Summary of 2016 Northern Long-eared Bat Research in Minnesota

Morgan Swingen[1], Richard Baker[2], Timothy Catton[3], Kari Kirschbaum[4], Gerda Nordquist[5], Brian Dirks[6], Ron Moen[1,7]

December 2016

Author Affiliations:
[1]Land, Water and Environment, Natural Resources Research Institute, University of Minnesota Duluth, Duluth, MN
[2]Division of Ecological and Water Resources, Minnesota Department of Natural Resources, St. Paul, MN
[3]Superior National Forest, USDA – Forest Service, Duluth, MN
[4]Chippewa National Forest, USDA – Forest Service, Cass Lake, MN
[5] Minnesota Biological Survey, Minnesota Department of Natural Resources, St. Paul, MN
[6] Camp Ripley Environmental Office, Minnesota Department of Natural Resources, Little Falls, MN
[7]Biology Department, Swenson College of Science and Engineering, University of Minnesota Duluth, Duluth, MN

NRRI Technical Report No. NRRI/TR-2016-41 Release 1.0

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Summary

Crews from the USDA – Forest Service, University of Minnesota - Natural Resources Research Institute, Minnesota Army National Guard (MNARNG), and Minnesota Department of Natural Resources captured 646 bats throughout the forested region of Minnesota from June 6 – July 21, 2016. Bats of 8 species were captured during mist-netting surveys, including the first evening bat (*Nycticeius humeralis*) confirmed in Minnesota. We captured 95 individuals of our target species, the northern long-eared bat, and attached transmitters to 45 adult females (39 reproductive, 6 non-reproductive or undetermined). These 45 bats were tracked to 111 unique roost trees of at least 20 species. Crews conducted emergence counts at roost trees and observed between 1-71 bats emerging. Roost trees varied in both DBH and height, as well as decay stage. The roosting patterns observed in 2016 were similar to those seen in 2015, where bats appear to be using a variety of available trees.

Introduction

Bats are an important part of Minnesota's ecosystems, likely providing many millions of dollars in pest control each year (Boyles et al. 2011). Seven species of bats are known residents of Minnesota: little brown bats (*Myotis lucifugus,* MYLU), northern long-eared bats (*Myotis septentrionalis*, MYSE), big brown bats (*Eptesicus fuscus,* EPFU), tricolored bats (*Perimyotis subflavus*, PESU), silver-haired bats (*Lasionycteris noctivagans,* LANO), eastern red bats (*Lasiurus borealis*, LABO), and hoary bats (*Lasiurus cinereus*, LACI). Four Minnesota bat species (MYSE, MYLU, EPFU, and PESU) hibernate in caves during the winter, and disperse widely across the state in spring, summer, and fall. Very little is known about the summer habitat use of these species.

The northern long-eared bat was listed as Threatened under the federal Endangered Species Act in April 2015, largely due to the impact of white-nose syndrome (U.S. Fish and Wildlife Service 2016). White-Nose Syndrome (WNS) is caused by the fungus *Pseudogymnoascus destructans* which leads to increased winter activity and extremely high mortality rates of cave-hibernating bats (Frick et al. 2010). WNS was discovered in New York state in 2006, and has been spreading through bat populations in the eastern U.S. states and Canadian provinces, with range expansions of WNS occurring every year (Turner et al. 2011). Winter hibernacula monitoring detected *P. destructans* in Minnesota in 2013, and recorded the first bat mortalities during January 2016 at Lake Vermilion - Soudan Underground Mine State Park (Minnesota Department of Natural Resources 2013, 2016a). Maintaining reproductive success will be critical to the viability of Minnesota's bat populations as WNS spreads in Minnesota. Obtaining knowledge about maternity roosts before a population decline occurs will be critical for future efforts to reduce negative impacts of forest management and provide high quality habitat to support recovery of bat populations. Implementing management strategies that minimize mortality will be of over-riding importance as WNS continues to affect Minnesota bats.

In 2015, the Minnesota legislature approved $1.25 million in Environment and Natural Resources Trust Fund (ENRTF) funding for the project *Endangered Bats, White-Nose Syndrome, and Forest Habitat* (M.L. 2015 Project 004-A), the goal of which is to collect data on the distribution and habitat use of the northern long-eared bat in Minnesota. This project is being conducted by the Minnesota Department of Natural Resources (MNDNR), the University of Minnesota Duluth – Natural Resources Research Institute (NRRI), the Minnesota Army National Guard (MNARNG), and the USDA-Forest Service (USFS). We are collecting data from across the state during 2015-2017. Preliminary data from 2015 were summarized in a report released in the fall of 2015 (Swingen et al. 2015). This report summarizes results from the 2016 field season of the ENRTF-funded project, with support from additional funding sources.

Methods

Bat Capture/Processing

Field crews set up fine mesh mist-nets (Avinet Inc, Dryden, NY, USA) along forested roads that could act as travel corridors for bats. Each night, 2-4 mist-nets were set up within 200 m of a central processing location. We opened mist-nets after sunset, and checked them every 15 minutes for 2-5 hours, depending on capture rates and weather conditions.

We identified each captured bat to species, and determined sex, age, and reproductive condition by physical examination. Each bat was also weighed and measured, and the wings were inspected for damage potentially caused by white-nose syndrome (Fig. 1, Fig. 2). Wing condition was scored from 0-3 according to the Reichard wing-damage index (Reichard and Kunz 2009). We then fitted each bat with an individually-numbered lipped aluminum wing band (Porzana Ltd., Icklesham, United Kingdom).

Figure 1. Photos showing the techniques for capturing and processing bats. Photo Credits: A – Superior National Forest; B, D – Brian Houck, NRRI; C – Peter Kienzler, NRRI.

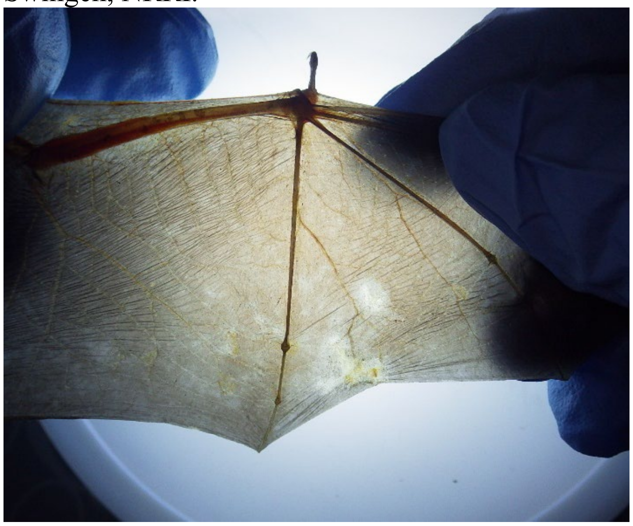
A: Mist-nets are raised on poles with a pulley system

B: A bat flies into the mist-net and is caught

C: Bats are handled with disposable nitrile gloves to prevent spread of WNS between bats

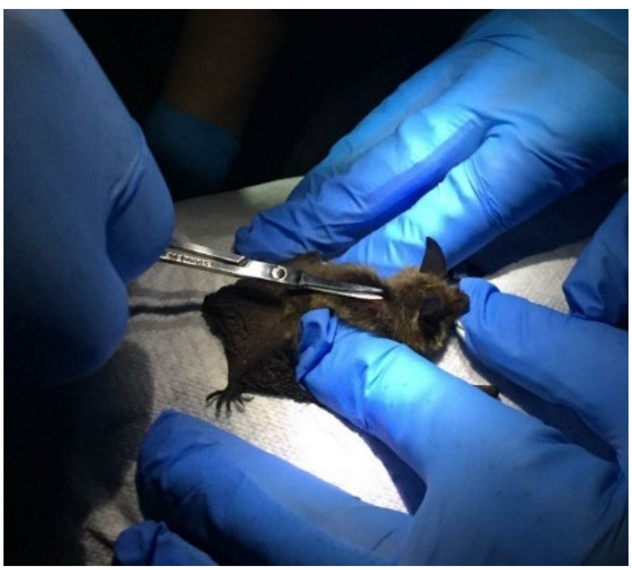
D: Bats are temporarily placed in plastic bags to measure the length of the forearm

Figure 2. Photos showing techniques for processing bats and attaching bands and transmitters. Photo Credits: A – Christi Spak, MN DNR; B – Ryan Pennesi, USFS; C – Sarah Baker, NRRI D – Morgan Swingen, NRRI.

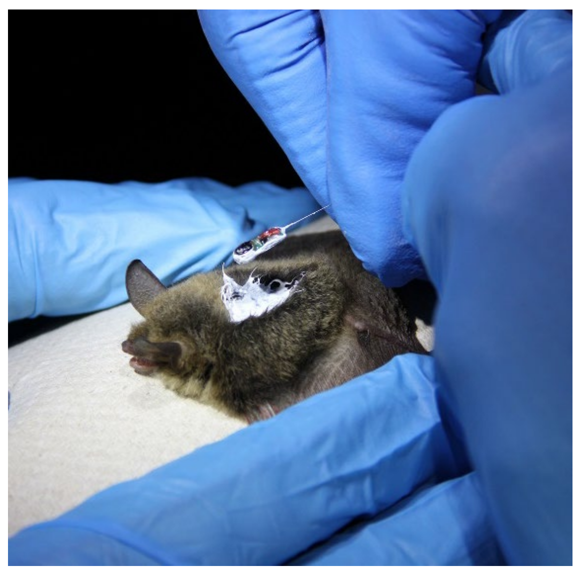


A: The wings are examined for damage consistent with WNS

B: A numbered band is attached to the forearm



C: A small patch of fur is trimmed from between the shoulder blades of bats receiving transmitters



D: A small transmitter is glued to the skin of the bat using surgical adhesive

Field crews attached radio-transmitters (A2414 Advanced Telemetry Systems Inc., Isanti, MN; or LB-2X, Holohil Systems Ltd., Carp, ON, Canada) to adult female MYSE. We trimmed a section of hair in the center of the back, and used surgical adhesive (Perma-Type, Permatype Company Inc., Plainville, CT, USA) to attach the transmitter to the skin (Fig. 2). We released all bats at the capture site after processing.

Tracking/Roost Tree Characterization

We tracked bats with radio-transmitters daily to their roosts using radio telemetry until the transmitter failed or fell off. Data recorded at each roost included roost type, tree species, and decay stage. At dusk, crews returned to the roost trees to conduct emergence surveys. During an emergence survey, personnel watched the roost tree from 30 minutes before sunset to 1 hour after sunset. During the survey we recorded the number of bats emerging during each 10-minute interval, the location of the exit point, and whether or not the transmitter left the tree.

Crews returned to each roost tree to conduct a more detailed tree characterization after bats left. This included measuring roost diameter at breast height (dbh), tree height, decay stage, canopy closure, slope, aspect, and recording details about the vegetation surrounding the roost tree. The same data were collected at two randomly chosen trees within 200 m from the roost tree. We used two-tailed unequal variances t-tests ($\alpha = 0.05$) to compare measurements of roost trees to random trees.

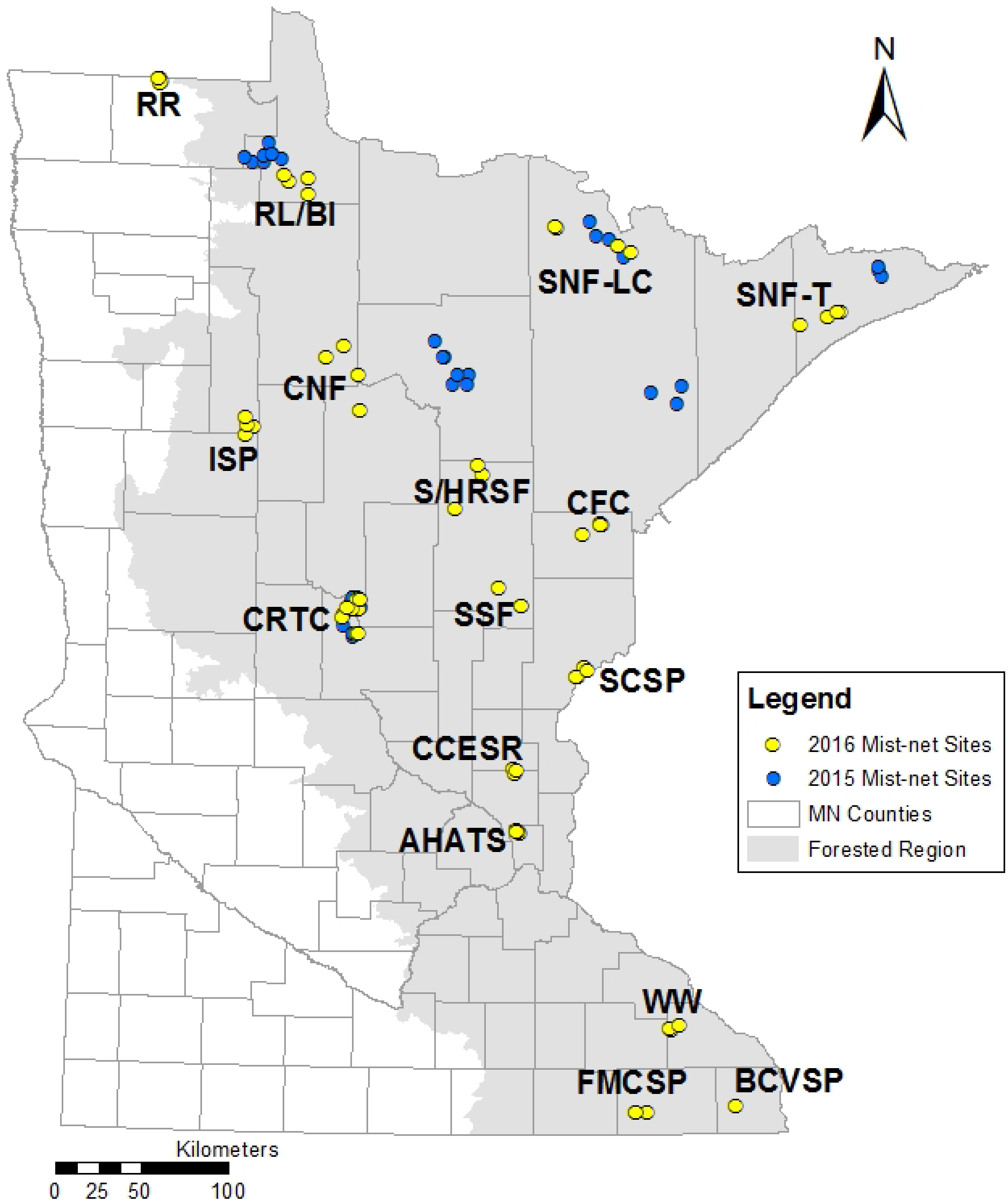
Study Area

We captured bats with mist-nets at 16 study areas throughout the forested region of the state of Minnesota (Table 1, Fig. 3).

Table 1. Names and abbreviations of study areas and dates during which bat mist-netting took place during the 2016 field season.

Study Area Name	Abbreviation	MN County	Ownership	Net Dates
Arden Hills Army Training Site	AHATS	Ramsey	Federal	7/6 - 7/9
Beaver Creek Valley State Park	BCVSP	Houston	State	6/18
Camp Ripley Training Center	CRTC	Morrison, Crow Wing	State	6/6 - 6/23
Cedar Creek Ecosystem Science Reserve	CCESR	Anoka, Isanti	University of MN	7/6 - 7/8
Cloquet Forestry Center	CFC	Carlton	University of MN	6/6 - 6/9
Chippewa National Forest – Blackduck and Walker Districts	CNF	Beltrami, Cass, Itasca	Federal	6/20 - 6/23
Forestville/Mystery Cave State Park	FMCSP	Fillmore	State	6/7 - 6/9
Itasca State Park	ISP	Becker, Clearwater, Hubbard	State	6/13 - 6/16
Red Lake WMA/Beltrami Island State Forest	RL/BI	Lake of the Woods, Roseau	State	7/12 - 7/15
Roseau River Wildlife Management Area	RR	Roseau	State	7/11 - 7/14
Savanna/Hill River State Forests	S/HRSF	Aitkin, St. Louis	State	6/13 - 6/16
Superior National Forest – LaCroix District	SNF-LC	Koochiching, St. Louis	Federal	6/27 - 6/30
Superior National Forest – Tofte District	SNF-T	Cook, Lake	Federal	7/18 - 7/21
Solana State Forest	SSF	Aitkin	State	7/11 - 7/14
St. Croix State Park	SCSP	Pine	State	6/26 - 6/29
Whitewater SP/Whitewater WMA	WW	Winona	State	6/15 - 6/17

Figure 3. Map of all 2015 and 2016 mist-netting locations. Mist-netting sites are generally clustered in groups of 2-4 in each location. 2016 study areas are labeled with abbrevations as listed in Table 1.



Results

Mist-Netting

We conducted 62 nights of mist-netting between June 6th and July 21st, 2016, with multiple crews operating simultaneously across the state. Mist-netting took place for 3 or 4 nights at each study area, with the exception of Beaver Creek Valley State Park which had only one night of mist-netting, and Camp Ripley Training Center which had 10 nights of mist-netting.

Species Captured

We captured and processed 646 bats over 900 net-hours (Fig. 4). We captured individuals of all seven native bat species, and also captured the first confirmed evening bat (*Nycticeius humeralis*) in Minnesota (Fig. 5, Table 2).

Figure 4. Map of bat mist-netting capture results in 2016 for all species. Capture results are displayed by site as listed in Table 1. The size of the symbol at each site represents the capture rate (bats/net-hour), and the label at each site indicates the total number of individuals captured.

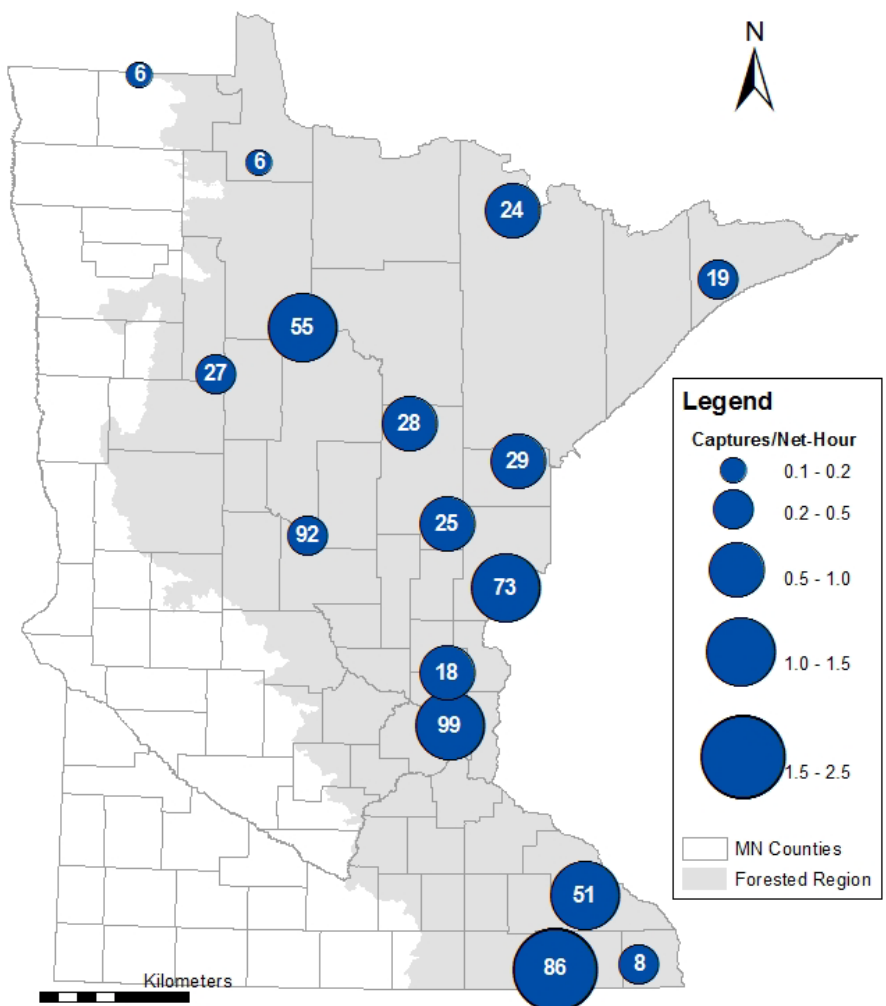
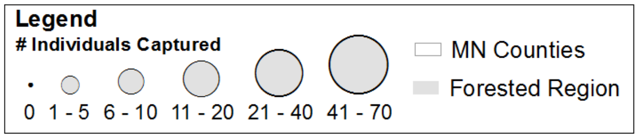
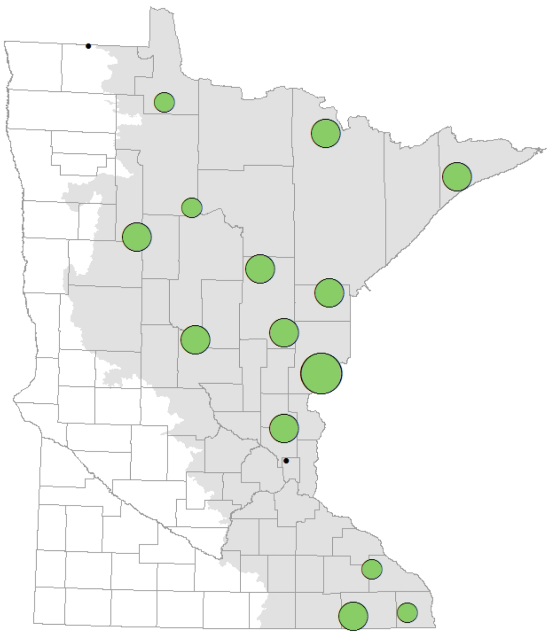
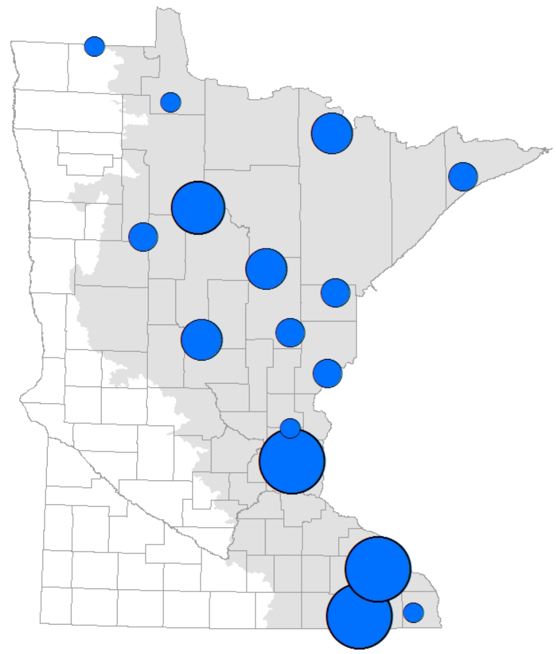


Figure 5. Maps of bat mist-netting capture results by species in 2016. Capture results are displayed by site as listed in Table 1. See Table 2 for total captures by species.

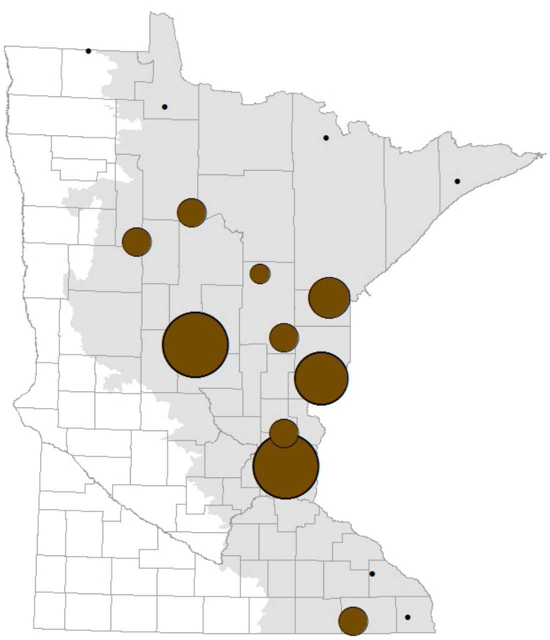




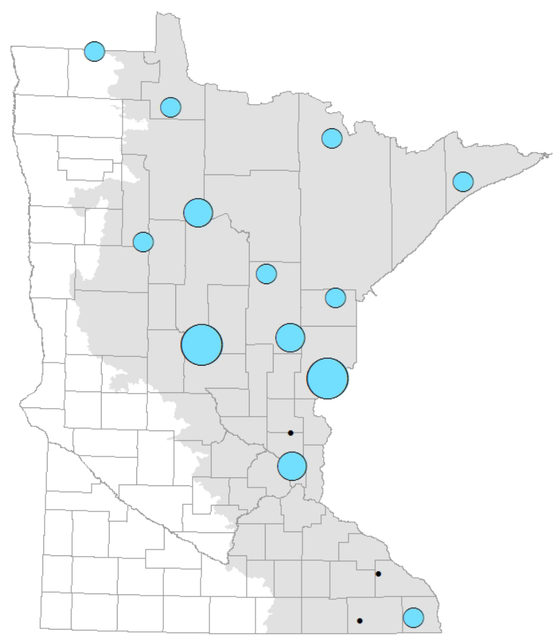
Northern long-eared bat



Little brown bat



Big brown bat



Eastern red bat

Figure 5 continued. Maps of bat mist-netting capture results by species in 2016. Capture results are displayed by site as listed in Table 1. See Figure 4 for capture totals at each site.

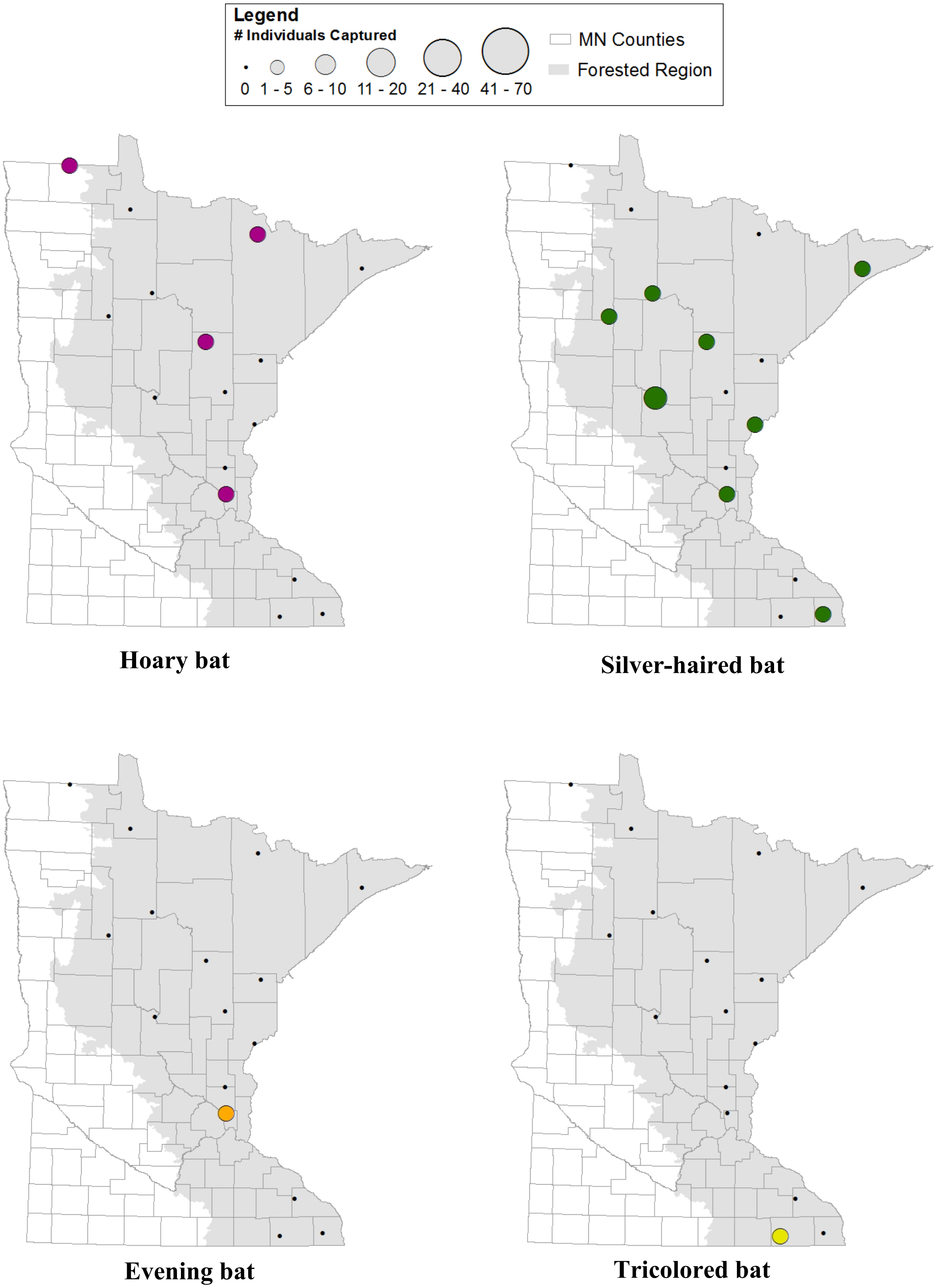


Table 2. Count of bats captured and processed during the 2016 field season by species and sex. EPFU – big brown bat, LABO – eastern red bat, LACI – hoary bat, LANO – silver-haired bat, MYLU – little brown bat, MYSE – northern long-eared bat, NYHU – evening bat, PESU – tricolored bat.

	Species Code								
Sex	**EPFU**	**LABO**	**LACI**	**LANO**	**MYLU**	**MYSE**	**NYHU**	**PESU**	**Total**
Female	76	23	6	12	175	58	1	0	**351**
Male	108	30	1	9	109	37	0	1	**295**
Total	**184**	**53**	**7**	**21**	**284**	**95**	**1**	**1**	**646**

Age and Reproductive Status of Captured Bats

Most bats captured were adults, but 49 juveniles were also captured, with the earliest juvenile captured being an EPFU captured on 7/6/2016 at AHATS. The first juvenile *Myotis* spp. was a MYLU captured on 7/7/2016, also at AHATS. Most captured female bats were pregnant or lactating, with the first lactating bat captured on 6/13/2016 (LACI) at S/HRSF and the first lactating *Myotis* spp. captured on 6/17/2016 at WW (Table 3).

Table 3. Number of individual bats captured of all species by age and reproductive condition by week. P – Pregnant, L – Lactating, TD – Testes descended, NR – Non-reproductive, U – Undetermined. This table only includes those adult bats for which the reproductive assessment had medium or high confidence.

		Adult Female				**Adult Male**			**Juvenile**	**Total Bats**
Week of Capture	**Net-Hours**	**P**	**L**	**NR**	**U**	**TD**	**NR**	**U**	**NR**	
6/6 - 6/12/2016	158	68	0	2	1	5	23	6	0	**105**
6/13 - 6/19/2016	211	58	12	3	1	11	32	6	0	**123**
6/20 - 6/26/2016	162	27	15	10	1	8	36	1	0	**98**
6/27 - 7/3/2016	86	6	18	6	0	4	51	0	0	**85**
7/4 - 7/10/2016	94	0	41	5	0	10	16	1	42	**115**
7/11 - 7/17/2016	136	6	2	4	0	8	14	1	0	**35**
7/18 - 7/23/2016	54	2	4	0	0	2	4	0	7	**19**
Total	**900**	**167**	**92**	**30**	**3**	**48**	**176**	**15**	**49**	**580**

Wing Damage of Capture Bats

Wing scores of 1 or higher were recorded for 276 of the 646 bats captured. The wing damage observed appeared to be consistent with damage caused by WNS, but damage alone does not confirm infection.

Radio-transmittered Bats

We attached transmitters to 45 female MYSE and 3 female MYLU. Of the 45 MYSE, 23 were pregnant at the time of capture, 16 were lactating, 5 were non-reproductive, and the reproductive status of one bat was undetermined. The 3 MYLU were lactating at the time of capture. The 48 bats with transmitters were tracked until the transmitters failed or fell off, which was between 2 – 12 days (median = 6).

Roost Trees

We tracked 42 MYSE and 2 MYLU to their roosts. The MYSE were tracked to 111 unique roost trees of at least 20 species, and one roost in a building (Table 4). The two MYLU were tracked to roosts in two different buildings. For those MYSE which were successfully tracked, we identified an average of 3 roosts per bat.

Table 4. Table of northern long-eared bat roosts identified in 2016 by tree species. Some roost trees were only identifiable to genus due to advanced decay. One additional MYSE roost not listed below was located in a building.

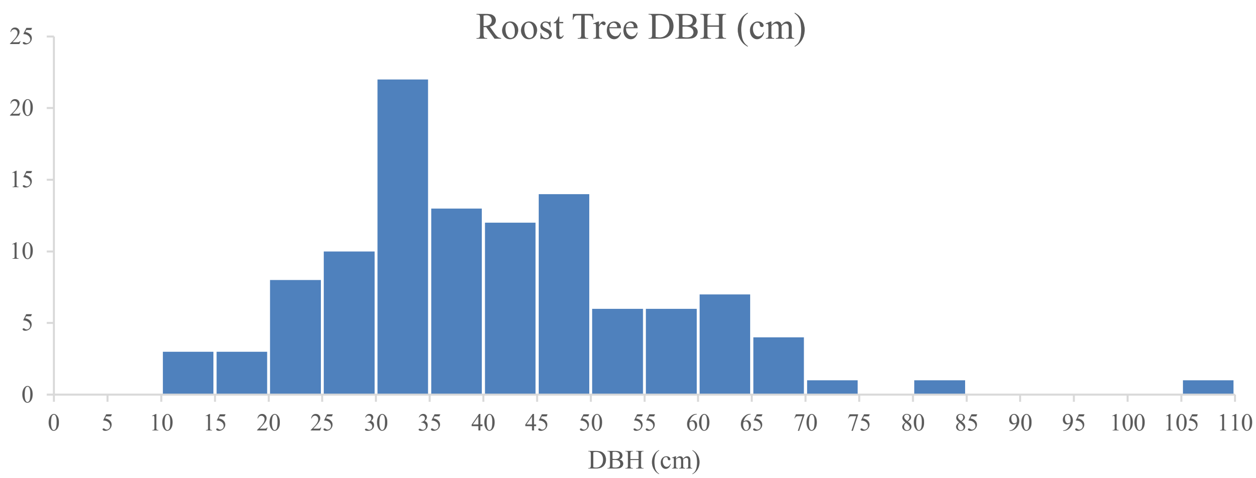
Tree Species Latin Name	**Common Name**	**# of Unique Roosts**	**# Bat-Days[a]**
Populus tremuloides	Quaking/trembling aspen	25	51
Acer rubrum	Red maple	16	45
Quercus rubra/ellipsoidalis[b]	Northern red oak/northern pin oak	13	20
Quercus rubra	Northern red oak	7	9
Betula papyrifera	Paper birch	5	9
Populus grandidentata	Big-tooth aspen	5	7
Tilia americana	American Basswood	5	6
Fraxinus nigra	Black ash	4	4
Fraxinus pennsylvanica	Green ash	4	5
Pinus strobus	White pine	4	6
Ulmus americana	American elm	4	4
Acer saccharum	Sugar maple	3	4
Larix laricina	Tamarack	3	3
Acer spp.	Maple (species unknown)	2	2
Fraxinus spp.	Ash (species unknown)	1	1
Juglans cinerea	Butternut/white walnut	1	1
Juglans nigra	Black walnut	1	2
Pinus resinosa	Red/Norway pine	1	4
Populus balsamifera	Balsam poplar	1	1
Populus spp.	Aspen (species unknown)	1	2
Quercus alba	White oak	1	1
Quercus macrocarpa	Bur oak	1	1
Quercus spp.	Oak (species unknown)	1	1
Robinia pseudoacacia	Black locust	1	1
Thuja occidentalis	Northern white cedar	1	2
	Total:	**111**	**192**

[a] We define one "Bat-Day" as one bat roosting in one tree for one day (only includes days when the transmitter was known to still be attached to the bat).

[b] In some areas where both northern red oak and northern pin oak occur and may hybridize (mainly at CCESR), they were lumped into one category.

The MYSE roost trees varied from 11 – 107 cm in diameter at breast height (DBH), with an average DBH of 41 cm (Fig. 6).

Figure 6. Frequency distribution of the DBH (diameter at breast height) of northern long-eared bat roost trees identified in 2016 (n = 111).



Roosts were located in both live and dead trees of varying decay stage (Fig. 7, Fig. 8). Tree height ranged from 3-30 m (average: 14 m). Crews were unable to measure the height of two roost trees that fell down before characterization.

Figure 7. Histogram showing variation in decay stage among 111 northern long-eared bat roost trees identified in Minnesota in 2016.

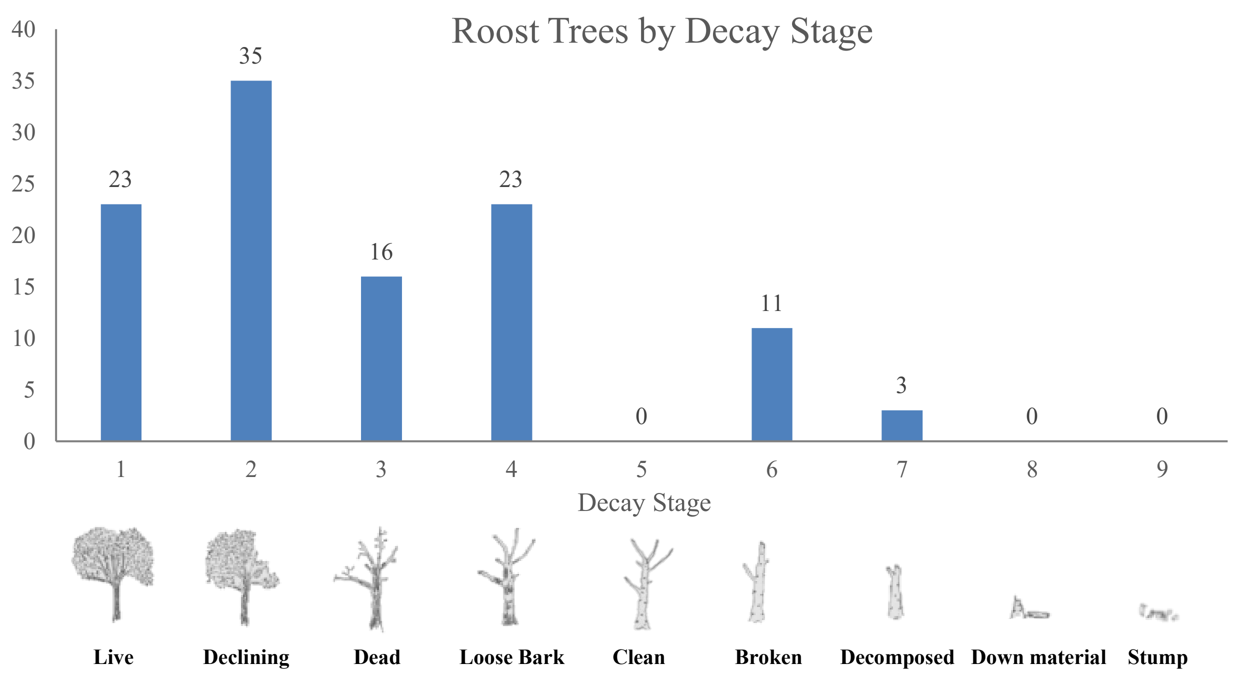


Figure 8. Photos of MYSE roost trees of various species and decay stages identified in 2016. Top row L to R: oak (*Quercus* spp.) snag at CCESR, live bigtooth aspen (*Populus grandidentata*) at ISP, and black ash (*Fraxinus nigra*) snag at S/HRSF. Bottom row L to R: live red maple (*Acer rubrum*) at CCESR, a red maple snag at CCESR, and a black walnut (*Juglans nigra*) snag at Whitewater WMA.

Movements

MYSE with transmitters moved often, spending an average of 1.25 days in each roost (maximum = 4 days), with pregnant bats spending 1.3 days on average, and lactating bats spending 1.1 days on average in each roost (of those roosting events with known start and end dates). Three separate bats with transmitters re-used roosts on non-consecutive days within the tracking period (e.g. moved from roost A on day 1 to roost B on day 2 and then back to roost A on day 3).

The average distance from the capture (foraging) location to the first roost was 589 m, with pregnant bats traveling further to their first roost than lactating bats on average (Table 5). Distance traveled between consecutive roosts was almost always less than 1 km, with 76% of consecutive roosts < 400 m apart.

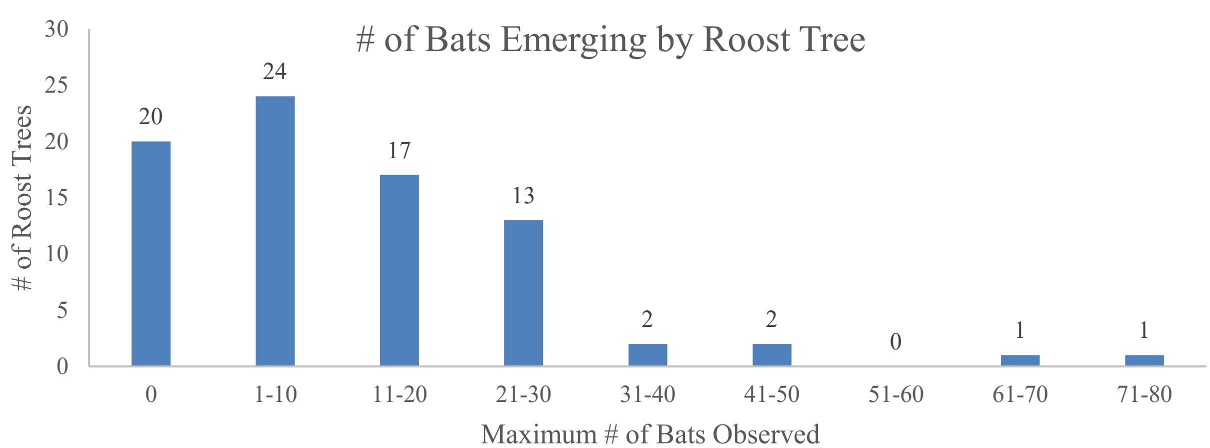
Table 5. Distances traveled (in meters) between roosts and between the capture location and the first roost by northern long-eared bats. Each cell shows the average distance followed by the range in parentheses.

	Pregnant MYSE	**Lactating MYSE**	**All MYSE**
Foraging Area to Roost	716 (24 – 2706)	469 (117 – 1672)	589 (26 – 2706)
Between Consecutive Roosts	341 (7 – 1424)	220 (10 – 669)	309 (7 – 1424)

Emergence Surveys

Field crews conducted 111 emergence surveys on 80 of the identified MYSE roost trees. Bats were observed exiting the tree in 81 of those surveys. Colony size (total count of bats during one survey) ranged from 1 – 71, and averaged 16.4 (Fig. 9). Bats were not observed during 30 surveys, which was due to vegetation obstructing the view, misidentification of the roost tree, weather conditions affecting the emergence behavior of the bats, or the maternity colony having moved to another tree (this sometimes occurred if the transmitter had fallen off of the bat in a previously used roost tree).

Figure 9. Histogram showing the maximum number of bats observed exiting surveyed roost trees during emergence surveys in 2016. If a roost was surveyed multiple times, the maximum number of bats exiting among all surveys is displayed in the figure so that each surveyed roost appears once (n = 80).



Crews also conducted an emergence count on the one building used as a roost by a MYSE. Personnel observed 64 bats emerging from the building during this survey. Five surveys were conducted on the two buildings that were used as roosts by two MYLU, those surveys tallied 297-494 bats emerging.

Discussion

Our project has identified northern long-eared bat roosts in at least 22 species of trees (17 in 2015 and 20 in 2016), including one invasive species (Black locust, *Robinia pseudoacacia*). Roosts are usually located in tree species that are common in a given area, which supports the hypothesis that tree species may not be as important to roost selection as other factors such as availability of cavities, cracks, and loose bark (Boyles 2007, Henderson and Broders 2008). In fact, we have identified MYSE roosts in all of the top ten most common tree species in Minnesota by volume as estimated by the U.S. Forest Service Forest Inventory program (Miles and VanderSchaaf 2015).

Northern long-eared bats switched roosts often in all areas of the state. The average roosting duration in our study (1.25 days) was less than that reported in Randolph County, West Virginia (5.3 d; Menzel et al. 2002) and the Black Hills of South Dakota (3.25 d; Cryan et al. 2001), but similar to that reported in Nova Scotia (1.4 d; Patriquin et al. 2010), Michigan (roughly 2 d, Foster and Kurta 1999), and Tucker County, West Virginia (1.35 d; Johnson et al. 2009). Our reported roosting durations are likely skewed low because the exact duration was almost always unknown for each bat's first and last roosting events.

The average distance moved by northern long-eared bats between consecutive roosts was similar in 2016 (309 m) and 2015 (235 m). Distances between roosts as reported in the literature vary widely, from most being less than 100 m in southern Illinois (Carter and Feldhamer 2005), to an average of 670 meters in Missouri (Timpone et al. 2010). Distances between consecutives roosts varied widely in our study as well (range 7 - 1424 m), but were similar to those reported in Wisconsin in 2015 (average 260 m, range 10 m – 880 m; Wisconsin Department of Natural Resources 2015). Our results suggest that the current 150 ft buffer of restricted tree harvest around known roost trees may not provide protection for many additional roosts. In fact, of the 111 northern long-eared bat roost trees identified during 2016 only 20 (18%) were within 150 ft of another roost tree identified in 2016. Of course our study did not identify all roost trees used by MYSE in a given area, but we did not observe strong "clustering" of roost trees, as has been noted in other studies (e.g. Sasse and Pekins 1996). However, the buffer is likely still beneficial in maintaining the microclimate and forest structure in the area immediately surrounding a known roost tree.

Field crews captured all 7 species of bats known to be residents of the state of Minnesota during 2016. In addition, we recorded the first capture of an evening bat (*Nycticeius humeralis*) in the state (Minnesota Department of Natural Resources 2016b). It is yet unknown if that capture represented a lone individual or a range extension for that species; however, Wisconsin also recently documented their first maternity colony of evening bats along the Illinois border (Wisconsin Department of Natural Resources 2016).

The proportion of bats with wing damage scores ≥ 1 ("light" damage or greater) was similar in 2016 (41.2%) and 2015 (38.3%), although more bats had scores ≥ 2 ("moderate" to "heavy" wing damage) in 2016 (3.4%) than in 2015 (0%). Wing damage does not confirm WNS, but *P. destructans* infection is known to cause lesions and loss of wing tissue (Reichard and Kunz 2009, Cryan et al. 2010). *P.destructans* was first detected in Soudan Underground Mine and Forestville/Mystery Cave State Parks in 2013, with mortalities observed at Soudan Underground Mine in 2016. Widespread population declines generally occur within 3-5 years of WNS being confirmed at a site, and we expect northern long-eared bat populations to decline >90% in the next few years, in addition to declines in populations of the other three cave-roosting bat species (Turner et al. 2011).

Under the Endangered Species Act, there are tree harvest restrictions within 150 ft of known, occupied roost trees in June and July. For more details on these restrictions, please visit the website of the U.S. Fish and Wildlife Service (https://www.fws.gov/Midwest/endangered/mammals/nleb/index.html). We intend to use the data collected in this project to inform future management decisions regarding the northern long-eared bat as WNS continues to spread across the United States.

Acknowledgements

We would like to thank the managers and staff at each study area for accommodating our research, and for logistical assistance. This fieldwork was conducted with the assistance of many field technicians, volunteers, and other personnel, thanks to all involved:

***UMD – Natural Resources Research Institute*:** S. Baker, M. Berkeland, J. Bollinger, M. Galey, K. Hennig, A. Holleran, B. Houck, P. Kienzler, B. McAlpin, A. Patterson, M. Swingen, C. Reno, and T. Upmann-Grunwald.

***USDA – Forest Service*:** T. Anderson, C. Beal, H. Becker, T. Catton, A. DeNasha, D. Grossheusch, M. Grover, J. Jordan, K. Kirschbaum, S. Malik-Wahls, R. Pennesi, A. Roberts, and P. Robertson.

MN DNR – Minnesota Biological Survey: M. Bowman, A. Herberg, A. Maleksi, G. Nordquist, C. Spak

MNARNG/MN DNR – Camp Ripley: J. Brezinka, N. Dietz, B. Dirks, K. Goodwin, E. Hoaglund, M. Lee, T. Mick, M. Rheude, P. Ruegemer, O. Scherping, C. Smith, Z. Tischler, and N. Wesenberg.

Funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund (ENRTF) as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR). The Trust Fund is a permanent fund constitutionally established by the citizens of Minnesota to assist in the protection, conservation, preservation, and enhancement of the state's air, water, land, fish, wildlife, and other natural resources. Currently 40% of net Minnesota State Lottery proceeds are dedicated to growing the Trust Fund and ensuring future benefits for Minnesota's environment and natural resources.

Additional funding was provided by the Blandin Foundation, the National Council for Air and Stream Improvement, Inc. (NCASI), USDA – Forest Service, USDI – Fish and Wildlife Service, USFWS State Wildlife Grant to the Minnesota Biological Survey and Reinvest In Minnesota's Critical Habitat Program, and the MN DNR. Funding for the Camp Ripley portion of this project was provided by the MN Department of Military Affairs (MN Army National Guard).

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