**Species Assessment and Listing Priority Assignment Form**

**Scientific Name:** *Myotis lucifugus*

**Common Name:** little brown bat, little brown myotis

**Lead Region:**

**Lead Region Contact:**

**Lead Field Office Contact**

**Information Current as of:**

**Status/Action**

\_\_\_ Funding provided for a proposed rule. Assessment not updated.

\_\_\_ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

\_\_\_ New Candidate

Continuing Candidate

\_\_\_ Candidate Removal

\_\_\_ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status

\_\_\_ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species

\_\_\_ Range is no longer a U.S. territory

\_\_\_ Insufficient information exists on biological vulnerability and threats to support listing

\_\_\_ Taxon mistakenly included in past notice of review

\_\_\_ Taxon does not meet the definition of "species"

\_\_\_ Taxon believed to be extinct

\_\_\_ Conservation efforts have removed or reduced threats

\_\_\_ More abundant than believed, diminished threats, or threats eliminated.

**Petition Information**

\_\_ Non-Petitioned

\_ \_ Petitioned

90-Day Positive:

12-Month Positive:

Did the Petition request a reclassification?

**For Petitioned Candidate species:**

Is the listing warranted? If yes, see summary threats below.

To Date, has publication of the proposal to list been precluded by other higher priority listing?

Explanation of why precluded:

**Extent of Occurrence/Area of Occupancy**

**Historical States/Territories/Countries of Occurrence:**

**Countries:** United States, Canada

**States/US Territories**: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming

**Provinces (Canada):** Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, and Yukon

**Current States/Counties/Territories/Countries of Occurrence:**

**Countries:** United States, Canada

**States/US Territories**: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming

**Provinces (Canada):** Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, and Yukon.

**Land Ownership:**

Spanning the vast majority of North America, the range of the little brown bat encompasses all manner of public and private lands. Caves or mines that are located on private property and serve as hibernacula present potential conflict with monitoring and protecting hibernating little brown bats, however, landowners typically cooperate with state agencies and support the installation of entrance gates to minimize disturbance to bats.

**Biological information:**

**Species Description:**

The little brown bat is a small, insectivorous North American bat with glossy fur of variable coloration ranging from dark to golden brown, sometimes having yellow or olive hues and is lighter on the ventral side (Fenton and Barclay 1980). Face, ears, and membranes are dark brown. Body mass ranges from 5-14 grams (usually 7-9 g) with females generally being larger and increasing body mass by approximately 30% during pregnancy (Barbour and Davis 1969, Kunz and Reichard 2010). Total body length is usually about 80-86 mm with the tail about averaging 36 mm (Miller and Allen 1928). Wingspan ranges from 222-269 mm (Barbour and Davis 1969). Forearm length ranges from 31-41 mm (Kunz and Reichard 2010). Little brown bats have a short rostrum, a graded upslope to the forehead, and relatively small ears (11-15.5 mm) and tragi (7-9 mm) (Fenton and Barclay 1980). Little brown bats are distinguishable from congener the federally endangered Indiana bat (*M. sodalis*) by the lack of a keel on their calcar and have hairs that extend beyond the toes. They may be distinguished from the federally threatened northern long-eared bat (*M. septentrionalis*) because the latter has significantly larger ears that extend well beyond the nose when laid forward (>2 mm) and a more prominent and pointed tragus. Shorter tibia, lack of keel on calcar and less fur on the undersurface of wings differentiate the little brown bat from the long-legged myotis (*M. volans*), and glossy fur distinguishes it from yuma myotis (*M. yumanensis*). Finally, little brown bats may be distinguished from the Arizona myotis (*M. occultus*), a formerly accepted subspecies of little brown bat, by its larger body size and lack of sagittal crest on the skull (Barbour and Davis 1969, Fenton and Barclay 1980). The little brown bat may be readily distinguishable from other North American *Myotis* spp. by body mass, relative size of feet, length of ears, and location of insertion of wing membranes (Fenton and Barclay 1980).

**Taxonomy:**

*Myotis lucifugus* belongs to the order Chiroptera, which comprises all bats, suborder Yangochiroptera (also referred to as Vespertilioniformes), which includes nearly all bat taxon previously categorized as the suborder Microchiroptera, or echolocating “microbats,” family Vespertilionidae, the largest family of bats referred to as “vesper,” “evening,” or “common bats,” and genus *Myotis,* a widespread and diverse group also known as “mouse-eared bats” (ITIS 2017, Hutcheon and Kirsch 2006).

There are presently five recognized subspecies of *Myotis lucifugus*: *M.l. alascensis*, (Miller, 1897), *M.l. carissima* (Thomas, 1904), *M.l. lucifugus* (Le Conte, 1831), *M.l. pernox* (Hollister, 1911), *M.l. relictus* (Harris, 1974) (ITIS 2017, Vonhof et al. 2015). Formerly, the Arizona myotis (*M. occultus*) was classified as a subspecies of *M. lucifugus* but has been accepted as a distinct species after much contention over its phelogeny and associations with *M.l. carissima* (Piaggio et al. 2002).

Kingdom Animalia – Animal, animaux, animals

Subkingdom Bilateria

Infrakingdom Deuterostomia

Phylum Chordata – chordates

Subphylum Vertebrata –vertebrates

Infraphylum Gnathostomata

Superclass Tetrapoda

Class Mammalia Linnaeus, 1758 –mammals

Subclass Theria Parker and Haswell, 1897

Infraclass Eutheria Gill, 1872

Order Chiroptera Blumenbach, 1779 – bats

Suborder Yangochiroptera Koopman, 1984

Superfamily Vespertilionoidea Gray, 1821

Family Vespertilionidae Gray, 1821 – vespertilionid bats

Subfamily Myotinae Tate, 1942

Genus Myotis Kaup, 1829 – mouse-eared bats

Species *Myotis lucifugus* (Le Conte, 1831) – little brown

bat, little brown myotis, Little Brown Myotis

Direct Children:

Subspecies Myotis lucifugus alascensis Miller, 1897

Subspecies Myotis lucifugus carissima Thomas, 1904

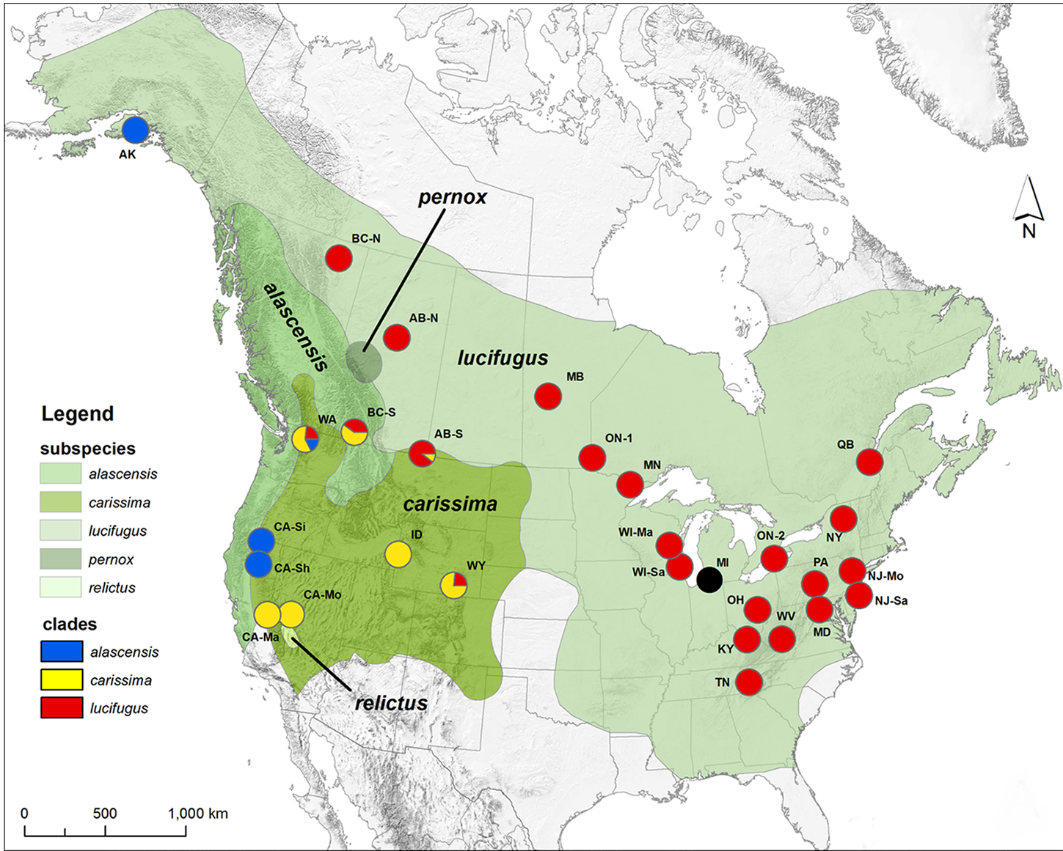
Subspecies Myotis lucifugus lucifugus (Le Conte, 1831)

Subspecies Myotis lucifugus pernox Hollister, 1911

Subspecies Myotis lucifugus relictus Harris, 1974

Integrated Taxonomic Information System, 2017

Subspecies *M.l. alascensis* ranges along the Pacific Coast from California to Nova Scotia, in central California it gives way to *M.l. carissima*, whose range begins in south-central California, extends up to southern Nova Scotia, east to central North and South Dakota, and south to the northern borders of New Mexico and Arizona. *M. l. lucifugus* encompasses the majority of the species’ range extending from Alaska through the south of the Northwest Territories, east to Newfoundland and Labrador, southeast northern Florida, and southwest to Oklahoma. *M.l. lucifugus* and *M.l. carissima* co-occur in southern Alberta and central Montana and genetic evidence suggests they interbreed. Subspecies *M.l. pernox* and *M.l. relictus* occupy relatively very small ranges in central Alberta and southeastern California, respectively (Fig. 1; Vonhof et al. 2015).



**Figure 1.** *Myotis lucifugus* range map showing subspecies distributions from Vonhof et al. 2015 depicting frequencies of mtDNA subspecies clades.

**Habitat / Life History:**

Little brown bats are habitat generalists capable of occupying a great variety of natural and urban environments, having requirements that change with season and vary by sex and reproductive condition. As characteristic of cave bats, they hibernate during winter and utilize transient roosts in the spring and fall as they migrate to and from summer habitat. In the summer, reproductive females form large maternity colonies while males and nonparous females typically roost solitarily or in small groups (Fenton and Barclay 1980). Although generally philopatric to summer habitat and hibernacula, they have been found to relocate from year to year in both cases (Norquay et al. 2013).

Caves and mines utilized as hibernacula are typically characterized by high humidity and relatively stable, cool temperatures above freezing, but hibernacula with ambient temperatures below freezing have been observed (Fenton and Barclay 1980). Little brown bats group together in large clusters of tens to thousands of individuals during hibernation. Duration of hibernation is largely dependent on the climate and length of hibernal period of the location (Kunz and Reichard 2010).

In the spring, from mid-March to mid-May, the majority of little brown bats depart hibernacula and migrate to summer habitat, relocating anywhere from short distances to over 600 km (Fenton and Barclay 1980, Norquay et al. 2013).

Reproductive females congregate in large maternity colonies to birth and rear young that, historically, ranged from 300-1200 individuals and reached as many as 3,000 (Humphrey and Cope 1976).

Little brown bats have a strong proclivity for day-roosting in buildings or similar man-made structures in the spring and summer, but also roost in cavities or sloughing bark of trees, under rocks, and occasionally in caves (Humphrey and Cope 1976, Fenton and Barclay 1980). While males appear to prefer natural roosts, females have been found to roost most commonly in structures, with over 90% of maternity colonies in New York believed to be in buildings (C. Herzog, NY Dept. Env. Cons., pers comm.; Randall et al. 2013). Ambient temperature and amount of shelter are considered to be of primary importance in roost selection. Reproductive females (i.e. maternity colonies) select for warmer temperatures that foster gestation and rapid growth of neonates, while males and nonparous females tend to use cooler sites conducive to lower body temperatures in daily torpor (Fenton and Barclay 1980). Proximity to water is thought to be an important factor in roost selection as little brown bats have an affinity for foraging over open water with aquatic insects, especially chironomids, constituting a staple of their diet (Fenton and Barclay 1980). Home range of little brown bats has been estimated to be about 30 ha during pregnancy and 17.6 ha during lactation (Henry et al. 2002).

In the fall, little brown bats return to hibernacula where they congregate in what is referred to as “fall swarming” (Humphrey and Cope 1976). During this time, they build fat reserves and mate promiscuously before entering winter hibernation (Humphrey and Cope 1976, Thomas et al. 1979). Females store sperm through the winter and ovulation and fertilization occur a few days after arousal from hibernation provided they have retained adequate metabolizable fat (Buchannon 1987, Kunz et al. 1998, Thomas et al. 1979). Parturition occurs from early May to early July, generally later in northern portions of their range. Young develop very rapidly, becoming volant in 3-4 weeks (Humphrey and Cope 1976). Historically, reproductive rates in little brown bats was very high averaging 95% before the onset of white-nose syndrome (Frick et al. 2010a). Reproduction is generally limited to one offspring per year, but twins have been reported (Humphrey and Cope 1976).

**Historical Range / Distribution:**

The historic distribution of the little brown bat encompasses the majority of North America excluding the southern Great Plains, the majority of Florida, southern California, the coast of the Carolinas and Virginia, and northern Alaska and Canada (Fig. 1; Fenton and Barclay 1980, Vanhof et al. 2015). The northern border of its range extends from Alaska along the southern border of the Yukon Territory and east to Newfoundland and Labrador. The southern extent of its range includes northern Florida, Alabama, Mississippi, Arkansas, the eastern halves of Oklahoma and Kansas, small sections along the northern borders of Nebraska, Colorado, the northernmost portions of New Mexico and Arizona, and all of California except for the Sonoran desert and the South Coast (Fenton and Barclay 1980, Vonhof et al. 2015). Their distribution is limited by accessibility to suitable hibernacula (i.e. caves or mines) in addition to climate (Kunz and Reichard 2010). The northeastern and mid-western United States historically supported the largest known colonies and were thought to support higher densities than the rest of their range owing to the prevalence of caves in the Appalachian Mountains and eastern Midwest (Kunz and Reichard 2010).

The range of the Arizona myotis (*M. occultus*) which includes Arizona, New Mexico, portions of the Sonoran Desert, and central Mexico previously contributed to the range of the little brown bat when it was considered a subspecies of *M. lucifugus* (Fenton and Barclay 1980, Vonhof et al. 2015).

**Current Range Distribution:**

The little brown bat is believed to occur throughout it’s historic range, albeit at dramatically reduced densities in the East where white-nose syndrome has caused precipitous declines. Systematic surveys that would confirm their expansive distribution are lacking, but current research is supportive of their persistence throughout. Their migratory nature, which affords them the ability to distribute over great distances (>600 km) throughout the landscape each spring, allows survivors of white-nose syndrome to re-colonize locations that may have been otherwise left unoccupied by bats killed by the disease (Norquist et al. 2012).

Extirpations from hibernacula have been observed by state agencies where numbers observable little brown bats have plummeted from hundreds or thousands to zero. For example in New Hampshire, of 11 monitored hibernacula, count numbers have fallen to zero at all but two caves where counts were one and two little brown bats (S. Houghton, NH Fish and Game, pers. comm.).

**Population Estimates / Status:**

*Population Estimates:*

Estimates of little brown bat populations are primarily based on data from surveys of observable bats in hibernacula, which provide relatively imprecise estimates. Mist-netting and acoustic survey provide relative measures of abundance via capture rate (captures per unit effort) and nightly activity (number of echolocation calls recorded nightly), respectively, that can be useful for measuring populations trends and estimating occupancy, but they do not provide for density estimates. The elusive nature of bats and limitations of survey methods render making accurate population estimates exceedingly difficult. Nevertheless, there have been a few attempts to approximate numbers of little brown bats on a broad scale in light of the impacts of white-nose syndrome, and long-term hibernacula monitoring offers insight on the severity of population losses to the disease (Table 1).

Frick et al. (2010b) estimated Northeastern little brown bat populations at 6.5 million in 2006 before the onset of white-nose syndrome. This region was thought to constitute the majority of their national population. Based on long-term hibernacula survey of 22 locations, populations were increasing prior to the emergence of the disease, then declined at rates of 30-99% at infected sites with a mean decline of 73% (Frick et al. 2010b).

Turner et al. (2011) compiled cave count data from 42 hibernacula in New York, Pennsylvania, Vermont, Virginia, and West Virginia finding a 91% decline, with numbers of observable bats falling from ~350,000 to 30,000, following the introduction of white-nose syndrome.

Russell et al. (2014) used hibernacula count data from 18 states to estimate wintering populations of little brown bats east of the 100th meridian to be 8.1 million in 2012. This included both regions in the northeast and mid-Atlantic where the disease was well established and areas where it was emerging or had not yet been reported. Among state experts surveyed by this study, mean estimate of eastern populations was thought to be 5.5 million with approximately 80% of the remaining population wintering in the upper Midwest where the disease was initially being detected and has since spread (Russell et al. 2014, whitenosesyndrome.org 2017).

The years following these studies have observed continued declines in little brown bats as the disease has established throughout the Northeast and Mid-Atlantic and continues to move west. Several states have conducted long term monitoring of hibernacula that estimate rates of decline.

In New York where the disease was first recorded in 2006, cave count numbers of little brown bats fell to approximately 9% of their pre-white-nose syndrome levels in 2011 but increased to 17% of pre-white-nose levels in 2016 and 2017 (C. Herzog, NY Dept. Env. Cons., pers. comm.). This may be interpreted either as indicative of population growth or the immigration of individuals that previously hibernated in neighboring states, which is plausible considering their ability to relocate (C. Herzog, NY Dept. Env. Cons., pers. comm., Norquay et al. 2013). Rates of detection by acoustic and mist-netting survey in New York have remained at roughly 10% of those observed pre-white-nose since 2010 (C. Herzog, NY Dept. Env. Cons., pers. comm.).

In Vermont, Aeolus Cave, historically New England’s largest hibernaculum estimated to contain approximately 300,000 little brown bats in the early 1960s, was estimated to have 70,000-90,000 in 2015, a ~70-77% reduction (Davis et al. 1965; A. Bennet, VT Fish and Wildlife, pers. comm.). Other hibernacula in the state have showed significant declines as well with several having post-white-nose syndrome counts of zero (A. Bennet, VT Fish and Wildlife, pers. comm.).

Monitoring of a single hibernacula in Connecticut observed a 90% percent decline in little brown bats from 2005 to 2017. Acoustic and mist net surveys have been unsystematic, with few occurring before the introduction of white-nose syndrome (K. Moran, CT Dept. of Energy and Env., pers. comm.).

Overall decline of little brown bats in New Hampshire is estimated to exceed 99% (Preston 2015). Of 11 monitored hibernacula that supported relatively small to moderate numbers of wintering little brown bats, 9 appeared to no longer contain them, one had a single little brown bat, and the last has not been revisited since 2010 (S. Houghton, NH Fish and Game, pers. comm.).

In Massachusetts, the most populated hibernacula experienced a reduction of 99.9% of little brown bats following the introduction of white-nose syndrome, and the state-wide wintering population estimated at 8,000-10,000 has been reduced to just 14 observable little brown bats (J. Longsdorf, MA Div. of Fisheries and Wildlife, pers. comm.).

Wintering populations in New Jersey have declined 98.9% based on hibernacula survey of 8 sites, 3 of which found no little brown bats present post-white-nose syndrome (M. Hall, NJ Fish and Wildlife, pers. comm.). Detections by acoustic survey exhibit a similar trend, and capture via mist-netting has become very rare (M. Hall, NJ Fish and Wildlife, pers. comm.).

Pennsylvania has also observed a 99% decline according to hibernacula surveys and an 88.6% decline in mist net capture rate from pre-white-nose years (2001-2008) compared to 2013 (Butchkoski and Bearer 2016).

Little brown bat populations had declined 97% by 2014 in West Virginia, but did show a slight increase from 2014 to 2016 based on winter surveys. Acoustic detections and capture rates show sharp declines as well. Previously the little brown bat was the second most common species captured in West Virginia during mist-netting surveys, but captures have fallen to just a few state-wide each year (C. Stihler, WV Div. of Nat. Res., pers. comm.).

In Virginia, the survey of 13 hibernacula observed a 99% decline in little brown bats following the introduction of white-nose syndrome (Powers et al. 2015). While they are still observed throughout Virginia, rates of detection of little brown bats by acoustic and mist net survey have become exceedingly low indicating declines of over 90% (R. Reynolds, VA Dept. of Game and Inland Fisheries, pers. comm.).

As the disease spreads, mid-western states are beginning to experience similar losses. In Indiana where white-nose syndrome was first observed in 2011, little brown bats have experienced a 90% decline in hibernacula survey and mist-netting capture rates have fallen by approximately 80% (Pettit and O’Keefe 2017). Midwest populations believed to comprise the majority of remaining eastern little brown bats now face mass mortality similar to that in the Northeast (Russell et al. 2014).

The little brown bat is widely accepted as one of the most widespread and abundant bat species in North America prior to the introduction of white-nose syndrome. Following its establishment, the disease has inflicted catastrophic mortality to hibernating little brown bats that has reduced their numbers to a little as 1% of prior levels in many northeastern and mid-Atlantic states (Table 1).

**Table 1.** Percent decline estimates of little brown bats by state with method of survey and the year white-nose syndrome was first recorded. Percent declines based on hibernacula surveys may be based on survey of a single or multiple hibernacula. Percent declines from mist-netting are based on state-wide capture rates. Rhode Island has no known hibernacula and lacks pre-white-nose syndrome mist-netting data. Delaware, Maine, and Maryland did not provide information. Indiana is included to demonstrate trends observed in the Midwest.

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| --- | --- | --- | --- |
| **State** | **Year WNS introduced** | **Percent decline** | **Survey method** |
| New York | 2006 | 91% | hibernacula survey |
| Vermont | 2007 | 70-77% | hibernacula survey |
| Connecticut | 2007 | 90% | hibernacula survey |
| Massachusetts | 2007 | 99.9% | hibernacula survey |
| New Hampshire | 2008 | 99% | hibernacula survey |
| New Jersey | 2008 | 98.9% | hibernacula survey |
| Pennsylvania | 2008 | 99% | hibernacula survey |
| 88.6% | mist-netting survey |
| West Virginia | 2008 | 97% | hibernacula survey |
| Virginia | 2008 | 99% | hibernacula survey |
| Indiana | 2011 | 90% | hibernacula survey |
| 80% | mist-netting survey |

*Listing status*-

Connecticut- state endangered

Delaware- state endangered

Maine- state endangered

Maryland- not listed

Massachusetts- state endangered

New Hampshire- state endangered

New Jersey- not listed; under review

New York- not listed; under review

Pennsylvania- not listed

Rhode Island- not listed; under review

Vermont- state endangered

Virginia- state endangered

West Virginia- not listed

**Distinct Population Segment (DPS):**

Not applicable

**threats**

**A. The present or threatened destruction, modification, or curtailment of its habitat range:**

*Deforestation/ Urban Development-*

Little brown bats roost in trees and rely on forests as habitat for foraging and maternity colonies, therefore, are susceptible to impacts of deforestation. Although deforestation does pose threat through habitat conversion and potential incidental take, little brown bats appear to be highly adaptable to urbanized and fragmented habitats (Coleman and Barclay 2011). It has been posited that habitat availability and connectivity are likely not limiting factors for bat populations whose numbers have been severely reduced by white-nose syndrome (Silvis et al. 2016, R. Reynolds, VA Dept. Game and Inland Fisheries, pers. comm.)

The ability of little brown bats to relocate and roost in structures likely makes them resilient to forest harvest. Tree clearing, however, is directly threatening to active maternity colonies, especially those with with nonvolant juveniles, which can occur from early May through mid-August depending on location (Humphrey and Cope 1976).

**B. Overutilization for commercial, recreational, scientific, or educational purposes:**

*Hibernacula Disturbance-*

Although not directly utilized for recreation purposes, the recreational activity of cavers poses a significant threat to little brown bats. Disturbances to hibernating bats with white-nose syndrome can cause additional arousal from torpor that may exacerbate the likelihood of mortality. Cavers represent a significant threat of spreading the fungus *P. destructans* that causes white-nose syndrome. There is a national white-nose syndrome decontamination protocol to prevent introductions fungus available here (<https://www.whitenosesyndrome.org/sites/default/files/resource/national_wns_decon_protocol_04.12.2016.pdf>). However, there is no enforcement of these protocols and adherence is left to the discretion of cave visitors.

Scientific monitoring of hibernacula, or cave counts, by researchers represent another potential means of disturbance to hibernating bats. Those conducting these surveys typically attempt to minimize disturbance, however, their mere presence likely has the potential to cause some degree of arousal in bats. Some state agencies advocate surveying hibernacula in a two or three year intervals to reduce this type of disturbance (S. Houghton, NH Fish and Wild. Prog., pers. comm.).

Mining represents another significant threat of disturbance to hibernating bats and hibernacula. Mining activity near occupied hibernacula has the potential to cause noise or physical disturbance to hibernating bats as well as impact the structure of hibernacula. Collapse of hibernacula walls or ceilings, closing of entrances, breaching of walls, and climatic impacts all have the potential to disturb bats or render hibernacula unusable. An active quarry next to Hellhole Cave, the largest hibernacula in West Virginia, is an example that poses significant threat to many hibernating bats imperiled by white-nose syndrome, including little brown bats (C. Stihler, WV, Dept. Nat. Res., pers. comm.)

**C. Disease or Predation:**

*White-nose Syndrome-*

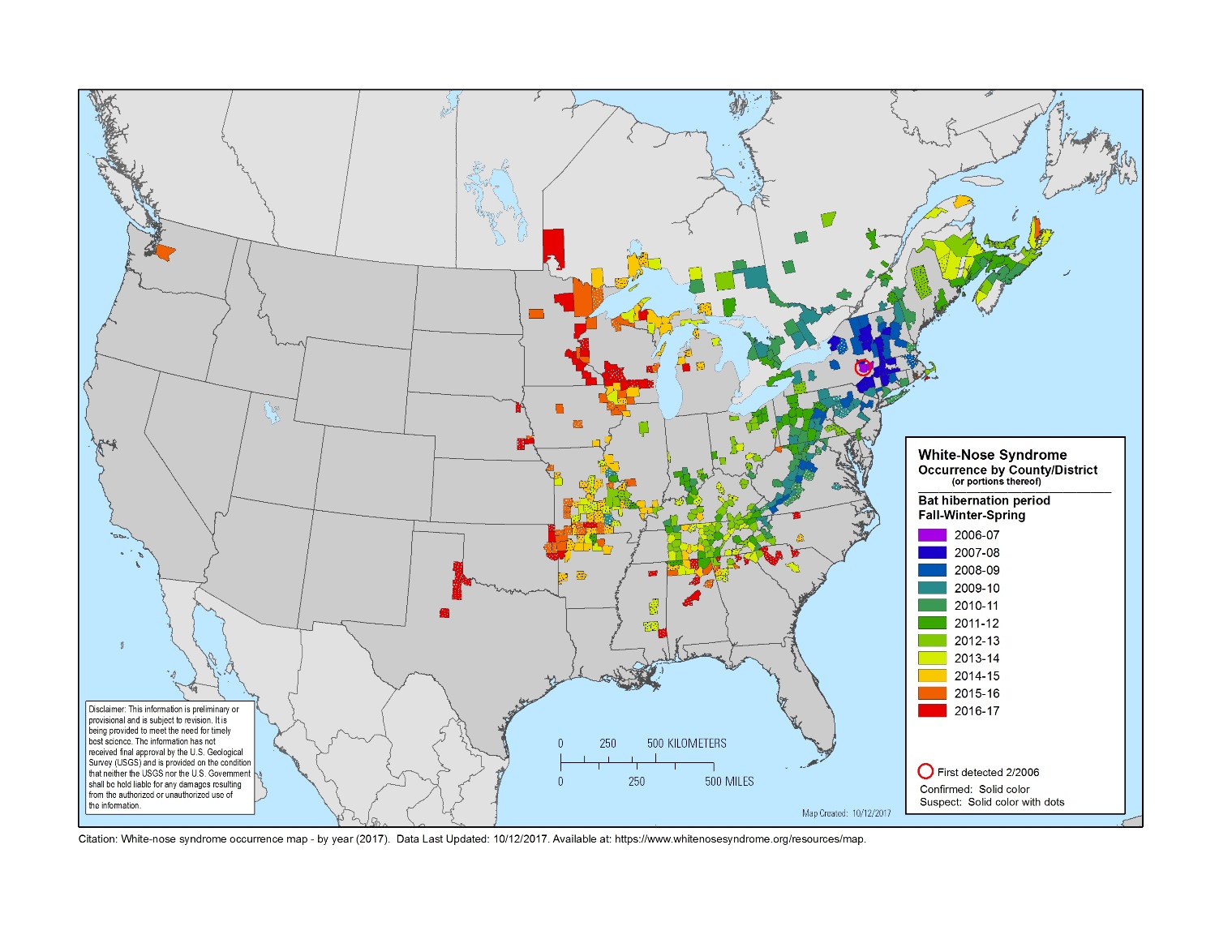
White-nose syndrome has caused precipitous mass mortality to little brown bats and severely threatens the survival of the species. As of 2012, it is estimated that 5.7-6.7 million bats have died from white-nose syndrome, making it one of the greatest wildlife epidemics in North America (USFWS 2012). In just five years following its initial detection, it spread throughout hibernacula in the Northeast and Mid-Atlantic, where states have reported declines of 90-99% in their little brown bat populations. In a little more than a decade, the disease has spread through hibernacula in the majority of the southern, central, and mid-western US as well as southeastern Canada, where reports of similar declines are beginning to emerge (Fig. 2; Pettit and O’Keefe 2017, whitenosesyndrome.org 2017). In light of observed declines, Frick et al. (2010b) simulated population dynamics using a stochastic population model incorporating demographic data from infected and uninfected populations and found there to be a 99% chance of regional extinction of the little brown bat in the northeastern US within 16 years.

White-nose syndrome is caused by the fungus *Pseudogymnoascus destructans*, formerly known as *Geomyces destructans* (Gargas et al. 2009, Minnis and Lidner 2013). It is believed to have originated from Europe where its widespread distribution appears to be historic, and it is not associated with bat mortality (Cryan et al. 2013, Puechmaille et al. 2011, Trivedi et al. 2017). This cold-adapted fungus thrives year-round in caves and mines where it infects hibernating bats often causing a powdery white coating of fungal hyphae and conidia that is visible on their wing membranes, ears, and noses, for which the pathogenic disease is named (Blehert et al. 2009, Gargas et al. 2009). Because immune function is dramatically reduced during hibernation, the fungus is able to penetrate the skin, hair follicles, and sebaceous glands of bats (Meteyer et al. 2009). Deeper invasion by the fungus digests and destroys connective tissue, blood, lymphatic vessels, elastin, and muscle fibers in the wings (Cryan et al. 2010, Meteyer et al. 2009). As infection progresses, it causes bats to increasingly arouse from torpor, resulting in premature depletion of fat reserves and often starvation (Cryan et al. 2013, Warnecke et al. 2012). Evidence suggests arousals are caused by dehydration and electrolyte depletion (Cryan et al. 2013, Willis et al. 2011). As immune function resumes in bats that survive infection, they can undergo immune reconstitution inflammatory syndrome, a dramatic and energetically costly inflammatory response that can increase tissue damage to the wings or cause death (Frick et al. 2015, Meteyer et al. 2012). Research does indicate that bats can recover from tissue damage, so are most likely able to heal if they can survive through the spring (Meteyer et al. 2011).

Reduction in recruitment in surviving bats, including little brown bats, has been observed following the introduction of white-nose syndrome (Francl et al. 2012). Because ovulation occurs just a few days after hibernation and requires females to have sufficient metabolizable fat reserves, it follows that reproduction would be reduced in survivors of infection (Kunz et al.1998). Additionally, great reductions in their numbers could reduce mating opportunities for persisting bats. With healthy little brown bats only capable of bearing one offspring per year, reduction in recruitment by white-nose syndrome poses additional threat to their persistence.

Severity of infection and rate of morality are variable among cave bat species with little brown bats, northern long-eared bats, and tri-colored bats (*Perimyotis subflavus)* experiencing the highest rates of infection and mortality (Frick et al. 2010b, Frick et al. 2017, Turner et al. 2011). Differences in selection for microclimate characteristics (e.g. humidity and temperature) within hibernacula, rate of evaporative water loss, and percent body fat are all potential factors thought to influence susceptibility to the disease (Cryan et al. 2013, Frank et al. 2014, Willis et al. 2011). Also, females appear to be more negatively affected by white-nose syndrome, likely because of the increased energetic demand of reproduction (Grieneisen et al. 2015).

White-nose syndrome was first observed in Howes Cave, New York in 2006 where researchers found cave floors littered with the bodies of dead little brown bats (Blehert et al. 2009). The fungus *P. destructans* is spread through physical contact, so contact between bats, bats and the environment, and humans and environment all serve as vectors for the disease (Coleman and Reichard 2014). The highly social behavior of bats, including clustering during hibernation, fall swarming, and grouping of maternity colonies, present opportunities for transmission. Their ability to migrate long distances in excess of 600 km and change locations for each of these life history events presents an exceedingly efficient mechanism of dispersal that has exacerbated the rate of fungal introductions to hibernacula (Norquay et al. 2013). Human-mediated introductions are also assumed to play a role in its spread Although a national decontamination protocol has been created for cavers, and many caves have been gated, anthropogenic introductions likely still occur.

Figure 2. Distribution of white-nose syndrome and year of introduction.

The current distribution of white-nose syndrome is available from the USFWS white-nose syndrome site: (Fig. 2; <https://www.whitenosesyndrome.org/maps/>). In recent years, *P. destructans* has colonized caves and mines in the Midwest, with recent introductions in Nebraska, Minnesota, Iowa, as well as Texas and Ontario (whitenosesyndrome.org 2017). In March 2016, the fungus was found on a bat in North Bend, Washington marking its first observation in the West (USGS 2016). The method of this introduction is unknown, but this detection is approximately 1,300 miles from the closest known occurrence (USGS 2016). Given the rate of spread in regions where *P. destructans* is already established and the potential for long-distance dispersal, continued spread of the fungus and resulting disease seems imminent.

Presently, there are no effective and practical methods of eliminating the fungus from hibernacula or preventing infection of bats in the wild, but many studies are focused on these objectives. Cheng et al. (2017) explored a potential probiotic treatment of bats that was found to reduce severity of infection but only when the bat was inoculated with the probiotic and the fungal pathogen simultaneously. Treatments of the probiotic prior to exposure to the fungus resulted in increased severity of infection (Cheng et al. 2017). Others have investigated means of inhibiting growth of *P. destructans* (Cornelison et al. 2014, Micalizzi et al. 2017). Emerging research is exploring chitosan, assorted antimicrobials, and enzyme inhibitors to treat bats, as well as, chlorine dioxide as an environmental cleansing agent and UV light to inhibit fungal growth (Palmer et al. 2018).

*Predation-*

Natural predators of little brown bats include owls, hawks, magpies, small carnivores, mice, and snakes (Fenton and Barclay 1980, Coleman and Barclay 2011). House cats are also capable of capturing them (Humphrey and Cope 1976). Predation most likely does not represent a significant threat to the species, however, the impacts of white-nose syndrome render all forms of mortality more accute.

**D. The inadequacy of existing regulatory mechanisms:**

Presently, conservation measures for little brown bats done on a state-by-state basis and vary considerably in their methods and implementation. Because little brown bats migrate long distances of over 600 km, routinely inhabit different states on a seasonal or annual basis, and switch hibernacula and summer maternity locations, a unified, regional approach to conservation is needed (Norquay et al. 2013). In light of the dramatic population reductions of the species, which routinely exceed 90% population losses where white-nose syndrome is present, thorough and strict regulatory mechanisms are required to provide the greatest chance of conservation and recovery. Additionally, lag time between the initial observation of white-nose syndrome in a state and its drafting and implementation of conservation measures may result in significant loss, whereas federal regulation allows for rapid execution of conservation measures in states where the disease is introduced.

Most importantly, essential hibernacula should be secured with “bat friendly” gates to prevent further introductions of *P. destructans*, and restrictions on nuisance exclusions of maternity colonies should be enacted where white-nose syndrome is present to protect the reproduction of surviving little brown bats.

**E. Other natural or manmade factors affecting its continued existence:**

*Wind Energy-*

Mortality from collisions with wind turbines represents another threat to little brown bats. Collisions with large-scale utility wind turbines and barotrauma have become increasing sources of mortality in bats as the utilization of wind energy has increased (Arnett et al. 2008, Baerwald et al. 2008). Wind turbine mortality is not as common among cave bats as tree bat species: eastern red bats (*Lasiurus borealis*), hoary bats (*L. cinereus*), and silver-haired bats (*L. noctivagans*) but has been documented (Kunz et al. 2007, Erickson et al. 2016).

*Mercury-*

Mercury is a highly toxic pollutant that may be particularly threatening to bats. A study by Yates et al. (2014) that sampled blood and fur from over 1400 bats in the Northeast and Mid-Atlantic found that 69% of bats sampled near point sources of mercury pollution, and 21% of bats not in proximity to point sources, had mercury levels capable of inducing neurochemical changes (Nam et al. 2012, Yates et al. 2014). Bats of the *Myotis* genus, including the little brown bat, were found to have higher levels of mercury than other species (Yates et al 2014). The contamination of surface waters with mercury is primarily the result of point source pollution and atmospheric deposition from activities such as fossil fuel combustion, garbage incineration, mining, textile manufacturing, and other industrial activities (Yates et al 2014). Because bats have very high metabolic demands, consume insects at a high rate, are long-lived, and occupy high trophic levels, they are are prone to bioaccumulating high levels of mercury (Yates et al. 2014). The neurological effects of mercury bioaccumulation in bats poses an individual threat to their endocrine and reproductive systems (Nam et al. 2012, Yates et al. 2014).

**Summary of Threats:**

Five of the five listing factors considered by the U.S Fish and Wildlife Service to determine listing priority assignment pose threats to the FSCs: (A) the present or threatened destruction, modification, or curtailment of its habitat range, (B) overutilization or commercial, recreational, scientific, or educational purposes, (C) disease or predation (D) the inadequacy of existing regulatory mechanisms, and (E) other natural or manmade factors affecting its continued existence. The primary threat to the little brown bat is the disease white-nose syndrome. Other threats are only significant in conjunction with the disease or in light of its impacts.

**Conservation Measures Planned or Implemented:**

Conservation measures for little brown bats focus primarily on protecting hibernating bats and maternity colonies. The majority of Northeast and Mid-Atlantic states have established some form of listing and/or protection for little brown bats. Also, hibernacula and roost tree protections associated with the federally threatened northern long-eared bat and federally endangered Indiana bat can convey umbrella protection to little brown bats (C. Herzog, NY Dept. of Env. Cons., pers. comm.; M. Hall, NJ Div. Fish and Wildlife, pers. comm.). Lethal control measures for nuisance cases are prohibited in Northeast and Mid-Atlantic states. Many states have similar approved methods, with some restricting timing of implementation in an effort to limit separation of mothers and nonvolant pups to reduce their mortality. All states conduct some level of bat monitoring in response to the impacts of white-nose syndrome.

*New Jersey*

The little brown bat is currently under review for state endangered status in New Jersey. The New Jersey Division of Fish and Wildlife (NJDFW) offers some of the most comprehensive conservation measures for little brown bats. They have gated nearly all known hibernacula and estimate that 98% of their hibernating bats do so behind the protection of locked “bat-friendly” gates (M. Hall, NJ Div. Fish and Wildlife, pers. comm.). The NJDFW has recently enacted Nuisance Wildlife Control Guidelines for Bats under their New Jersey Endangered and Nongame Species Conservation Act (“ENSCA”-- N.J.S.A. 23:2A-1-13), which prohibits take of nongame wildlife. These regulations outlaw lethal methods of nuisance control for bats and provide restrictions targeted at protecting bats in dwellings during the maternity season and through the winter. Exclusions of bats from dwellings are not permitted from May 1 to July 31, during the maternity season, or from October 16 to March 31, during their period of hibernation. Little brown bats are not known to overwinter in buildings, but summer restrictions provide essential protection to their maternity colonies as the majority are believed to occur in dwellings or other structures in the Northeast (Fenton and Barclay 1980). These regulations provide for exceptions to be made by the New Jersey Department of Health in consultation with the NJDFW in instances of threat to public health or safety and include specifications as to permissible methods exclusion. Also, Conserve Wildlife Foundation of New Jersey (CWFNJ) provides free bat boxes for exclusion projects, which provide an alternative roosting site for evicted colonies. (<http://www.state.nj.us/dep/fgw/ensp/pdf/bat_control.pdf>) (NJDFW 2017). The NJDFW also conducts public outreach in conjunction with CWFNJ and other non-governmental organizations about the dangers of white-nose syndrome. Finally, tree removal associated with federally-funded projects is regulated from April 1-September 30 in the northern half of New Jersey to prevent potential take of Indiana bats, which likely offers collateral benefit to little brown bats. The NJDFW monitors bat populations with surveys in at least eight hibernacula locations and with state-wide acoustic surveys and sporadic mist-netting during the summer (M. Hall, NJ Div. Fish and Wild., pers. comm.).

*New Hampshire*

The little brown bat is listed as state endangered in New Hampshire. Bat removals from buildings are regulated and the exclusion of white-nose imperiled species, including little brown bats, is prohibited from May 15- August 15 unless in the instance of public health or safety. All exclusions must be performed by a certified wildlife control operator using approved methods. The New Hampshire Department of Energy and Environmental Protection (NHDEEP) also regulates proposed development projects in proximity to known maternity colonies or hibernacula and has gated two of their hibernacula. The NHDEEP conducts mist-netting and acoustic survey during the summer and hibernacula surveys on a three year rotation to limit disturbance to bats (S. Houghton, NH Fish and Wild. Prog., pers. comm.).

*Vermont*

In Vermont, the little brown bat is listed as state endangered. Exclusions of nuisance bats are regulated by best management practices established by the Vermont Fish and Wildlife Department (VFWD). Licensed operators must use approved methods, and exclusion from the primary entrance is prohibited from mid-May to mid-August. More information on exclusion regulations is available from ([http://www.vtfishandwildlife.com/batbmps](http://www.vtfishandwildlife.com/common/pages/DisplayFile.aspx?itemId=110672%20)). The VFWD has gated a few of their hibernacula and posted signs at others to discourage visitation in the winter and promote decontamination of clothes and equipment. Forest management restrictions for northern long-eared and Indiana bats in Vermont likely benefit little brown bats as well. Curtailment of wind energy turbines reduces bat fatalities and wind facilities pay in to a mitigation fund that provides resources for maternity colony survey and protection. The VFWD environmental review process for development projects can require mitigation for the demolition of buildings that harbor little brown bats. They also engage in public outreach, promote the use of bat boxes, and coordinate with landowners who own property with hibernacula. The VFWD conducts extensive monitoring of little brown bat populations with hibernacula surveys, mist-netting, fall swarm surveys, acoustic surveys, nuisance reports, rehabilitation submissions, and an extensive maternity colony monitoring program (A. Bennett, VT Fish and Wild. Dept., pers. comm.).

*New York*

The little brown bat is not listed in New York but is under review as a Species of Special Concern, a status that offers protection from intentional but not incidental take. The New York Department of Environmental Conservation (NYDEC) plans to gate its largest hibernacula on public lands. Exclusion of nuisance bats is not restricted in New York due to complications associated with their potential to transmit rabies. Some existing protections to the federally-listed northern long-eared bat likely provide umbrella protection to the little brown bat in New York, as they are known to share hibernacula and threats such as summer forestry activity. The NYDEC tracks populations by monitoring 48 hibernacula and conducts mist-netting surveys in the summer (C. Herzog, NY Dept. of Env. Cons., pers. comm.).

*Rhode Island*

Currently unlisted, the little brown bat is under review for state listing by the Rhode Island Division of Fish and Wildlife (RIDFW). Nuisance wildlife control regulations do not limit timing of exclusions but revisions are under consideration. There are no known little brown bat hibernacula in Rhode Island. The RIDFW began systematic summer bat surveys in 2010 to monitor populations (C. Brown, RI Div. of Fish and Wild., pers. comm.).

*West Virginia*

The little brown bat is currently not listed in West Virginia. The West Virginia Department of Natural Resources (WVDNR) has detailed regulations for exclusions that prohibit closing primary openings from May 1-August 15 and encourage tolerance to bats in unoccupied buildings. Most of the primary hibernacula of little brown bats in West Virginia are gated and closed during the winter due to presence of federally listed Indiana bat and Townsend’s big-eared bat (*Corynorhinus townsendii*). The WVDNR and Monongahela National Forest manage forests to specifically benefit bats where they have authority. They also engage in public outreach about white-nose syndrome and cooperate with private landowners whose property includes hibernacula. The WVDNR performs cave counts in their many hibernacula and monitor summer populations via mist-netting and acoustic surveys (C. Stihler, WV Div. Nat. Res., pers. comm.).

*Virginia*

Virginia listed the little brown bat as state endangered in 2016. The Virginia Department of Game and Inland Fisheries (VDGIF) published best management practices concerning little brown and tri-colored bats that imposes restrictions on nuisance exclusion and disturbance in proximity to hibernacula and roosts. They require that exclusions be performed by certified operators and prohibit exclusion of little brown bat maternity colonies from May 15 through August 31. However, exceptions are allowed in instances of threat to human health at the discretion of the property owner. Removal of trees, prescribed fire, and land disturbance within a 150 foot radius of known roosts is prohibited from June 1 through July 31. Around hibernacula, from December 1 to April 30 tree removal, prescribed fire, and land disturbance impacting entrances is prohibited. From September 1 to November 30 the radius of protection increases to 0.25 miles, inside of which trees may be harvested, but stipulations require the retention of certain numbers of snags and large, spreading trees based on the size of harvest. Requirements for leaving such trees are imposed to provide sufficient roosting opportunities during fall swarm. In all instances, exceptions may be made when public safety or property damage is of concern. In Virginia, many hibernacula are protected and the VDGIF continues to search for new hibernacula and cooperate with private landowners to minimize disturbance. Further information on Virginia regulations concerning little brown bats is available from (<https://www.dgif.virginia.gov/wp-content/uploads/LBBA_TCBA_Guidance.pdf>). The VDGIF in conjunction with the USGS, Virginia Tech, Radford University, and the Virginia Department of Conservation and Recreation conducts extensive monitoring throughout the state through mist-netting, harp-trapping, acoustic survey, and hibernacula survey (R. Reynolds, VA Dept. of Game and Inland Fisheries, pers. comm.).

*Connecticut*

The little brown bat is listed as state endangered in Connecticut. The Connecticut Department of Energy Environmental Protection (CTDEEP) does not regulate nuisance removals of bats but discourages exclusions during the maternity season, promotes bat house installation, and prohibits lethal controls unless there is public health risk. The Wildlife Division of the CTDEEP performs environmental reviews for state-permitted or state-funded development projects that may recommend restrictions to forest harvest, prescribed burns, or retention of suitable roost trees. The CTDEEP has gated six of its hibernacula, installs bat houses, and provides technical assistance for bat exclusion and management. The CTDEEP engages in public outreach through communication, presentations, and publications. They also began a Bat Appreciation Day featuring posters, talks, and activities promoting bat conservation. The CTDEEP started state-wide acoustic survey in 2011 and continue ongoing monitoring of one of their hibernacula but have discontinued permitting mist net survey in attempt to minimize spread of the fungus and stress to bats (K. Moran, CT Dept. Energy and Env. Protection, pers. comm.).

*Massachusetts*

The little brown bat is state endangered in Massachusetts. The Massachusetts Division of Fisheries and Wildlife (MADFW) provides detailed guidelines on bats and how to exclude them, which is restricted from April 1 through July 30. They conduct scattered acoustic surveys, monitor several persisting maternity colonies, and conduct hibernacula surveys to track changes to little brown bat populations (J. Longsdorf, MA Div. Fisheries and Wildlife, pers. comm.).

**Recommended Conservation Measures:**

The conservation measures for little brown bats utilized by states provide an excellent framework to draw from when considering conservation at the regional or national scale. Enforcement of such regulations is most needed in areas where white-nose syndrome occurs.

Gating hibernacula with bat-friendly gates, or otherwise restricting access to uninfected hibernacula is extremely important for reducing new and distant introductions of the fungus *P. destructans* as in the case of North Bend, Washington (USGS 2016). Although national white-nose decontamination protocols exist, there are no means of enforcing them, so any accessible hibernacula is susceptible to introduction. Restricting access also eliminates direct disturbances to hibernating bats that can increase likelihood of mortality where white-nose syndrome occurs. Enforcement of decontamination protocols for those who are permitted to enter hibernacula will help to slow the spread of white-nose syndrome.

Little brown bats have a strong proclivity for establishing maternity colonies in buildings, and because their numbers and recruitment have been dramatically reduced by white-nose syndrome, protecting their reproduction in dwellings and other structures is essential to their conservation. Restrictions regarding nuisance removal of little brown bats is common among states impacted by white-nose syndrome, but these restrictions are not enacted in all states where it is present. Guidelines that ensure the use of nonlethal removal by trained operators using approved, humane methods such as one-way exclusion will reduce mortality. Prohibiting exclusion during the maternity season, which occurs sometime from May to August depending on location, helps ensure that mothers in persisting maternity colonies are not separated from nonvolant offspring, improving chances of their survival. Additionally, installation of bat boxes can provide alternative roosting locations for maternity colonies.

Restrictions to tree removal in proximity to known maternity colonies and hibernacula during the summer and fall, respectively, help ensure adequate roosting opportunities are available to little brown bats during essential stages of reproduction.

Outreach campaigns to educate the public about the dangers of white-nose syndrome, threat of extinction to little brown bats, and the ecological importance of bats will improve public awareness about this devastating disease and increase public support of conservation initiatives.

**For species that are being removed from candidate status:**

Not applicable

\_\_\_\_ Is the removal based in whole or in part on one or more individual conservation efforts that you

determined met the standards in the [Policy for Evaluation of Conservation Efforts When Making Listing Decisions](http://www.gpo.gov/fdsys/granule/FR-2003-03-28/03-7364/content-detail.html) (PECE)?

**Description of Monitoring:**

See Conservation Measures Planned or Implemented

**Species Assessment/Listing Priority Assignment Form – Development:**

**Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:**

Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, Virginia, West Virginia

**Indicate which State(s) did not provide any information or comment:**

Delaware, Maine, Maryland, Pennsylvania

**State Coordination:**

State agencies, universities, and research institutions participate in joint working groups the Northeast Bat Working Group and Southeastern Bat Diversity Network that have annual meetings to discuss bat management. In regard to conservation and monitoring, state coordination appears to be limited with those where white-nose syndrome is present managing independently. State agencies do cooperate in identifying the locations of forearm-banded bats when captured or observed in hibernacula counts. Are more integrated regional approach to management and conservation would likely benefit state initiatives.

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*Following Section for U.S. Fish and Wildlife Service Use Only*

**Priority Table**

|  |  |  |  |
| --- | --- | --- | --- |
| Magnitude | Immediacy | Taxonomy | Priority |
| High | Imminent | Monotypic genus | 1 |
| Species | 2 |
| Subspecies/Population | 3 |
| Non-Imminent | Monotypic genus | 4 |
| Species | 5 |
| Subspecies/Population | 6 |
| Moderate to Low | Imminent | Monotypic genus | 7 |
| Species | 8 |
| Subspecies/Population | 9 |
| Non-Imminent | Monotypic genus | 10 |
| Species | 11 |
| Subspecies/Population | 12 |

**Rationale for Change in Listing Priority Number:**

**Magnitude:**

**Imminence:**

\_\_\_\_ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

**Emergency Listing Review**

\_\_\_\_ Is Emergency Listing Warranted?

**---------------------------------------------------------------------------------------------------------------------------------------**

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