Northern Long-Eared Bat (*Myotis septentrionalis*) Species Guidance

Family: Vespertilionidae- the evening bats

State Status: Threatened

State Rank: S1S3

Federal Status: Threatened

Global Rank: G1G2

Wildlife Action Plan Area of Importance Score: 3

Range of the northern long-eared bat in Wisconsin. Source: WI Bat Program 2012

Dave Redell, Wisconsin DNR

Species Information

General Description: The northern long-eared bat, also referred to as the northern bat, is a medium-sized member of the genus *Myotis.* Adults weigh five to nine grams (0.2-0.3 oz). Individual weights vary seasonally and are lowest in the spring as bats emerge from hibernation (WI Bat Program 2010). Total length is 77-92 mm (3.0-3.63 in), adult forearm length is 34-38 mm (1.3-1.5 in), and females are generally larger than males (Kurta 1995). Wingspan is 23-26 cm (9.1-10.2 in; Barbour and Davis 1969). Fur color is light to dark brown. The northern long-eared bat is classified as a cave bat because it uses caves and mines for hibernation.

Similar Species: Three bat species in Wisconsin- the northern long-eared bat, the little brown bat (*Myotis lucifugus*) and the Indiana (*Myotis sodalis*) bat – are best distinguished by close (in-hand) inspection. The northern long-eared bat is most often confused with the little brown bat. The northern long-eared bat has longer ears than the little brown bat, and when folded alongside the head, the tips of the ears should extend 3 mm or more past the tip of the nose. Little brown bat ear length in Wisconsin, however, can be highly variable, and tragus shape and length in relation to the rest of the ear are the two best features to use to distinguish these two species (Fig. 1). The tragus of the northern long-eared bat is more pointed and spear-like than that of the little brown bat. The little brown bat also has a glossier appearance than the northern long-eared. The northern long-eared bat may also be confused with the Indiana bat, but the two can be distinguished much the same way as the little brown bat from the northern long-eared bat. The Indiana bat's keeled calcar, a spur of cartilage extended from the ankle and supporting the interfemoral membrane, is a distinguishing feature that the northern long-eared bat lacks. The northern long-eared bat can be identified by the echolocation call (Fig. 2), however both other *Myotis* species share similar call characteristics, and only trained individuals should positively identify the species through echolocation calls.

Figure 1. The asymmetrical tragus of the little brown bat (left), and the symmetrical, spear-like tragus of the northern long-eared bat (right). Dave Redell, Wisconsin DNR

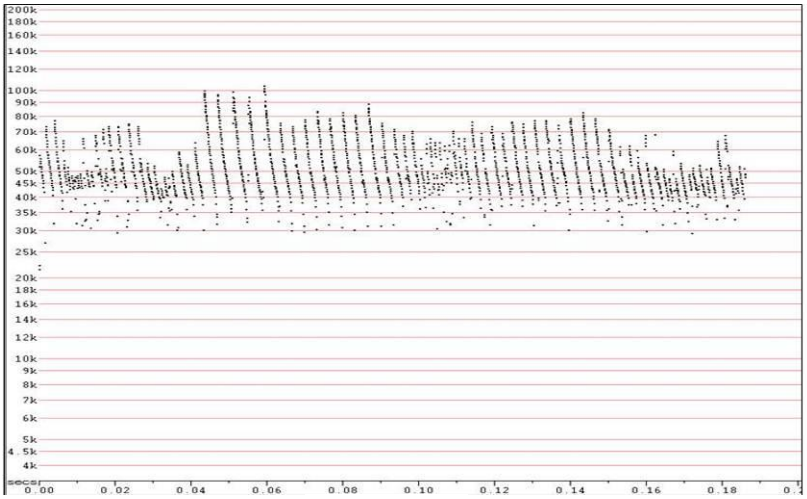


Figure 2. Echolocation call: Northern long-eared bats produce high-frequency calls of a shorter duration, broader bandwidth and lower intensity than other *Myotis* species. The call frequency ranges between 126 and 40 kHz (Caceres and Barclay 2000). The northern long-eared bat sonogram may appear similar to the little brown bat and the Indiana bat.

Associated Species: Northern long-eared bat predators include owls, hawks, occasionally snakes, and raccoons (*Procyon lotor*). As many as 13 feral cats have also been observed congregating at a mine entrance at dusk to prey upon bats as they leave the hibernaculum (D. Redell pers. obs.). Northern long-eared bats often share hibernacula with other bat species such as the tricolored bat (*Perimyotis subflavus*), the little brown bat, the big brown bat (*Eptesicus fuscus*) and the Indiana bat, but the northern bat rarely, if ever, forms hibernating clusters with other species. Northern long-eared bats forage with other bat species, but there is no evidence of direct competition between species.

State Distribution and Abundance: Northern long-eared bats are found throughout the state of Wisconsin (but see "Threats" section below), but they are never abundant (Jackson 1961, WDNR 2013).

Global Distribution and Abundance: Northern long-eared bats are widely distributed in the eastern United States and Canada, with the exception of the very southeastern United States and Texas (see Fig. 3, BCI 2012).

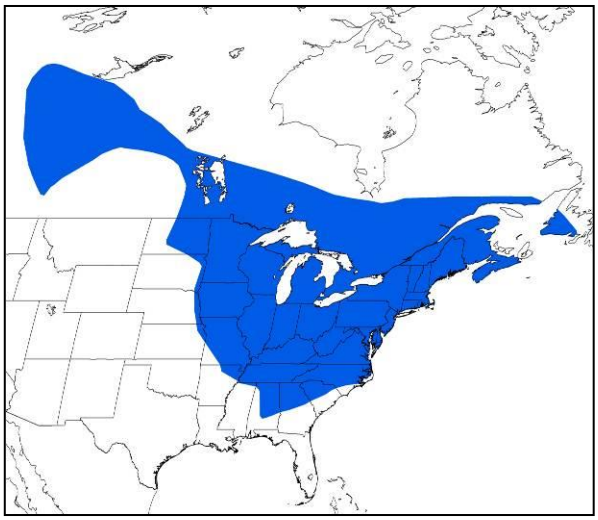
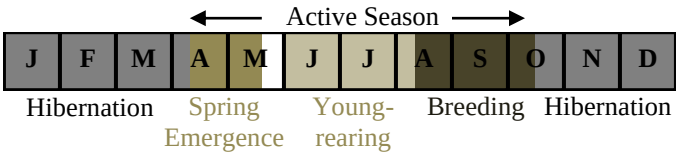


Figure 3. Global distribution of *Myotis septentrionalis*. (BCI 2012)

Diet: The northern long-eared bat is insectivorous and uses echolocation to locate and capture prey. Northern long-eared bat prey includes moths (*Lepidoptera*), flies (*Diptera*) and beetles (*Coleoptera*). This species is commonly referred to as a gleaning bat because it often catches insects that are at rest on leaves or twigs, in addition to catching insects that are flying (Lee and McCracken 2004).

Reproductive Cycle: The reproductive cycle for the northern long-eared bat begins when breeding occurs in the fall and sometimes into winter hibernation. Sperm is stored in the uterus of the female until April or May when the females emerge from hibernation and fertilization occurs. Females form small maternity colonies of up to 30 bats in late spring and females give birth to a single pup in June or early July (Caceres and Barclay 2000, Owen et. al. 2002). Pups are born hairless and flightless. The pup nurses for about a month and is left at the roost nightly while the mother goes out to feed. The pup begins to fly and explore on its own at four to six weeks. Maternity colonies disperse shortly after young are volant (able to fly) and bats move closer to hibernacula in the fall and mate before they hibernate. Young of the year do not usually mate, but some juvenile males appear reproductively active (WI Bat Program 2009, 2010). More research is needed to determine breeding and reproductive behavior of the northern long-eared bat.



Ecology: Female and male northern long-eared bats emerge from hibernation in April and May. In summer, the northern long-eared bat roosts alone, or females may form a colony with some other females. The northern long-eared bat chooses day roosts in tall trees and snags. Night roosts for this species include caves and rock shelters where they will rest between feeding bouts (Caceres and Barclay 2000). Roost fidelity is low in this species, and individual bats switch roosts about every two days in the summer (Foster and Kurta 1999, WDNR 2015). This species is a relatively long lived mammal for its size, and usually lives up to 8-10 years. Banding records indicated a northern long-eared bat caught in the wild lived up to 18 years (Caceres and Barclay 2000). In the fall, northern long-eared bats will make short migrations from summer habitat to winter hibernacula (caves and abandoned mines), and will often return to the same hibernaculum but not always in sequential seasons (Caceres and Barclay 2000). This species hibernates with other species such as the little brown bat and tri-colored bat, but often in different parts of the hibernaculum. The northern long-eared bat hibernates deep in crevices, rather than clustering on exposed surfaces like other cave bats, which makes it difficult to survey and monitor for this species during the winter (Caceres and Barclay 2000). More research is needed on northern long-eared bats' basic life history and behavior.

Natural Community Associations: (WDNR 2005 and WDNR 2009)

Many bat species are associated more with structural features within natural communities than with any particular natural community or group of natural communities (see "Habitat" section).

Significant: coldwater streams, coolwater streams, ephemeral pond
Moderate: alder thicket, bog relict, boreal rich fen, calcareous fen (southern), central sands pine – oak forest, coastal plain marsh, emergent aquatic, floodplain forest, hemlock relict, inland lakes, northern dry forest, northern dry-mesic forest, northern hardwood

swamp, northern mesic forest, northern sedge meadow, oak barrens, oak woodland, open bog, shrub carr, southern dry forest, southern dry-mesic forest, southern hardwood swamp, southern mesic forest, southern sedge meadow, submergent aquatic, submergent aquatic-oligotrophic marsh, warmwater rivers, warmwater streams, white pine – red maple swamp
Minimal: none

Habitat: Northern long-eared bat habitat use changes over the course of the year, and varies based on sex and reproductive status. Reproductive females often use different summer habitat from males and non-reproductive females.

Summer: Northern long-eared bats commonly roost in trees but have been known to roost in man-made structures. This species often roosts under bark close to the tree trunk, or in crevices of tree species such as maples, oaks and ashes (Foster and Kurta 1999, WDNR 2015). Northern long-eared bats prefer to roost in tall trees with a dynamic forest structure including old growth and some young trees (Foster and Kurta 1999). Females form small maternity colonies which are commonly located in trees, but also occur under shingles, and in man-made structures like bat houses and buildings. Northern long-eared bats commonly forage within the forest and below the canopy mainly in upland forests on hillsides and ridges (Owen et al. 2003), but have also been noted to forage along paths, ponds and streams, and at forest edges. Foster and Kurta (1999) found all roost trees to be close to wetlands. More information is needed to more fully describe northern long-eared bat foraging habitats in Wisconsin.

Home range: Owen et al. (2003) found that in West Virginia northern long-eared bats use approximately 150 acres for their home range in summer and similarly Yates et al. (2014) found northern long-eared bats using approximately 250 acres for their home range. Home ranges can also change based on reproductive status, As with other *Myotis* species, Lacki et al (2009) found that female northern long-eared bats had a larger home range when pregnant (289 acres) compared to lactating females (45.9 acres). More information is needed to accurately describe northern long-eared bat home range and habitat in Wisconsin.

Winter: The northern long-eared bat hibernates in caves and abandoned mines in winter and tends to be found in deep crevices (Kurta 1994, Caceres and Barclay 2000). More research is needed to determine what characteristics make suitable caves and mines for northern long-eared bat hibernation.

Northern long-eared bat hibernacula in southwestern Wisconsin: Passage of a mine in Grant County that houses northern bats (left), and solitary northern long-eared bat in a crevice in Pierce County (right). Heather Kaarakka, Wisconsin DNR

Edge habitat (transition zone between two types of vegetation) is important for northern long-eared bats as they migrate and forage. When bats migrate from wintering caves to summer habitat or commute from roosts to feeding grounds, they move through the landscape in a manner that protects them from wind and predators. Instead of flying the shortest distance across a field, for instance, bats will take longer routes that follow edge habitat. In addition to offering protection, this behavior may also allow bats more feeding opportunities because food is more abundant around edge habitat (Limpens and Kapteyn 1991). Commuting along edge habitat may assist the bats with navigation and orientation through use of linear edges as landmarks (Verboom and Huitema 1997).

Threats: Lack of information on bat species' basic ecology is one of the greatest threats to bat conservation in Wisconsin. The northern long-eared bat faces two emerging threats, and several ongoing threats. White-nose syndrome (WNS) was discovered in 2006 in a hibernaculum in New York State, and appears as a white, powdery substance on the bat's face, tail and wings. White-nose syndrome has spread rapidly since 2007 to other hibernacula in neighboring states (USFWS 2012). Infected little brown bat and northern bat hibernacula in New York and surrounding states have experienced mortality rates of over 90%. White-nose syndrome has been called the "most precipitous wildlife decline in the past century in North America" (BCI 2009), and is caused by a fungus called *Pseudogymnoascus destructans* (Lorch et al. 2011, Minnis and Lindner 2013). This fungus grows best in the cool, wet conditions of

hibernacula (Verant et al. 2012). Mortality from the fungus appears to come from increased arousals during torpor, which deplete bats' fat reserves and cause starvation (Reeder et al. 2012) and dehydration (Cryan et al. 2010). For up-to-date WNS information, see the USFWS WNS website and the USGS National Wildlife Health Center website (see *Additional Information).* As of March, 2015, WNS has been confirmed in five counties in Wisconsin, and the fungus has been discovered in an additional three counties. Cave-hibernating bats, including the northern long-eared bat, should be monitored closely for any indication of WNS; the Wisconsin Bat Program conducts WNS surveillance and monitoring in the state.

Wind power is another emerging threat to bats – wind turbines have been shown to fatally impact all bat species in Wisconsin (Johnson 2003, Arnett et al. 2008). Wind-turbine blades cause mortality through direct impact or through the pressure differential caused by the motion of the spinning blades. This pressure differential causes a bat's lungs to fill with fluid as it flies near the spinning blades, and this phenomenon (known as barotrauma) kills the bat instantly (Baerwald et. al. 2008). More research is under way to better understand bat wind-turbine vulnerabilities, but current studies suggest that bats face the greatest risk during migration from summer foraging sites to wintering grounds (tree bats) or hibernacula (cave bats) (Johnson 2003, Kunz et al. 2007). Research is needed on all Wisconsin bat species to better understand wind-turbine mortality in the state and the long term population impacts of turbine-related deaths.

Northern long-eared bats also face the ongoing threat of habitat degradation. Habitat degradation is caused by increased agricultural, industrial, and household pesticide use, and it has negative effects on bats through direct exposure and through dietary accumulation (O'Shea et al. 2001). Pesticides are a threat to many taxa, but bats may be more vulnerable than other small mammals due to certain life characteristics (Shore et al. 1996, O'Shea et al. 2001). Bats' longevity and high trophic level means pesticides can concentrate in their body fat (Clark and Prouty 1977, Clark 1988). Even after pesticide exposure ceases, residues can be passed on to nursing young (Clark 1988). Bat species that migrate long distances may be more affected because pesticide residues become increasingly concentrated in the brain tissue as fat reserves are depleted during long-distance flights. This concentration can lead to convulsions and even death (Geluso et al. 1976, Clark 1978).

Northern long-eared bats also face the ongoing threat of hibernaculum disturbance from humans entering hibernacula in winter and waking bats from torpor. Bats in torpor reduce their metabolism and body temperature to low levels that require less energy than being fully awake. Interrupting torpor costs energy; a little brown bat uses up to 100 mg of fat reserves waking and the returning to torpor (and more if the bat starts flying), or the energetic equivalent of up to 67 days of torpor (Thomas et al. 1990, Thomas 1992). This loss clearly represents a large percentage of total body weight of the bat, and repeated arousals may cause bats to run out of energy reserves before spring arrives and therefore starve in the hibernaculum or die from exposure if they seek food outside (Thomas 1995).

Climate Change Impacts: The effects of climate change on the northern long-eared bat are unclear. Predictions suggest a northward expansion in the ranges of all cave-bat species, in pursuit of optimal hibernation (Humphries et al. 2002, USFWS 2007). This prediction assumes an abundance of suitable caves and other hibernaculum structures further north, but this assumption may not hold for karst-free regions at higher latitudes. Bat species may adapt by reducing torpor depth and duration during winter if prey insect species are available for more of the year (Weller et al. 2009), but bats' adaptive capacities in this regard may be limited and are not well known. Shifts in prey insect emergence may also cause mismatches with bat emergence and cause food shortages in the spring or fall.

Survey Guidelines: Persons handling northern long-eared bats must possess a valid Federal Endangered Species Permit and State Endangered and Threatened Species Permit. If surveys are being conducted for regulatory purposes, survey protocols and surveyor qualifications must first be approved by the Endangered Resources Review Program (see *Contact Information*).

Acoustic surveys, which should be done by trained individuals, are performed for all Wisconsin bat species in spring, summer, and fall; and are used to determine presence/absence, phenology, and distribution around the state. The Wisconsin Bat Program's eventual goal is to use acoustic survey data to determine bat population trends in Wisconsin. Northern long-eared bats are ubiquitous around the state, and therefore surveys can be done wherever appropriate habitat exists. Acoustic recording systems that detect echolocation calls can survey bats as they fly through an area. The bat detection system detects and records these acoustic signals as bats fly by, and records the date and time of each encounter. The Wisconsin Bat Program currently uses broadband frequency division ultrasound detection equipment with a PDA (Personal Data Assistant) and a Global Positioning System. Start acoustic surveys half an hour after sunset, but only if the daytime temperature exceeds 50° F, and conduct the survey for at least one hour. There are three seasons for acoustic surveys: spring (April and May), summer (June and July), and fall (August and September). Acoustic surveys record bat passes, which can then be identified to species by trained individuals. These surveys could be used by land managers to create inventories of species distribution and relative abundance. Visit the Wisconsin bat monitoring website for additional information.

Wisconsin DNR also conducts a roost monitoring program to determine abundance of bats roosting in buildings and bat houses. People with bat houses or other roost sites identify species and count bats over the summer at night as bats leave the roost. People who find a bat roost while doing field surveys should contact the Wisconsin Bat Program to report the information. Summarize results, including survey dates, times, weather conditions, number of detections, detection locations, and behavioral data and submit via the WDNR online report: <http://dnr.wi.gov, keyword "rare animal field report form">

Management Guidelines

The following guidelines typically describe actions that will help maintain or enhance habitat for the species. These actions are not mandatory unless required by a permit, authorization or approval.

Summer Management

Roost availability is thought to limit northern long-eared bat populations, as it does for many bat species, and thus habitat management is important for the continued survival of this species (Duchamp et al. 2007). Northern long-eared bats are forest dwelling bats, and forest management to promote occupation by this species should increase roosting and foraging habitat (see Habitat section above). Northern long-eared bats have been shown to use both live and dead trees for roosting sites (Foster and Kurta 1999, WDNR 2015). These bats often roost under exfoliating bark, and therefore snags and dying trees may be important for encouraging northern long-eared bats. Forest managers are encouraged to promote mixed-species, mixed-aged plots as the northern long-eared bat chooses trees based on suitability of crevices and bark as roosts, rather than on tree species (Foster and Kurta 1999). The northern long-eared bat is known to switch roost trees frequently (about every 2 days) over the course of the summer, and therefore this species needs a large number of trees (Foster and Kurta 1999, WDNR 2015). As with many bat species, suitable forested habitat for northern long-eared bats is a multi-species matrix that contains some open areas (Owen et al. 2003).

Linear corridors are important for migrating and commuting bats, and forests may be managed such that suitable foraging habitat is connected by corridors; this may include managing edge habitat along roads, logging trails and riparian habitat. Land managers should also make an effort to reduce or eliminate burdock (*Arctium minus*), an exotic weed that produces seeds that trap bats and cause death from exposure.

Special consideration should be given to protecting snags or dying trees, especially those near known roost locations, particularly from June 1 through August 15 while bats may have flightless pups at the roost.

Seasonal pools in woodlands may be important foraging and water sources for the northern long-eared bat and other Wisconsin bat species because they provide areas for feeding and drinking in an otherwise closed-canopy forest (Francl 2008). Pool size and depth do not appear to determine usage by northern long-eared bats; instead the presence of an opening in the forest is enough to encourage foraging and drinking (Francl 2008).

Fall Management

During fall swarm, large proportions of Wisconsin's cave bat population gather near entrances of the state's hibernacula (see "Habitat" section), and become concentrated and vulnerable to direct impacts. To avoid disturbance during crucial life history events, management activities such as logging and use of heavy machinery within 0.25 miles of hibernacula entrances must not take place because bats may use the surrounding area for roosting.

Winter Management

Little is known about how northern long-eared bats choose hibernation sites, but suitable Wisconsin hibernacula typically have steady temperatures between 4° C and 12° C (39-53° F), high humidity, and no human disturbance. Artificial sites that can mimic this environment may provide suitable hibernacula. Artificial hibernacula include bunkers, food storage-caves and basements. Contact the Wisconsin Bat Program to inquire about developing artificial hibernacula.

Natural hibernacula can also be managed to encourage bat use. For example, closing but not sealing the entrance to an abandoned mine not only buffers temperature and humidity, but also reduces disturbance from humans and predators. Eliminating disturbance from humans, except for WNS surveillance, is the best management activity for natural cave hibernacula. Contact the Wisconsin Bat Program for more information about managing bat hibernacula.

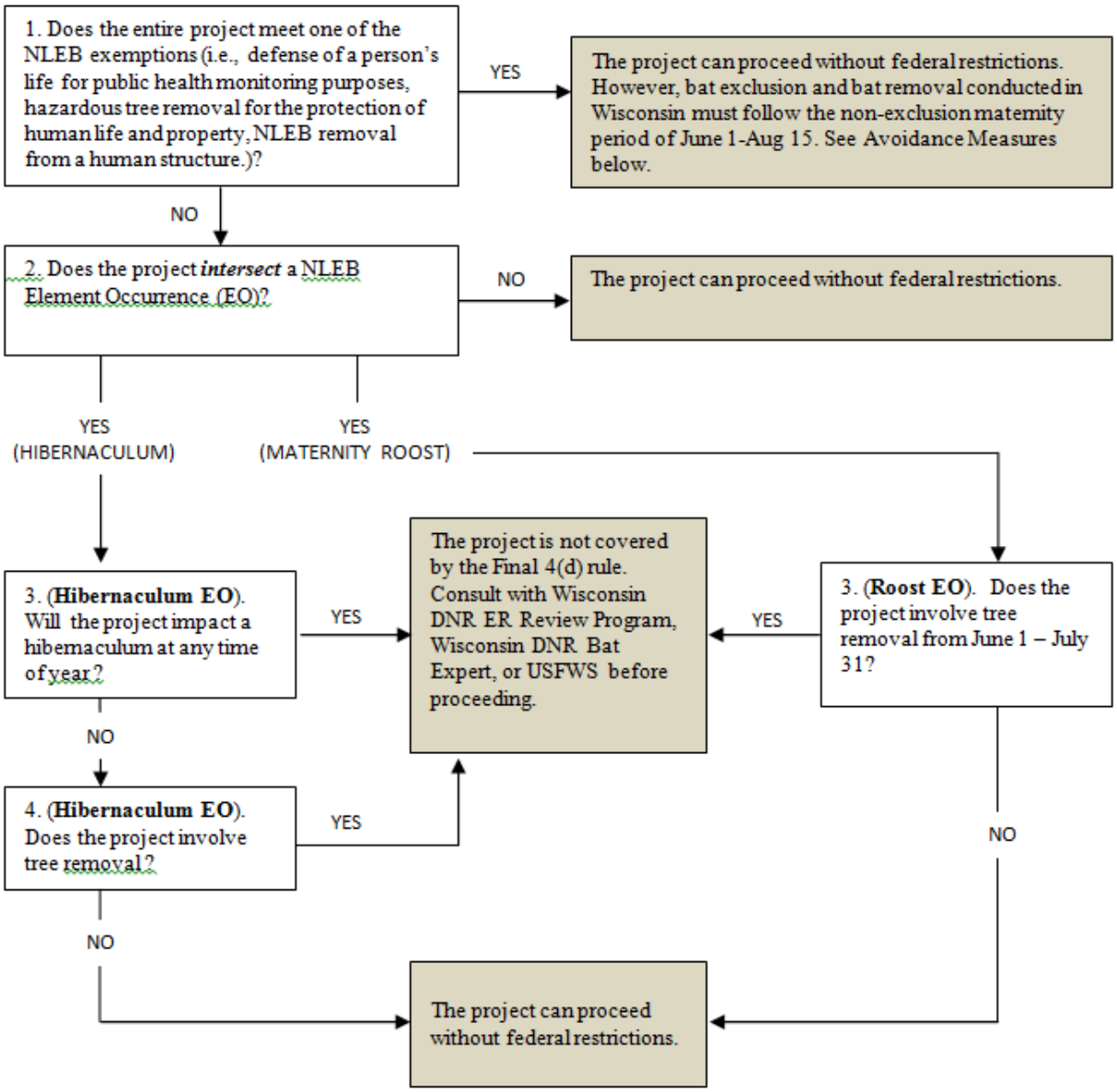
Northern long-eared bats – and their populations as a whole – are particularly vulnerable during winter hibernation because they are concentrated in just a few major hibernacula and because repeated disturbance during hibernation can lead to mortality (see "Threats" section above). Each time a bat is aroused from torpor, it uses up a substantial proportion of the fat reserves it relies on to hibernate through the winter and faces greater odds of starvation before spring (see "Threats" section above). Therefore, avoid entering hibernacula from October 1 through May 15 unless conducting approved and permitted management, surveillance, or research.

Screening Procedures

The following procedures must be followed by DNR staff reviewing proposed projects for potential impacts to the species.

These are the procedures in their simplest form which is sufficient for many activities such as tree cutting. If your project is funded all or in part by the federal government and/or occurs on federal lands, please work with the responsible federal agency for next steps, rather than the flowchart. The USFWS has developed a biological determination that federal agencies can use. For more information, see the USFWS' northern long-eared bat page: www.fws.gov/Midwest/endangered/mammals/nleb/index.html. Additional state restrictions can apply in some cases – see *Avoidance Measures* below.

Those seeking to complete wind farm projects should review and follow the Guidance for Minimizing Impacts to Natural Resources from Terrestrial Commercial Wind Energy Development created by the WDNR.



Avoidance Measures

The following measures are specific actions required by DNR to avoid take (mortality) of state threatened or endangered species per Wisconsin's Endangered Species law (s. 29.604, Wis. Stats.) These guidelines are typically not mandatory for non-listed species (e.g., special concern species) unless required by a permit, authorization or approval.

According to Wisconsin's Endangered Species Law (s. 29.604, Wis. Stats.), it is illegal to take, transport, possess, process, or sell any wild animal on the Wisconsin Endangered and Threatened Species List (ch. NR 27, Wis. Admin. Code). Take of an animal is defined as shooting, shooting at, pursuing, hunting, catching or killing. Northern long-eared bat is also protected by the federal Endangered Species Act which prohibits take of this species at the federal level (See screening procedures above).

If *Screening Procedures* above indicate that avoidance measures are required for a project, follow the measures below. If you have not yet read through *Screening Procedures*, please review them first to determine if avoidance measures are necessary for the project.

1. The simplest and preferred method to avoid take of northern long-eared bats is to avoid directly impacting individuals, known northern long-eared bat locations, or areas of suitable habitat (described above in the "Habitat" section and in *Screening Procedures*). The U.S. Fish and Wildlife Services identifies humans and their equipment as a possible vectors for spores of *Psuedogymnoascus destructans* – the fungus that causes white-nose syndrome (WNS) – and therefore simply entering hibernacula at any time of year and moving between them poses threats to bats. Cavers and researchers must observe all cave and mine closures and decontamination protocols (s. NR 40.07, Wis. Admin. Code; see *Additional Information*). In addition, it is illegal to use pesticides and poisons when attempting to evict bats from house roosts (s. 94.708, Wis. Stats.).
2. Tree removal may not take place within 0.25 miles of a known NLEB hibernaculum, and may not take place within150 feet of a known roost tree from June 1 through July 31.

2. If suitable habitat cannot be avoided, follow these time-of-year restrictions to avoid take:

Summer Avoidance **(June 1-Aug 15)**

Reproductive females and their young are highly vulnerable to mass mortality during the species' maternity period (June 1 – August 15) because they may aggregate in maternity colonies, and because pups cannot fly and therefore cannot leave the roost for several weeks after birth. Maternity colonies may occur in human structures, and those seeking to exclude bats from a building or other roost must follow the Cave Bat Broad Incidental Take Permit and Authorization (see *Additional Information*). As well, impacts to known maternity roost trees and tree removal within 150 feet of known maternity roost trees should be avoided during the summer maternity period (June 1- July 31 per federal guidance; however, we recommend Aug 15 in Wisconsin , where possible.).

3. If impacts cannot be avoided during restoration or management activities, including wind projects and forestry management, but activities are covered under the Cave Bat Broad Incidental Take Permit and Authorization; the project is covered for any unintentional take that may occur. For information about natural roost avoidance, see *Management Guidelines* and "Habitat" section above.

4. If northern long-eared bat impacts cannot be avoided, please contact the Natural Heritage Conservation Incidental Take Coordinator (see *Contact Information*) to discuss possible project-specific avoidance measures. If take cannot be avoided, an Incidental Take Permit or Authorization (see *Additional Information*) and Federal Incidental Take Permit are necessary.

Additional Information

References

Arnett, E. B., W. K. Brown, W.P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. G. O'Connell, M. D. Piorkowski, R. D. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal Wildlife Management 72: 61-78.

Baerwald, E.F., G. H. D'Amours, B. J. Klug, R. M. Barclay. 2008. Barotrauma is a Significant Cause of Bat Fatalities at Wind Turbines. Current Biology 18(16).

Barbour, R.W, and W.H. Davis. 1969 Bats of America. The University Press of Kentucky.Lexinton, KY.

Bat Conservation International [BCI]. 2001. Bats in Eastern Woodlands.

Bat Conservation International [BCI]. 2009. "White Nose Syndrome." <http://batcon.org/index.php/what-we-do/white-nose-syndrome.html> (accessed Dec 2009).

Bat Conservation International [BCI]. . "Bat Species Profiles: Myotis septentrionalis." Bat Conservation International, 2012. <http://batcon.org/index.php/all-about-bats/species-profiles.html> (accessed Sept 2012).

Boyles J.G., P.M. Cryan, G.F. McCracken, T.H. Kunz. 2011. Economic importance of bats in agriculture. Science 332:41-42.

Caceres, M. C., R. M. Barclay. 2000. *Myotis septentrionalis.* Mammalian Species 634: 1-4

Clark, D. R. Jr. 1988. Environmental contaminants and the management of bat populations in the United States. Pp. 409-413 in R. C. Szaro, K. S. Severson, and D. R. Patton (eds.), Proceedings of the Symposium on Management of Amphibians and Reptiles and Small Mammals of North America, Flagstaff, AZ. USDA Forest Service, General Technical Report RM-166.

Clark, D. R. Jr., R. K. LaVal, and D. M. Swineford. 1978. Dieldrin-induced mortality in an endangered species, the Gray bat (*Myotis grisescens*). Science 199:1357-1359.

Clark, D. R. Jr. and R. M. Prouty. 1977. Experimental feeding of DDE and PCB to female big brown bats (*Eptesicus fuscus*). Journal of Toxicology and Environmental health 2:917-928.

Cryan, P.M., C.U. Meteyer, J.G. Boyles and D.S Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135-142.

Duchamp, J.E., E.B. Arnett, M.A. Larson, R.K. Swihart. 2007. Ecological considerations for landscape-level management of bats. Pp 237-361 in M.J. Lacki, J.P. Hayes, A. Kurta (eds), Bats in Forests: Conservation and management. John Hopkins University press. Baltimore, MD.

Francl, K. E. 2008. Summer bat activity at woodland seasonal pools in the northern Great Lakes region. Wetlands. 28: 117-124.

Foster, R. W., 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.

Geluso, K. N., J. S. Altenbach, and D. E. Wilson. 1976. Bat mortality: Pesticide poisoning and migratory stress. Science, 194(4261): 184-186.

Humphries, M. M., D. W. Thomas, and J. R. Speakman. 2002. Climate-mediated energetic constraints on the distribution of hibernating mammals. Nature 418:313-316

Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. 2006. USFWS. Fort Snelling, Minnesota.

Jackson, H. Mammals of Wisconsin. 1961. The University of Wisconsin Press. Madison, WI.

Johnson, G. D., W. P. Erickson, M.D. Strickland, M. F. Shepherd, D. A. Shepherd. 2003. Mortality of Bats at a Large-scale wind power development at buffalo ridge, Minnesota. American Midland Naturalist 50: 332-342.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: Questions, research needs, and hypotheses. Front Ecol. Environment 5: 315-324.

Kurta, A. 1995. Mammals of the great lakes region. Ann Arbor: University of Michigan Press.

Lacki, M. J., J. P. Hayes, A. Kurta. Bats in Forests: Conservation and management. Baltimore: John Hopkins University Press, 2007. Pp 250.

Lacki, M.J., D. R. Cox, L. E. Dodd, and M. B.. Dickinson. 2009 Response of Northern bats (Myotis septentrionalis) to Prescribed Fires in Eastern Kentucky Forests Journal of Mammalogy. 90 (5), 1165-1175

Lee, Y. F., G. F. McCracken. 2004. Flight activity and food habits of three species of *Myotis* bats (Chiroptera: Vespertilionidae) in sympatry. Zoological Studies 43: 589-597.

Limpens, H., K. Kapteyn. 1991. Bats, their behavior and linear landscape elements. Myotis 29: 39-48.

Lorch, J.M., C.U. Meteyer, M.J. Behr, J.G. Boyles, P.M. Cryan, A.C.Hicks, A.E.Ballmann, J.T.H. Coleman, D.N.Redell, D.M.Reeder and D.S.Blehert. 2011 Experimental infection of bats with Geomyces destructans causes white-nose syndrome. Nature 480:376-378.

Minnis, A. M. and D. L. Lindner. 2013. Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. Nov., in bat hibernacula of eastern North America. Fungal Biology 117: 638-649.

Nowak, R. M. Walker's bats of the world. Baltimore: John Hopkins University Press, 1991.

O'Shea, T. J., A. L. Everette, and L. E. Ellison. 2001. Cyclodiene Insecticide, DDE, DDT, Arsenic, and Mercury contamination of big brown bats (*Eptesicus fuscus*) foraging at a Colorado superfund site. Archives of Environmental Contamination and Toxicology 40:112-120.

Owen, S. F., M. Menzel, W. M. Ford, B. R. Chapman, K. V. Miller, J. W. Edwards, P. B. Wood. 2002. Roost tree selection by maternity colonies of northern long-eared myotis in an intensively managed forest. Gen. Tech. Rep. NE-292. Newtown Square, PA: U.S. Department of Agriculture, Forest service, Northeastern Research Station. 6 p.

Owen, S. F., M. Menzel, W. M. Ford, B. R. Chapman, K. V. Miller, J. W. Edwards, P. B. Wood. 2003. Home-range size and habitat used by the northern Myotis (*Myotis septentrionalis*). American Midland Naturalist 150:352-359.

Reeder, D., C.L. Frank, G.G. Turner, C.U. Meteyer, A. Kurta, E.R. Britzke, M.E. Vodzak, S.R. Darling, C.W. Stihler, A.C. Hicks, R. Jacob, L.E. Grieneisen, S.A. Brownlee, L.K. Muller, D.S. Blehert. 2012. Frequent arousal from hibernation linked to severity of infection and mortality in bats with White-nose syndrome. PLoS ONE 7: e38920. doi:10.1371/journal.pone.0038920.

Redell, D. 2005. Behavioral ecology of bats using the Neda mine hibernaculum. Thesis: University of Wisconsin, Madison.

Shore, R. F., D. G. Myhill, and J. A. Wright. 1996. Comparison of the toxicity to laboratory mice and pipistrelle bats *Pipistrellus pipistrellus* of exposure to remedially-treated timber. Environmental Toxicology and Pharmacology 2:125-129.

Thomas D. W. 1992. Lack of evidence for a biological alarm clock in bats (*Myotis* spp.) hibernating under natural conditions. Canadian Journal of Zoology 71:1-3.

Thomas D. W., M. Dorais, J. M. Bergeron. 1990. Winter energy budget and costs of arousals for hibernating little brown bats, *Myotis lucifugus*. Journal Mammalogy 71: 475-479.

USFWS [United States Fish and Wildlife Service]. 2007. Indiana Bat (*Myotis sodalis*) Draft Recovery Plan: First Revision. < http://www.fws.gov/midwest/endangered/mammals/inba/pdf/inba_fnldrftrecpln_apr07.pdf>

USFWS [US Fish and Wildlife Service]. "White nose syndrome in bats: Frequently asked questions" *US Fish and Wildlife Service Northeast Region.* April 2009. USFWS. <http://www.fws.gov/northeast/pdf/white-nosefaqs.pdf> (accessed Oct 2009).

USFWS [US Fish and Wildlife Service]. "White nose syndrome in bats: for cavers" *US Fish and Wildlife Services Northeast Region.* November 2009. USFWS. < http://whitenosesyndrome.org/resources/cavers> (accessed Dec 2009).

Verboom, B., H. Huitema. 1997. The Importance of linear landscapes for the pipistrelle *Pipistrellus pipistrellus* and the serotine bat *Eptesicus serotinus.* Landscape Ecology 12: 117-125.

Verant, M.L., J.G. Boyles, W.W. Waldrep Jr, G. Wibbelt, D.S. Blehert. 2012. Temperature-dependant growth of *Geomyces destructans*, the fungus that causes bat white-nose syndrome. PLoS ONE 7: e46280. doi:10.1371/journal.pone.0046280

Weller, T. J., P. M. Cryan, and T. J. O'Shea. 2009. Broadening the focus of bat conservation and research in the USA for the 21st century. Endangered Species Research 8:129-145.

Wisconsin Bat Program. 2008, 2009, 2010, 2012. Unpublished Data.

WDNR [Wisconsin Department of Natural Resources]. 2005. Wisconsin's Strategy for Wildlife Species of Greatest Conservation Need: A State Wildlife Action Plan. Madison, Wisconsin, USA. <http://dnr.wi.gov, key word "Wildlife Action Plan">

WDNR [Wisconsin Department of Natural Resources]. 2009. Wisconsin wildlife action plan species profile: Northern Long-eared Bat. (accessed May 27, 2012). Madison, Wisconsin, USA. <material now available on the Natural Heritage Conservation species Web page: http://dnr.wi.gov, key word "biodiversity">

WDNR [Wisconsin Department of Natural Resources]. 2012. Conducting Endangered Resources Reviews: A Step-by-Step Guide for Wisconsin DNR Staff. Bureau of Endangered Resources. Wisconsin Department of Natural Resources, Madison, Wisconsin.

WDNR [Wisconsin Department of Natural Resources]. 2013. Natural Heritage Inventory database. Accessed 29 July 2013.

WICCI [Wisconsin Initiative on Climate Change Impacts]. 2011. Wisconsin's Changing Climate: Impacts and Adaptation. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, Wisconsin, USA. <http://www.wicci.wisc.edu/report/2011_WICCI-Report.pdf>

Yates, D., M. Ingalls, L. Eaton, and N. Pau. 2014. Home range analysis and roost tree selection of Northern long-eared (Myotis septentrionalis) and Eastern small-footed bats (Myotis leibii) at Great Bay NWR, NH. [Poster]. Northeastern Bat Working Group Meeting, Clinton, New Jersey.

Linked Websites:

- Cave bat Broad Incidental Take Permit and Authorization:< http://dnr.wi.gov/topic/erreview/itbats.html>
- Natural Communities of Wisconsin: <http://dnr.wi.gov/org/land/er/communities/>
- Natural Heritage Conservation Permit Requirements: <http://dnr.wi.gov/topic/EndangeredResources/permits.html>
- Rare Animal Field Report Form: <http://dnr.wi.gov, key word "rare animal field report form">
- USFW WNS Website: <http://www.whitenosesyndrome.org>
- USGS National Wildlife Health Center: <http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/>
- Wind Guidance: <http://dnr.wi.gov/topic/Sectors/documents/energy/WindGuidelines.pdf>
- Wisconsin Bat Program Exclusion Instructions: <http://wiatri.net/inventory/bats/Monitoring/Roosts/docs/BatExclusion.pdf>
- Wisconsin Bat Program: <http://wiatri.net/inventory/bats>
- WDNR Decontamination Protocols for Preventing Spread of White-nose syndrome: <http://dnr.wi.gov/topic/WildlifeHabitat/documents/WNS_DeconProtocols.pdf>
- Wisconsin Endangered and Threatened Species: <http://dnr.wi.gov, key word "endangered resources">
- Wisconsin Endangered and Threatened Species Permit: <http://dnr.wi.gov, key word "endangered species permit">"
- Wisconsin Initiative on Climate Change Impacts: <http://www.wicci.wisc.edu/>
- Wisconsin Natural Heritage Inventory Working List Key: <http://dnr.wi.gov/topic/NHI/WList.html>
- Wisconsin's Wildlife Action Plan: <http://dnr.wi.gov/topic/wildlifehabitat/actionplan.html>

Funding

- Natural Resources Foundation of Wisconsin: <http://www.wisconservation.org/>
- USFWS State Wildlife Grants Program: <http://wsfrprograms.fws.gov/subpages/grantprograms/swg/swg.htm>
- Wisconsin Natural Heritage Conservation Fund

- Wisconsin DNR Division of Forestry

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