near large hibernacula)	9,154,011 (84%)	1,761,326 (16%)	0.09	0.01
		47,266 Little brown bats (broader landscape)	5,226,638 (84%)	1,020,798 (16%)	0.08	0.01
		70.433 Northern long-eared bats	14,380,649 (84%)	2,782,123.71 (14%)	<0.01	<0.01
		2,300 Tricolored bats	6,357,924 (82%)	1,433,615 (16%)	<0.01	<0.01

Area Occupied	Acres of All Land Classes within Area Occupied (% State)	Total Number of Bats	Acres of Forested Habitat by Quality (% State)		Bats Per Acre	
			High	Low	High	Low
Nonvolant Pups						
All forested lands	17,162,773 Acres (48%)	46,800 Little brown bats (near large hibernacula)	9,154,011 (84%)	1,761,326 (16%)	0.04	<0.01
		23,633 Little brown bats (broader landscape)	5,226,638 (84%)	1,020,798 (16%)	0.04	<0.01
		35,217 Northern long-eared bats	14,380,649 (84%)	2,782,123.71 (14%)	<0.01	<0.01
		1,150 Tricolored bats	6,357,924 (82%)	1,433,615 (18%)	<0.01	<0.01
Once Pups are Flying						
All forested lands	17,162,773 Acres (48%)	140,399 Little brown bats (near large hibernacula)	9,154,011 (84%)	1,761,326 (16%)	0.13	0.01
		70,899 Little brown bats (broader landscape)	5,226,638 (84%)	1,020,798 (16%)	0.11	0.01
		105,649 Northern long-eared bats	14,380,649 (84%)	2,782,123.71 (14%)	0.01	<0.01
		3,450 Tricolored bats	6,357,924 (82%)	1,433,615 (18%)	<0.01	<0.01

[a] All population numbers are pre-WNS

3.7 References

3.7.1 Written References

Ainslie, W. B. 1983. Status, Habitat Preferences, and Management of Southwest Wisconsin bats. Master's Thesis, University of Wisconsin-Stevens Point, Stevens Point, Wisconsin.

Amelon, S., and D. Burhans. 2006. Conservation assessment: *Myotis septentrionalis* (northern long-eared bat) in the Eastern United States. U.S. Department of Agriculture, Forest Service, General Technical Report NC-260: Conservation Assessments for Five Forest Bat Species in the Eastern United States.

Anthony, E. L. P., and T. H. Kunz. 1977. Feeding strategies of the little brown bat, *Myotis lucifugus*, in southern New Hampshire. *Ecology* 58:775-786.

Auteri, G., and A. Kurta. 2015. New records of evening bats in Washtenaw County, Michigan. *Michigan Birds and Natural History* 22:225-227.

Barclay, M. R. 1991. Population structure of temperate zone insectivorous bats in relation to foraging behaviour and energy demand. *Journal of Animal Ecology* 60:165-178.

Barclay, R. M. R., and R. M. Brigham. 1991. Prey detection, dietary niche breadth, and body size in bats: Why are aerial insectivorous bats so small. *The American Naturalist* 137:693-703.

Belda, M., E. Holtanová, T. Halenka, and J. Kalvová. 2014. Climate classification revisited: from Köppen to Trewartha. *Climate Research* 59:1-13.

Belwood, J. J., and M. B. Fenton. 1976. Variation in the diet of *Myotis lucifugus* (Chiroptera: Vespertilionidae). *Canadian Journal of Zoology* 54:1674-1678.

Bergeson, S. M. 2012. Examining the suitability of the little brown bat (*Myotis lucifugus*) as a surrogate for the endangered Indiana bat (*M. sodalis)*. Master's thesis. Ball State University, Muncie, Indiana. 99 pp.

Bergeson, S. M., T. C. Carter, and M. D. Whitby. 2013. Partitioning of foraging resources between sympatric Indiana and little brown bats. *Journal of Mammalogy* 94:1311-1320.

Boland, J. L., J. P. Hayes, W. P. Smith, and M. M. Huso. 2009. Selection of day-roosts by Keen's myotis (*Myotis keenii)* at multiple spatial scales. *Journal of Mammalogy* 90:222-234.

Brack, V., Jr., and R. E. Mumford. 1984. The distribution of *Pipistrellus subflavus* and the limit of the Wisconsinan glaciation: an interface. *American Midland Naturalist* 112:397-401.

Brack, V., Jr., and J. O. Whitaker, Jr. 2001. Foods of the northern myotis, *Myotis septentrionalis*, from Missouri and Indiana, with notes on foraging. *Acta Chiropterologica* 3:203-210.

Carey, H. V., M. T. Andrews, and S. L. Martin. 2003. Mammalian hibernation: cellular and molecular responses to depressed metabolism and low temperature. *Physiological Reviews* 83:1153-1181.

Carpenter, R. D. 1974. American Beech, USDA Forest Service, American Woods, FS-220.

Carter, T. 2006. Indiana bats in the Midwest: the importance of hydric habitats. *Journal of Wildlife Management* 70:1185-1190.

Catton, T. J. 2014. Summary of the 2014 Minnesota northern long-eared bat summer habitat use in Minnesota project (preliminary report). U.S. Department of Agriculture, Forest Service, Superior National Forest, Kawishiwi Ranger District, Ely, Minnesota. 9 pp.

Chenger, J. 2007. Bedford County Pennsylvania, South Penn Tunnel 2007 Indiana bat migration. Bat Conservation and Management, Inc. and Sanders Environmental, Inc.

Cole, K.L., M.B. Davis, F. Stearns, G. Guntenspergen, and K. Walker. 1998. In Sisk, T.D. (ed.), Perspectives on the land use history of North America: a context for understanding our changing environment. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-1998-0003 (Revised September 1999). Washington DC.

Commission for Environmental Cooperation. 2014. *Terrestrial Ecosystems – Description*. Available: http://www.cec.org/Page.asp?PageID=122&ContentID=1329. Accessed: July 30, 2015.

Curtis, J. T. 1959. *The vegetation of Wisconsin: an ordination of plant communities.* Madison, University of Wisconsin Press.

Dorr, J. A., and D. F. Eschman. 1970. *Geology of Michigan*. Ann Arbor, MI: University of Michigan Press.

Duveneck, M. J., R. M. Scheller, M. A. White, S. D. Handler, and C. Ravenscroft. 2014. Climate change effects on northern Great Lake (USA) forests: a case for preserving diversity. *Ecosphere* 5: 1-26.

ESI. 2005. 2005 summer mist net survey for bats at naval support activity Crane, Crane, Indiana. Authors: Jason Duffey, Adam Mann, and Virgil Brack, Jr., Ph.D. Prepared for Indiana Department of Natural Resources, Division of Natural Preserves by Environmental Solutions & Innovations, Inc. Cincinnati, Ohio. 68 pp.

Fennemann, N. M., and D. W. Johnson. 1946. Physiographic divisions of the conterminous U.S. U,S, Department of the Interior, Geological Survey. Reston, VA.

Fenton, M. B., and G. P. Bell. 1979. Echolocation and feeding behavior in four species of Myotis (Chiroptera). *Canadian Journal of Zoology* 57:1271-1277.

Foster, R. W., and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (*Myotis sodalis*). *Journal of Mammalogy* 80:659-672.

Frelich, L. E. 1995. Old forest in the Lake States today and before European settlement. *Natural Areas Journal* 15: 157-167.

Frelich, L. E., and C. G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the Upper Great Lakes Region. *Ecological Monographs* 61(2):159-162.

Frelich, L. E., and P. B. Reich. 2009. Wilderness conservation in an era of global warming and invasive species: a case study from Minnesota's Boundary Waters Canoe Area Wilderness. Natural Areas Journal 29:385-393.

Frick, W. F., T. L. Cheng, K. E. Langwig, J. R. Hoyt, A. F. Janicki, K. L. Parise, J. T. Foster, and A. M. Kilpatrick. 2017. Pathogen dynamics during invasion and establishment of white-nose syndrome explain mechanisms of host persistence. *Ecology* 98:624-631.

Gargas, A., M.T. Trest, M. Christensen, T.J. Volk, and D.S. Blehert. 2009. *Geomyces destructans* sp. nov. associated with bat white-nose syndrome. *Mycotaxon* 108: 147-154.

Gumbert, M. W., J. M. O'Keefe, and J. R. MacGregor. 2002. Roost fidelity in Kentucky, Pages 143-152 *in* Conference Roost fidelity in Kentucky. KY1836.

Harvey, M. J., J. S. Altenbach, and T. L. Best. 1999. Bats of the United States. Arkansas Game and Fish Commission, Little Rock, Arkansas, 64 pp.

Helms, J. S. 2010. Little bat and a big city: nocturnal behavior of the tricolored bat, (*Perimyotis subflavus*) near Indianapolis Airport.

Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, and K. Megown. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States – representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing* 81: 345-354.

Humphrey, S. R., and J. B. Cope. 1976. Population ecology of the little brown bat, *Myotis lucifugus*, in Indiana and north central Kentucky. American Society of Mammologists Special Publication No. 4. 81 pp.

Johnstone, J. F., C. D. Allen, J. F. Franklin, L. E. Frelich, B. J. Harvey, P. E. Higuera, M. C. Mack, R. K. Meentemeyer, M. R. Metz, G. L. W. Perry, T. Schoennagel and M. G. Turner. 2016. Changing disturbance regimes, ecological memory, and forest resilience. Frontiers in Ecology and the Environment 14:369-378.

Kling, G. W., K. Hayhoe, L. B. Johnson, J. J. Magnuson, S. Polasky, S. K. Robinson, B. J. Shuter, M. M. Wander, D.J. Wuebbles, and D.R. Zak. 2003. Confronting climate change in the Great Lakes region: impacts on our communities and ecosystems. The Union of Concerned Scientists and The Ecological Society of America. Cambridge, MA and Washington, D.C. 92 pp.

Kunkel, K. E, L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S. D. Hilberg, M. S. Timlin, L. Stoecker, N.E. Westcott and J.G. Dobson. 2013. *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 3. Climate of the Midwest U.S.* NOAA Technical Report NESDIS 142-3, 95 pp.

Kunz, T. H. 1973. Resource utilization: Temporal and spatial components of bat activity in central Iowa. *Journal of Mammalogy* 54:14-32.

Kunz, T. H., and J. Reichard. 2010. Status review of the little brown myotis (*Myotis lucifugus*) and determination that immediate listing under the endangered species act is scientifically and legally warranted. Boston University's Center for Ecology and Conservation Biology.

Kurta, A. 1995. *Mammals of the Great Lakes Region.* University of Michigan Press, Ann Arbor, MI.

Kurta, A. 2005. Roosting ecology and behavior of Indiana bats (*Myotis sodalis*) in summer. *in* The Indiana Bat and Coal Mining: A Technical Interactive Forum. Office of Surface Mining, U.S. Department of the Interior.

Kurta, A. 2008. Bats of Michigan. Indiana State Center for North American Bat Research and Conservation, Publication 2.

Kurta, A. 2010. Reproductive timing, distribution, and sex ratios of tree bats in Lower Michigan. *Journal of Mammalogy* 91:586–592.

Kurta, A., J. Caryl, and T. Lipps. 1997. Bats and Tippy Dam: species composition, seasonal use, and environmental parameters. *Michigan Academician* XXIX:473-490.

Kurta, A., D. King, J. A. Teramino, J. M. Stribley, and K. J. Williams. 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. *American Midland Naturalist* 129:132-138.

Kurta, A., and S. W. Murray. 2002. Philopatry and migration of banded Indiana bats (*Myotis sodalis*) and effects of radio transmitters. *Journal of Mammalogy* 83:585-589.

Kurta, A., and H. Rice. 2002. Ecology and management of the Indiana bat in Michigan. *Michigan Academician* 34:175-190.

Kurta, A., and S. M. Smith. 2014. Hibernating bats and abandoned mines in the upper peninsula of Michigan. *Northeastern Naturalist* 21:597-605.

Kurta, A., and S. M. Smith. 2017. Exploration of Bat Hibernacula, Population Monitoring, and Surveillance for White-Nose Syndrome. An Annual Report to the Michigan Department of Natural Resources on Activities Performed in Winter 2016–2017. 22 pp. Kurta, A., and A. E. Tibbels. 2000. Preliminary investigation of the use of Anabat for identifying bats in the Manistee National Forest. U.S. Department of Agriculture, Forest Service, Manistee National Forest, Cadillac, Michigan. 26 pp.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*), Pages 102-117 *in* Conference Ecological, behavioral, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). 811.

Lacki, M. J., J. P. Hayes, and A. Kurta, eds. 2007. Bats in Forests: Conservation and Management. Johns Hopkins University Press. Baltimore, MD. 329 pp.

Langwig, K. E., W. F. Frick, J. T. Bried, A. C. Hicks, T. H. Kunz, and A. M. Kilpatrick. 2012. Sociality, density-dependence and microclimates determine the persistence of populations suffering from a novel fungal disease, white-nose syndrome. *Ecology Letters*.

Langwig, K. E., W. F. Frick, J. R. Hoyt, K. L. Parise, K. P. Drees, T. H. Kunz, J. T. Foster, and A. M. Kilpatrick. 2016. Drivers of variation in species impacts for a multi-host fungal disease of bats. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 371:1-9.

Lorch, J. M., L. K. Muller, R. E. Russell, M. O'Connor, D. L. Lindner, and D. S. Blehert. 2013. Distribution and environmental persistence of the causative agent of White-nose Syndrome, *Geomyces destructans*, in bat hibernacula of the eastern United States. *Applied and Environmental* Microbiology 79:1293-1301.

Lowe, A. J. 2012. Swarming behaviour and fall roost-use of little brown (*Myotis lucifugus*), and northern long-eared bats (*Myotis septentrionalis*) in Nova Scotia, Canada. Master's thesis. St. Mary's University, Halifax, Nova Scotia, Canada.

Lucas, M. D., R. M. Ross, and A. N. Swaby (eds.). 2014. *The Teacher-Friendly Guide to the Earth Science of the Midwestern US.* Paleontological Research Institution, Ithaca, New York..

Michigan Department of Health and Human Services. 2017. Michigan Emerging Disease Issues. Available: www.michigan.gov/emergingdiseases. Accessed: March 8, 2017.

Michigan Department of Natural Resources and Environment. 1995. [Full citation forthcoming].

Michigan Department of Natural Resources and Environment. 2010. White-nose Syndrome (WNS) response plan. Michigan Department of Natural Resources and Environment, Wildlife Division, Lansing, Michigan. 20 pp.

Minnesota Department of Natural Resources and Environment. 1994. [Full citation forthcoming].

Minnesota Department of Natural Resources and Environment. 2013. Fungus dangerous to bats detected at 2 Minnesota state parks. Available: http://news.dnr.state.mn.us/2013/08/09/fungus-dangerous-to-bats-detected-at-2-minnesota-state-parks/. Accessed: March 8, 2017.

Minnesota Department of Natural Resources and Environment. 2016. White-nose syndrome, a disease that can kill bats, confirmed in Minnesota. Available: http://news.dnr.state.mn.us/2016/03/09/white-nose-syndrome-a-disease-that-can-kill-bats-confirmed-in-minnesota/. Accessed: March 3, 2017.

Mitchell, M., and J. Kienholz. 1997. A climatological analysis of the Köppen Dfa/Dfb boundary in eastern North America, 1901-1990. *The Ohio Journal of Science* 97: 53-58.

Mundell, J., S. J. Taff, M. Kilgore and S. Snyder. 2007. *Assessing trends in forest parcelization and development in Minnesota: an Itasca County case study.* Staff Paper Series 192. College of Food, Agriculture and Natural Resources. University of Minnesota, St. Paul MN.

Murray, S. W., and A. Kurta. 2004. Nocturnal activity of the endangered Indiana bat (*Myotis sodalis*). *London Journal of Zoology* 262:197-206.

O'Connell, B. M., B. L. Conkling and A. L. Wilson. 2016. The Forest Inventory and Analysis database: Database description and user guide version 6.1.1 for Phase 2. U.S. Department of Agriculture, Forest Service, Washington, DC.

O'Shea, T. J., P. M. Cryan, E. A. Snider, E. W. Valdez, L. E. Ellison, and D. J. Neubaum. 2011. Bats of Mesa Verde National Park, Colorado: Composition, reproduction, and roosting habits. *Monographs of the Western North American Naturalist* 5:1-19.

Ojakangas, R. W., and C. L. Matsch. 1982. *Minnesota's Geology*. Minneapolis, MN: University of Minnesota Press.

Palik, B. J., and K. S. Pregitzer. 1992. The repeatability of stem exclusion during even-aged development of bigtooth aspen dominated forests. *Canadian Journal of Forest Research* 23: 1156-1168.

Pauli, B. 2014. Nocturnal and diurnal habitat of Indiana and Northern long-eared bats, and the simulated effect of timber harvest on habitat suitability. Doctoral Dissertation. Purdue University, West Lafayette, IN.

Perry, R. W., and R. E. Thill. 2007. Tree roosting by male and female eastern pipistrelles in a forested landscape. *Journal of Mammalogy* 88:974–981.

Rhemtulla, J. M., D. J. Mladenoff and M. K. Clayton. 2009. Legacies of historical land use on regional forest composition and structure in Wisconsin, USA (mid-1800s–1930s–2000s). Ecological Applications 19:1061-1078.

Rockey, C. D., J. P. Stumpf, and A. Kurta. 2013. Additional winter recoveries of Indiana bats (*Myotis sodalis*) banded during summer in Michigan. *Northeastern Naturalist* 20:N8-N13.

Rommé, R. C., A. B. Henry, R. A. King, T. Glueck, and K. Tyrell. 2002. Home range near hibernacula in spring and autumn. 2002, 4089.

Rouse, J. D., and R. J. Willson. 2002. COSEWIC assessment and update status report on the massasauga *Sistrurus catenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 23 pp.

Sheets, J. J., J. O. Whitaker Jr., V. Brack Jr., and D. W. Sparks. 2013. Bats of the hardwood ecosystem experiment before timber harvest: assessment and prognosis. Pages 191-202 *in* The Hardwood Ecosystem Experiment: a framework for studying responses to forest management (R. K. Swihart, M. R. Saunders, R. A. Kalb, G. S. Haulton, C. H. Michler, eds.). General Technical Report NRS-P-108. U.S. Department of Agriculture, Forest Service, Northern Research Station. Newtown Square, Pennsylvania.

Schneider, D. A., M. E. Bickford, W. F. Cannon, K. J. Schultz, and M. A. Hamilton. 2003. Age of volcanic rocks and syndepositional iron formations, Marquette Range Supergroup: implications for the tectonic Paleoproterozoic iron formations of the Lake Superior region. *Canadian Journal of Earth Sciences* 39(6): 999-1012.

Schulte, L. A., D. J. Mladenoff, T. R. Crow, L. C. Merrick, and D. T. Cleland. 2007. Homogenization of northern U,S, Great Lakes forests due to land use. *Landscape Ecology* 22:1089-1103.

Silvis, A., S. D. Gehrt, and R. A. Williams. 2016. Effects of shelterwood harvest and prescribed fire in upland Appalachian hardwood forests on bat activity. *Forest Ecology and Management* 360:205-212.

Slider, R. M., and A. Kurta. 2011. Surge tunnels in quarries as potential hibernacula for bats. Notes of the Northeastern Naturalist 18:378-381.

Snetsinger, S., and S. Ventura. 2000. Land cover change in the Great Lakes region from mid-nineteenth century to present. U.S. Department of Agriculture, North Central Forest Research Station, St. Paul MN.

Snider, E. A., P. M. Cryan, and K. R. Wilson. 2013. Roost selection by western long-eared myotis (*Myotis* evotis) in burned and unburned pinon–juniper woodlands of southwestern Colorado. *Journal of Mammalogy* 94:640-649.

Sparks, D. W., J. O. Whitaker, Jr., and C. M. Ritzi. 2004. Foraging ecology of the endangered Indiana bat., *in* Conference Foraging ecology of the endangered Indiana bat., 1771.

Stearns F., and G. E. Likens. 2002. One hundred years of recovery of a pine forest in northern Wisconsin. *The American Midland Naturalist* 148:2-19.

Stephenson, D. A., A. H. Fleming and D. M. Mickelson. 1988. Glacial deposits, Ch. 35. In pp. 301-314 *The Geology of North America, Vol 0-2, Hydrogeology*, W. Back and J.S. Rosenshein (eds.). Geological Society of America, Boulder CO.

Swingen, M., R. Baker, T. Catton, K. Kirschbaum, G. E. Nordquist, B. Dirks, and R. Moen. 2016. Summary of 2016 northern long-eared bat research in Minnesota. University of Minnesota, Natural Resources Research Institute, Duluth, Minnesota. NRRI Technical Report No. NRRI/TR-2016-41. 17 pp.

Tinsley, K. 2016. Status review for the eastern subspecies of the little brown bat (*Myotis lucifugus lucifugus*). Prepared for U.S. Department of Interior, U.S. Fish and Wildlife Service, Region 3, Bloomington, Minnesota. 150 pp

Trewartha G. T., and L. H. Horn. 1980. *An Introduction to Climate*. New York, NY: McGraw-Hill.

US. Department of Agriculture Soil Survey Staff. 2015. Illustrated guide to soil taxonomy. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.U.S. Environmental Protection Agency. 2013. Level III ecoregions of the continental United States. U.S. EPA, National Health and Environmental Effects Research Laboratory, Corvallis, OR. https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states.

U.S. Fish and Wildlife Service. 2007. Indiana bat (*Myotis sodalis*) draft recovery plan: first revision. U.S. Department of the Interior, Fish and Wildlife Service. Ft. Snelling, MN. 258 pp.

U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the eastern small- footed bat and the northern long- eared bat as endangered or threatened species; listing the northern long-eared bat as an endangered species. U. S. Department of Interior, Fish and Wildlife Service, *in Federal Register*, Volume 78, No. 191, Wednesday, October 2, 2013.

U.S. Fish and Wildlife Service. 2014. Northern long-eared bat interim conference and planning guidance: USFWS Regions 2, 3, 4, 5, & 6. U.S. Department of Interior, Fish and Wildlife Service. 67 pp.

U.S. Fish and Wildlife Service. 2015. 2015 population estimates for the Indiana bat (*Myotis sodalis*) by USFWS region. U.S. Department of Interior. Fish and Wildlife Service. 8 pp.

U.S. Fish and Wildlife Service. 2015. 2015 Rangewide population estimate for the Indiana bat (*Myotis sodalis*) by USFWS region. U.S. Department of Interior, Fish and Wildlife Service, Ecological Services Field Office, Bloomington, Indiana.

Veilleux, J. P., J. O. Whitaker, Jr, and S. L. Veilleux. 2003. Tree-roosting ecology of reproductive female eastern Pipistrelles, *Pipistrellus subflavus*, in Indiana. *Journal of Mammalogy* 84:1068-1075.

Whitaker, J. O., Jr. 1998. Life history and roost switching in six summer colonies of eastern pipistrelles in buildings. *Journal of Mammalogy* 79:651-659.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack, Jr. 2004. Bats of the Indianapolis International airport area, 1991–2001. *Proceedings of the Indiana Academy of Science* 113:151-161.

Whitaker, J. O., Jr., D. W. Sparks, and V. Brack, Jr. 2006. Use of artificial roost structures by bats at the Indianapolis International Airport. Environmental Management 38:28-36.

White-Nose Syndrome.org. 2017. A Coordinated Response to the Devastating Bat Disease. Available: www.whitenosesyndrome.org. Accessed: April 7, 2017.

Wickham, J. D., S. V. Stehman, L. Gass, J. Dewitz, J. A. Fry and T. G. Wade. 2013. Accuracy assessment of NLCD 2006 land cover and impervious surface. Remote Sensing of Environment 130:294-304. Wiken, E., F. Jiménez Nava, and G. Griffith. 2011. North American Terrestrial Ecoregions-Level III. Commission for Environmental Cooperation, Montreal, Canada. 149 pp.

Winhold, L. 2007. Community ecology of bats in southern Lower Michigan, with emphasis on roost selection by Myotis. Master's thesis, Eastern Michigan University, Ypsilanti, Michigan.

Winhold, L., and A. Kurta. 2006. Aspects of migration by the endangered Indiana bat, *Myotis sodalis*. *Bat Research News* 47:1-6.

Winhold, L., A. Kurta, and G. W. Foster. 2008. Long-term change in an assemblage of North American bats: are eastern red bats declining? *Acta Chiropterologica* 10:359–366.

Wisconsin Department of Natural Resources. 2011. Draft White Nose Syndrome (WNS) surveillance and response implementation strategy. Bureau of Endangered Resources, Bureau of Wildlife Management, Madison, WI. 71 pp.

Wisconsin Department of Natural Resources. 2013. Eastern pipistrelle (*Perimyotis subflavus*) species guidance. Bureau of Natural Heritage Conservation. Madison, WI. 10 pp.

WDNR. 2016. Locations of industrial sand mines and processing plants in Wisconsin. *in*, Wisconsin Department of Natural Resources, Madison, Wisconsin. Available: http://dnr.wi.gov/topic/mines/ismmap.html. Accessed: 10 July 2017.

Wisconsin Department of Natural Resources. 2015. White-nose syndrome spreading in Wisconsin bats. Bureau of Endangered Resources. Bureau of Wildlife Management. Madison, WI. 3 pp.

Zukal, J., H. Bandouchova, T. Bartonicka, H. Berkova, V. Brack, J. Brichta, M. Dolinay, K. S. Jaron, V. Kovacova, M. Kovarik, N. Martı´nkova, K. Ondracek, Z. Rehak, G. G. Turner, and J. Pikula. 2014. White-Nose Syndrome fungus: a generalist pathogen of hibernating bats. *PLoS ONE* 9:1-10.

3.7.2 Personal Communications

Kurta, A. Professor of Biology, Eastern Michigan University. February 24, 2017. Email with D. W. Sparks. ESI regarding estimating bat populations in the Lake States.

White, J. P. Wildlife Biologist, Wisconsin Department of Natural Resources. March 15, 2017. Email with D. W. Sparks. ESI regarding estimating bat populations in the Lake States.

Kurta, A. 2008. Bats of Michigan. Indiana State Center for North American Bat Research and Conservation, Publication 2.

Kurta, A., and S. M. Smith. 2014. Hibernating bats and abandoned mines in the upper peninsula of Michigan. *Northeasten Naturalist* 21:597-605.

Slider, R. M., and A. Kurta. 2011. Surge tunnels in quarries as potential hibernacula for bats. Notes of the *Northeastern Naturalist* 18:378-381.

Tinsley, K. 2016. Status review for the eastern subspecies of the little brown bat (Myotis lucifugus lucifugus). Prepared for U.S. Department of Interior, U.S. Fish and Wildlife Service, Region 3, Bloomington, Minnesota. 150 pp.

USFWS. 2011. Questions and answers pertaining to effects analyses for Indiana bats and wind energy projects (revised: 22 August 2011). U.S. Department of Interior, Fish and Wildlife Service.

USFWS. 2015. 2015 Rangewide population estimate for the Indiana bat (Myotis sodalis) by USFWS region. U.S. Department of Interior, Fish and Wildlife Service, Ecological Services Field Office, Bloomington, Indiana.

WDNR. 2016. Locations of industrial sand mines and processing plants in Wisconsin. Available: http://dnr.wi.gov/topic/mines/ismmap.html. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Wickham, J., S. V. Stehman, L. Gass, J. A. Dewitz, D. G. Sorenson, B. J. Granneman, R. V. Poss, and L. A. Baer. 2017. Thematic accuracy assessment of the 2011 National Land Cover Database (NLCD). Remote Sensing of Environment 191:328-341.