# Baseline Capture Rates and Roosting Habits of *Myotis septentrionalis* (Northern Long-Eared Bat) Prior to White-Nose Syndrome Detection in the Southern Appalachians

Author(s): Vanessa G. Rojas, Joy M. O'Keefe and Susan C. Loeb
Source: Southeastern Naturalist, 16(2):140-148.
Published By: Eagle Hill Institute
https://doi.org/10.1656/058.016.0202
URL: http://www.bioone.org/doi/full/10.1656/058.016.0202

# Baseline Capture Rates and Roosting Habits of *Myotis septentrionalis* (Northern Long-eared Bat) Prior to White-nose Syndrome Detection in the Southern Appalachians

Vanessa G. Rojas[1,*], Joy M. O'Keefe[1], and Susan C. Loeb[2]

**Abstract** - *Myotis septentrionalis* (Northern Long-eared Bat) is a federally threatened insectivorous bat facing devastating population declines due to white-nose syndrome (WNS). Our study provides pre-WNS (2009) capture rates and roosting-behavior data for Northern Long-eared Bats in the southern Appalachians. We conducted mist-net surveys at 37 sites and radio-tracked female Northern Long-eared Bats to their day roosts in eastern Tennessee and western North Carolina. We compared tree and plot characteristics for roosts and corresponding random trees using Wilcoxon rank-sum tests. Our 43 survey nights yielded 302 bats of 11 species; Northern Long-eared Bats were the most commonly captured species ($n$ = 97). We located 14 unique roosts for 7 radio-tracked bats; *Pinus strobus* (White Pine) snags ($n$ = 8) were the most common roost sites. We observed a colony of 72 bats using a White Pine snag as a maternity roost. Roost trees were significantly larger in diameter and had more solar exposure above the roost and within the plot than random trees. Our data show the high abundance of Northern Long-eared Bats pre-WNS, highlight the use of White Pine roosts in an area impacted by a *Dendroctonus frontalis* (Southern Pine Beetle) outbreak, and support previous determinations of roost-selection flexibility by Northern Long-eared Bats across their range.

## Introduction

*Myotis septentrionalis* (Northern Long-eared Bat) is a small (6–9 g) insectivorous bat found in eastern North America, ranging from southern Canada into the Northeast, Midwest, and most of the southeastern US (Caceres and Barclay 2000). Northern Long-eared Bats hibernate in cold caves and mines during winter (Caceres and Barclay 2000), but roost in forests and forage along forested hillsides and ridges during summer (Foster and Kurta 1999). Despite their wide distribution, Northern Long-eared Bat populations are decreasing rapidly across a large portion of their range due to white-nose syndrome (WNS), a devastating fungal disease that has reduced overwintering populations by >90% in many infected winter hibernacula (USFWS 2016). Due to significant population declines, Northern Long-eared Bats were listed as a federally threatened species (USFWS 2015).

Roosts are crucial to bats for rearing young, protection from weather and predators, and hibernation (Kunz and Lumsden 2003). During spring and summer,

[1]Department of Biology, Indiana State University, Terre Haute, IN 47809. [2]USDA Forest Service, Southern Research Station, Clemson, SC 29634. [*]Corresponding author - vanessaxrojas@gmail.com.

Manuscript Editor: Roger Perry

Northern Long-eared Bats primarily roost in cracks, crevices, and exfoliating bark of trees in upland forests (Lacki et al. 2009, Silvis et al. 2016) and wetlands (Foster and Kurta 1999). However, roost characteristics and tree species used as roosts vary across the species' range. For example, Jung et al. (2004) found that Northern Long-eared Bats use *Pinus strobus* L. (White Pine) snags more than expected in Ontario, Canada. In Michigan, Northern Long-eared Bats mainly use *Acer saccharinum* L. (Silver Maple) and *Fraxinus pennsylvanica* Marsh. (Green Ash), and roost in live trees and snags in about equal proportions (Foster and Kurta 1999). In a pine-dominated landscape in Arkansas, 71% of roosts used by male and female Northern Long-eared Bats were in *Pinus echinata* Mill. (Shortleaf Pine; Perry and Thill 2007).

It is important to know more about the roosting ecology of the Northern Long-eared Bat across its range in order to protect summer populations and habitats, especially during the critical maternity stage, and to protect survivors in areas impacted by WNS. White-nose syndrome was first documented in the southern Appalachian Mountains during the winter of 2009–2010 (USFWS 2010), which followed the period of this study; hence, our work provides pre-WNS data on capture rates and roosting habits of Northern Long-eared Bats in this region. Our data can serve as a reference for future recovery efforts.

## Field-site Description

We worked in a 281,788-ha area in the Great Smoky Mountains National Park, Cherokee National Forest, and Nantahala National Forest, in eastern Tennessee and western North Carolina. Elevation within this area varied from 250 m to 2025 m above sea level (asl), but we focused survey efforts in mixed pine–hardwood forests at <1000 m asl. *Quercus* (oak; 68% of forest cover) and *Pinus* spp. (yellow pine; 15%) (SAMAB 1996) were the most common forest types in our survey areas. The primary vegetation communities used by bats were low-elevation pine, *Tsuga canadensis* (L.) Carriére (Eastern Hemlock), Eastern Hemlock–White Pine, acidic cove, and oak–hickory forests (Schafale 2012). Most of the study area was forested (>90%), mainly with mid-successional forest, but it also contained some young and old-growth forest. Management in this region included prescribed fire and timber harvests (national forests only), however bats were not tracked to recently burned or harvested stands during our study. Natural disturbances included *Dendroctonus frontalis* Zimmermann (Southern Pine Beetle; Nowak et al. 2008) and *Adelges tsugae* Annand (Hemlock Woolly Adelgid; Nuckolls et al. 2009) outbreaks, which caused widespread formations of pine and Eastern Hemlock snags, respectively. Mean minimum and maximum daily temperatures were 15.7 °C and 28.6 °C in June, and 15.7 °C and 27.2 °C in July. Total precipitation was 6.4 cm both in June and July. The State Climate Office of North Carolina Raleigh, NC, provided weather data obtained from a station near the center of our study area (Robbinsville, NC, Station NCHE, elevation 640 m asl).

## Methods

We conducted our study from 1 June to 29 July 2009. We used mist nets (Avinet, Inc., Dryden, NY) to survey for bats at 37 sites located on roads and trails beside perennial streams 10–20 m in width. Our surveys occurred between 2045 and 0200 EDT, with nets checked at 8-minute intervals. For each survey, we placed 2–7 net-sets (single or double-high nets) across roads, trails, and streams with edge and canopy cover that created forested corridors for potential flyways. Capture rates were defined as:

$$\frac{\text{number of bats captured}}{(\text{total net area}) \times (\text{total hours})} \times 1000,$$

where total net area is expressed as $m^2$ and capture rate is presented as captures per 1000 $m^2h$.

We identified captured bats to species and marked them with a uniquely numbered, lipped aluminum forearm band (USFS-SRS or USFS-NC; Lambournes, Ltd., Birmingham, UK) of the appropriate size (2.9 mm or 4.2 mm). We recorded sex, age, reproductive condition, weight (g), and forearm length (mm) of each bat. Based on radio-transmitter availability and time constraints, we selected 8 Northern Long-eared Bats that weighed ≥7 g for radio telemetry; for each bat, we trimmed fur and attached a 0.42-g radio transmitter (Holohil Systems, Ltd., ON, Canada) between the scapulae using surgical glue (Torbot Group, Inc., Cranston, RI). We released all bats at the point of capture. Animal capture and handling methods were approved by the Clemson University Animal Research Committee (Animal Use Protocol 2009-016) and conducted under the American Society of Mammalogists' guidelines (Animal Care and Use Committee 1998). Field work was conducted under permits held by J.M. O'Keefe: USFWS federal recovery permit TE206872, North Carolina permit ES261, Tennessee permit 3148, and National Park Service Permits GRSM-2009-SCI-0075 and GRSM-2012-SCI-0085.

Using a Telonics TR-5 receiver (Telonics, Inc., Mesa, AZ) and a 3-element Yagi antenna, we radio-tracked bats to day roosts and recorded GPS coordinates for each tree location. For 6 roosts, we were able to visually locate the specific roost location on the tree and confirm roost sites with observations at dusk, counting bats that emerged from the tree. For roost trees containing ≥2 bats (all snags), we identified a random snag with visible roost potential (i.e., bark peeling from the tree trunk or a crevice). We used a method described by O'Keefe and Loeb (2017) to locate a random snag to pair with a known roost, which facilitated stand-level comparisons between roosts and random trees. We recorded tree and plot characteristics for 8 of the 14 roost trees and 6 corresponding random trees. Time and personnel constraints made it impossible for us to complete random plots for every roost. Thus, we prioritized measuring random-tree characteristics for roosts with ≥2 bats. Two roost trees were within the same 0.1-ha plot, which was centered between the 2 roosts and matched with 1 random plot; thus, we measured only 7 plots for 8 roost trees. At each tree (roost or random; hereafter, focal tree), we recorded species, diameter at breast height (DBH, cm), and tree height (m). We documented total number of live trees and snags ≥10 cm DBH in a 0.1-ha plot around each focal tree. We tallied all saplings ≤8.9 m from the focal tree. We estimated percent canopy closure to the nearest 25% for the entire plot and directly above the focal tree. For each focal tree, we measured distance to the nearest road (m) and stream (m) in a GIS (ArcMap v10, Esri, Redlands, CA). The National Park Service and USDA Forest Service provided spatial data for major roads and minor roads/trails; we acquired stream data from the National Hydrography Dataset (USGS 2013). We used Wilcoxon rank-sum tests to compare quantitative traits of roost and random plots, and present means ± 1 standard error for these variables and for elevation, aspect, and slope of roost locations.

## Results

We conducted 43 nights of netting, for a total effort of 11,202 $m^2h$ (net area × hours), and captured 302 bats of 11 species (Table 1). We averaged 7 captures per survey night, with a variation of 0–29 bats; only 2 nights did not yield captures. Northern Long-eared Bats and *Lasiurus borealis* (Eastern Red Bat) were captured most often; 97 and 58 captures, respectively. We captured 38 adult female, 31 adult male, and 26 juvenile Northern Long-eared Bats, plus 2 individuals (1 male) with incomplete data. The capture rate across the entire season for Northern Long-eared Bats was 8.66 bats per 1000 $m^2h$ (Table 1). A typical survey night (81.5 $m^2$ total net area × 3.15 hours) yielded 2.22 Northern Long-eared Bats with a maximum of 10 bats captured during 1 net night; we did not capture this species on 10 survey nights.

We radio-tracked 8 reproductive female Northern Long-eared Bats (2 pregnant, 4 lactating, 2 post-lactating) and documented 14 unique roosts for 7 bats. Roost trees were used 1−4 days each over tracking periods of 2–5 days/bat (mean = 4.3 days/bat). Of the 14 roost trees we located, 11 were snags: 8 White Pine, 2 *Pinus virginiana* Mill. (Virginia Pine), and 1 *Quercus rubra* L. (Northern Red Oak). The

Table 1. Capture results from 43 summer mistnetting surveys of Northern Long-eared Bats in the Cherokee National Forest, Nantahala National Forest, and Great Smoky Mountains National Park in June and July 2009. Capture results include total number of individuals captured during 43 surveys (# bats), and capture rate ([# bats captured / (total net area × total hours)] x 1000) or captures per 1000 $m^2h$.

| Species | Authority | Common name | # bats | Rate |
|---|---|---|---|---|
| *Corynorhinus rafinesquii* | Lesson | Rafinesque's Big-eared Bat | 3 | 0.27 |
| *Eptesicus fuscus* | Palisot de Beauvois | Big Brown Bat | 35 | 3.12 |
| *Lasiurus borealis* | Müller | Eastern Red Bat | 58 | 5.18 |
| *Lasiurus cinereus* | Palisot de Beauvois | Hoary Bat | 2 | 0.18 |
| *Lasionycteris noctivigans* | La Conte | Silver-haired Bat | 9 | 0.80 |
| *Myotis leibii* | Audubon and Bachman | Eastern Small-footed Bat | 1 | 0.09 |
| *Myotis lucifugus* | Le Conte | Little Brown Bat | 29 | 2.59 |
| *Myotis septentrionalis* | Trouessart | Northern Long-eared Bat | 97 | 8.66 |
| *Myotis sodalis* | Miller and Allen | Indiana Bat | 46 | 4.11 |
| *Nycticeius humeralis* | Rafinesque | Evening Bat | 3 | 0.27 |
| *Perimyotis subflavus* | F. Cuvier | Tri-colored Bat | 19 | 1.70 |

remainder of the roosts were in live trees: 1 *Acer rubrum* L. (Red Maple), 1 *Quercus alba* L. (White Oak), and 1 damaged hardwood sapling (unidentified species). We recorded and analyzed tree and plot characteristics for 8 focal roost-trees, all snags: 6 White Pine, 1 Virginia Pine, and 1 Northern Red Oak. White Pine roosts were at all slope positions (lower, mid, and upland), whereas the Virginia Pine and the Northern Red Oak were upland roosts. Roost trees were at a mean elevation of 473 ± 78 m, a mean slope of 32.3 ± 22.2%, and were usually south-facing (mean aspect = 187 ± 75°). Roost trees had an average diameter of 58.2 ± 8.1 cm and were significantly larger than random trees ($P = 0.008$; Table 2). Canopy closure above roost trees (22 ± 9%) was less than half the closure above random trees ($P = 0.03$). Within the 0.1-ha plot, canopy closure was significantly less than closure in random plots ($P = 0.002$). Roosts were closer to streams than roads, with a mean distance of 98 ± 24 m to a stream and 1140 ± 367 m to a road.

We conducted 1 emergence count at 6 focal trees. The largest colony sizes detected were 72 bats roosting under exfoliating bark of a White Pine snag (27.0 m tall, 94.2 cm DBH) and 19 individuals under exfoliating bark of another White Pine snag (22.0 m tall, 89.5 cm DBH), both located in Great Smoky Mountains National Park. We noted 4 other roosts under exfoliating bark of snags (11.9–39.0 m tall, 42–62 cm DBH) that held 1–4 bats each. We conducted all emergence counts in early to mid-June (pre-volant period), except 1, which was conducted in early July and yielded only 1 bat. We counted only bats that emerged from roost trees.

## Discussion

This study presents capture rates and the first description of roost-tree characteristics for Northern Long-eared Bats in the southern Appalachian Mountains of North Carolina and Tennessee. During the study period, Northern Long-eared Bats were relatively common; we captured more of them per typical net-night than all

Table 2. Mean (± SE) characteristics of Northern Long-eared Bat tree roosts, random trees, and habitat within 0.1-ha plots centered on focal trees in the Cherokee National Forest, Nantahala National Forest, and Great Smoky Mountains National Park in June and July 2009. $W$ = Wilcoxon rank-sum test statistic and $P$ = significance measured at $\alpha < 0.05$.

| | Roost plots ($n$ = 8) | | Random plots ($n$ = 6) | | |
|---|---|---|---|---|---|
| Characteristic | Mean | Variation | Mean | $W$ | $P$ |
| Height (m) | 20.5 ± 4.0 | 4.6–39.0 | 12.4 ± 1.5 | 15.0 | 0.282 |
| Diameter (cm) | 58.2 ± 8.1 | 28.8–94.2 | 22.8 ± 6.4 | 4.0 | 0.008 |
| % bark remaining | 59 ± 7 | 30–80 | 63 ± 17 | 29.0 | 0.558 |
| % canopy closure above roost | 22 ± 9 | 0–50 | 67 ± 15 | 40.5 | 0.032 |
| % plot canopy closure | 50 ± 6 | 25–69 | 83 ± 3 | 48.0 | 0.002 |
| # snags in plot | 11 ± 2 | 4–19 | 10 ± 5 | 11.5 | 0.120 |
| # live trees in plot | 40 ± 7 | 17–79 | 49 ± 4 | 38.5 | 0.069 |
| # saplings | 80 ± 18 | 34–168 | 59 ± 15 | 20.5 | 0.698 |
| Distance to road (m) | 1140 ± 367 | 367–3313 | 1227 ± 427 | 26.0 | 0.852 |
| Distance to water (m) | 98 ± 24 | 14–228 | 452 ± 234 | 34.5 | 0.196 |

other bat species. Our documentation of a large pre-volant colony (72 bats emerged) in a White Pine snag that was likely killed by Southern Pine Beetles (Nowak et al. 2008), is similar to findings in other regions. For example, pre-volant colony sizes for Northern Long-eared Bats have been as high as 60 bats using a cavity roost in a live Silver Maple in Michigan (Foster and Kurta 1999), 65 in a hardwood in West Virginia (Menzel et al. 2002), and 75 in a Northern Red Oak snag in North Carolina (O'Keefe 2009). This study was done in tandem with a higher priority *Myotis sodalis* (Indiana Bat) project. Our limited data for Northern Long-eared Bats relate to time and personnel constraints, and we recognize these limitations (e.g., small sample-size collected and data for only 1 year; Silvis et al. 2015); however, given the decline of Northern Long-eared Bat populations (USFWS 2016) and our limited ability to obtain further data on this species, the data presented here are highly valuable for developing conservation and recovery strategies for this species in the Southern Appalachians.

Northern Long-eared Bat roost-tree selection appears to vary by region, suggesting they are a flexible species. Our study was not the first to document the use of pine by Northern Long-eared Bats. Male Northern Long-eared Bats in central Ontario use White Pine roosts most often and more than would be expected if they utilized that tree species in proportion to availability (Jung et al. 2004). In northeastern Kentucky, Northern Long-eared Bat roosting is mainly solitary and in Shortleaf Pine and *Oxydendrum arboreum* (*L*.) DC. (Sourwood) (Lacki and Schwierjohann 2001). Northern Long-eared Bats in Arkansas prefer Shortleaf Pine snag roosts over hardwood snags (Perry and Thill 2007). In South Dakota, female Northern Long-eared Bats roost in *Pinus ponderosa* L. (Ponderosa Pine), most of which are snags (81%; Cryan et al. 2001). Although Northern Long-eared Bats use primarily oak species along with other hardwoods in northwestern North Carolina, they have also been documented using White Pine and 2 unknown *Pinus* species (O'Keefe 2009). However, selection for hardwood roosts predominates for this species throughout much of its distribution. Examples of hardwoods used by lactating females include *Robinia pseudoacacia* L. (Black Locust) (WV; Johnson et al. 2009, Menzel et al. 2002), *Sassafras albidum* (Nutt.) Nees (Sassafras) (KY; Silvis et al. 2012), Silver Maple (MI; Foster and Kurta 1999), *Fagus grandifolia* Ehrh. (American Beech) (NH; Sasse and Pekins 1996), and *Quercus palustris* Münchh. (Pin Oak) (IL; Carter and Feldhamer 2005).

All of the roosts we observed were under bark, yet it is also common for Northern Long-eared Bats to use crevices and cavities. We might expect roost type (bark or crevice) to be predicted by tree species, but there is variation. Our results were similar to findings of Jung et al. (2004) who found that Northern Long-eared Bats roost primarily under exfoliating bark (81.8% of roosts), mainly in White Pine snags. However, current data suggest Northern Long-eared Bats are flexible with regard to where in the tree they roost, using both cavities and crevices (Johnson et al. 2009, Lacki et al. 2009, Silvis et al. 2012). For example, in Arkansas, female Northern Long-eared Bats roost under bark and in crevices at similar rates (43%), and cavities minimally (14%), whereas males use bark roosts (61%) more often than cavities (25%) and crevices (15%); most roosts were in Shortleaf Pine snags (67%; Perry and Thill 2007). Nearly equal bark- and cavity-use proportions have been documented in hardwood roosts used by Northern Long-eared Bats in Michigan (Foster and Kurta 1999). Many researchers do not present roost- and available-tree characteristics such as decay stage, percentage of bark available, or presence of cavities. With limited information available on specific characteristics of Northern Long-eared Bat roosts across the species' range, we cannot conclude that the use of bark, crevice, or cavity is dependent on tree species.

Large trees with moderate to abundant solar exposure are important maternity roosts for Northern Long-eared Bats. Although roost and random plots were similar in snag, live tree, and sapling counts, they differed in canopy closure, both above the roost and within the plot. Canopy closure at roosts varies from 22% to 83% across various Northern Long-eared Bat habitats in different portions of its range. Bats in our study used trees with greater mean solar exposure (22 ± 9% canopy closure) than populations in the Midwest (39–44%; Carter and Feldhamer 2005, Foster and Kurta 1999, Jung et al. 2004), Northeast (83%; Sasse and Pekins 1996), and Central Appalachians (66–92%; Lacki and Schwierjohann 2001, Menzel et al. 2002). Regional variation might be explained by differences in ambient conditions and characteristics of available roosts (Patriquin et al. 2016).

We have presented data on capture rates and the roosting characteristics of Northern Long-eared Bats in the southern Appalachians to aid in defining suitable summer habitat for the species across its range. Our capture-rate data provide pre-WNS records in a region now heavily impacted by this disease. Our data support the notion that roosting flexibility helps explain why Northern Long-eared Bats were once a common forest bat with a wide distribution (Lacki et al. 2009). Recognizing that populations are being drastically impacted by WNS, we recommend future surveys to locate roosts and determine relative abundance of Northern Long-eared Bats.

## Acknowledgments

We thank Dylan Horvath, Caroline Byrne, Dottie Brown, Mary Miller, and Eric Winters for field assistance. We thank the National Park Service, US Forest Service Southern Research Station, Clemson University, and the Tallassee Fund (administered by Tennessee Wildlife Resources Agency) for funding and logistical support. We thank the manuscript editor and 2 reviewers for comments that improved the manuscript.

## Literature Cited

Animal Care and Use Committee. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. Journal of Mammalogy 79:1416–1431.

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

Carter, T.C., and G.A. Feldhamer. 2005. Roost-tree use by maternity colonies of Indiana Bats and Northern Long-eared Bats in southern Illinois. Forest Ecology and Management 219:259–268.

Cryan, P.M., M.A. Bogan, and G.M. Yanega. 2001. Roosting habits of four bat species in the Black Hills of South Dakota. Acta Chiropterologica 3:43–52.

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

Johnson, J.B., J.W. Edwards, W.M. Ford, and J.E. Gates. 2009. Northern Myotis (*Myotis septentrionalis*) roost-tree selection in a central Appalachian Mountains hardwood forest subjected to prescribed fire. Forest Ecology and Management 258:233–242.

Jung, T.S., I.D. Thompson, and R.D. Titman. 2004. Roost-site selection by forest-dwelling male *Myotis* in central Ontario, Canada. Forest Ecology and Management 202:325–335.

Kunz, T.H., and L.F. Lumsden. 2003. Ecology of cavity- and foliage-roosting bats. Pp. 3–89, *In* T.H. Kunz, and M.B. Fenton (Eds.). Bat Ecology. University of Chicago Press, Chicago, IL. 779 pp.

Lacki, M.J., and J.H. Schwierjohann. 2001. Day-roost characteristics of northern bats in mixed mesophytic forest. Journal of Wildlife Management 65:482–488.

Lacki, M.J., D.R. Cox, and M.B. Dickinson. 2009. Meta-analysis of summer roosting characteristics of two species of *Myotis* bats. American Midland Naturalist 162:318–326.

Menzel, M.A., S.F. Owen, W.M. Ford, J.W. Edwards, P.B. Wood, B.R. Chapman, and K.V. Miller. 2002. Roost-tree selection by Northern Long-eared Bat (*Myotis septentrionalis*) maternity colonies in an industrial forest of the central Appalachian Mountains. Forest Ecology and Management 155:107–114.

Nowak, J., C. Asaro, K. Klepzig, and R. Billings. 2008. The Southern Pine Beetle prevention initiative: Working for healthier forests. Journal of Forestry 106:261–267.

Nuckolls A.E., N. Wurzburger, C.R. Ford, R.L. Hendrick, J.M. Vose, and B.D. Kloeppel. 2009. Hemlock declines rapidly with Hemlock Woolly Adelgid infestation: Impacts on the carbon cycle of southern Appalachian forest. Ecosystems 12:179–190.

O'Keefe, J.M. 2009. Roosting and foraging ecology of forest bats in the southern Appalachian Mountains. Ph.D. Dissertation. Clemson University, Clemson, SC. 152 pp.

O'Keefe, J.M., and S.C. Loeb. 2017. Indiana Bats roost in ephemeral, fire-dependent pine snags in the southern Appalachian Mountains, USA. Forest Ecology and Management 391:264–274.

Patriquin, K.L., M.L. Leonard, H.G. Broders, W.M. Ford, E.R. Britzke, and A. Silvis. 2016. Weather as a proximate explanation for fission–fusion dynamics in female Northern Long-eared Bats. Animal Behaviour 122:47–57.

Perry, R.W., and R.E. Thill. 2007. Roost selection by male and female Northern Long-eared Bats in a pine-dominated landscape. Forest Ecology and Management 247:220–226.

Sasse, D.B., and P.J. Pekins. 1996. Summer roosting ecology of Northern Long-eared Bats (*Myotis septentrionalis*) in the White Mountain National Forest. Pp. 91–101, *In* R.M.R. Barclay, and R.M. Brigham (Eds.). Bats and Forests Symposium. Canada Research Branch, B.C. Ministry of Forestry, Victoria, BC, Canada. 292 pp.

Schafale, M.P. 2012. Guide to the natural communities of North Carolina, 4$^{th}$ approximation. North Carolina Heritage Program, Department of Environment and Natural Resources, Raleigh, NC. 209 pp.

Silvis, A., W.M. Ford, E.R. Britzke, N.R. Beane, and J.B. Johnson. 2012. Forest succession and maternity-roost selection by *Myotis septentrionalis* in a mesophytic hardwood forest. International Journal of Forestry Research. Available online at http://dx.doi.org/10.1155/2012/148106. Accessed 6 March 2017.

Silvis, A., W.M. Ford, and E.R. Britzke. 2015. Day-roost tree selection by Northern Long-eared Bats: What do random-tree comparisons and one year of data really tell us? Global Ecology and Conservation 3:756–763.

Silvis, A., R.W. Perry, and W.M. Ford. 2016. Relationships of three species of white-nose syndrome-impacted bats to forest condition and management. General Technical Report SRS-214. US Forest Service, Southern Research Station, Asheville, NC. 57 pp.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian assessment terrestrial technical report. Report 5 of 5. US Department of Agriculture, Forest Service, Southern Region, Atlanta, GA. Available online at http://www.samab.org/wp-content/uploads/2011/06/SAMAB_SAA_terrestrial_report.pdf. Accessed 6 March 2017.

US Geological Survey (USGS). 2013. National Hydrography Dataset (NHD). Available online at http://nhd.usgs.gov/data.html. Accessed 1 February 2013.

US Fish and Wildlife Service (USFWS). 2010. TWRA confirms first cases of white nose syndrome in Tennessee bats (press release). Available online at https://www.fws.gov/southeast/news/2010/r10-014.html. Accessed 23 August 2016.

USFWS. 2015. Endangered and threatened wildlife and plants; Threatened species status for the Northern Long-eared Bat with 4(d) Rule. Federal Register 80 (2 April 2015, 50 CFR 17):17973–18033. Available online at https://federalregister.gov/a/2015-07069. Accessed 26 April 2016.

USFWS. 2016. Endangered and threatened wildlife and plants; Determination that designation of critical habitat is not prudent for the northern long-eared bat. Federal Register 81 (27 April 2016; 50 CFR 17):24707–24717. Available online at https://federalregister.gov/a/2016-09673. Accessed 26 April 2016.