

Historical northern long-eared bat occurrence in Minnesota based on acoustic surveys



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Summary

Although long thought to exist throughout the forested region of Minnesota, occurrence records for northern long-eared bats (*Myotis septentrionalis*) were historically based on winter hibernacula records and sporadic summer observations. The ability to record and identify bats by their echolocation calls allowed scientists to more systematically survey for bats in Minnesota beginning in the 2000s; however, these data were not compiled in a central database. With the arrival of white-nose syndrome in Minnesota and the federal listing of the northern long-eared bat in 2015 as threatened under the Endangered Species Act, the need for a more detailed and current distribution map for this species was evident. In this report, we summarize the occurrence records for northern long-eared bats based on specimens collected, existing acoustic survey data from various sources collected prior to 2015, and acoustic survey data collected from 2015 to 2017. Northern long-eared bats do appear to be distributed throughout the forested region of Minnesota. Presence has been documented in the northern half of the state, surrounding the Twin Cities metropolitan area, and in the southeast corner of the state. Detection of the northern long-eared bat in almost every attempt suggests that the species is also present in unsurveyed regions of the forested regions of the state, although it is less common than the little brown bat (*M. lucifugus*), especially after white-nose syndrome has led to mortalities in Minnesota.

Cover photograph: The cover shows an Anabat detector enclosed in a protective box with a reflector plate that would reflect bat calls into the microphone.

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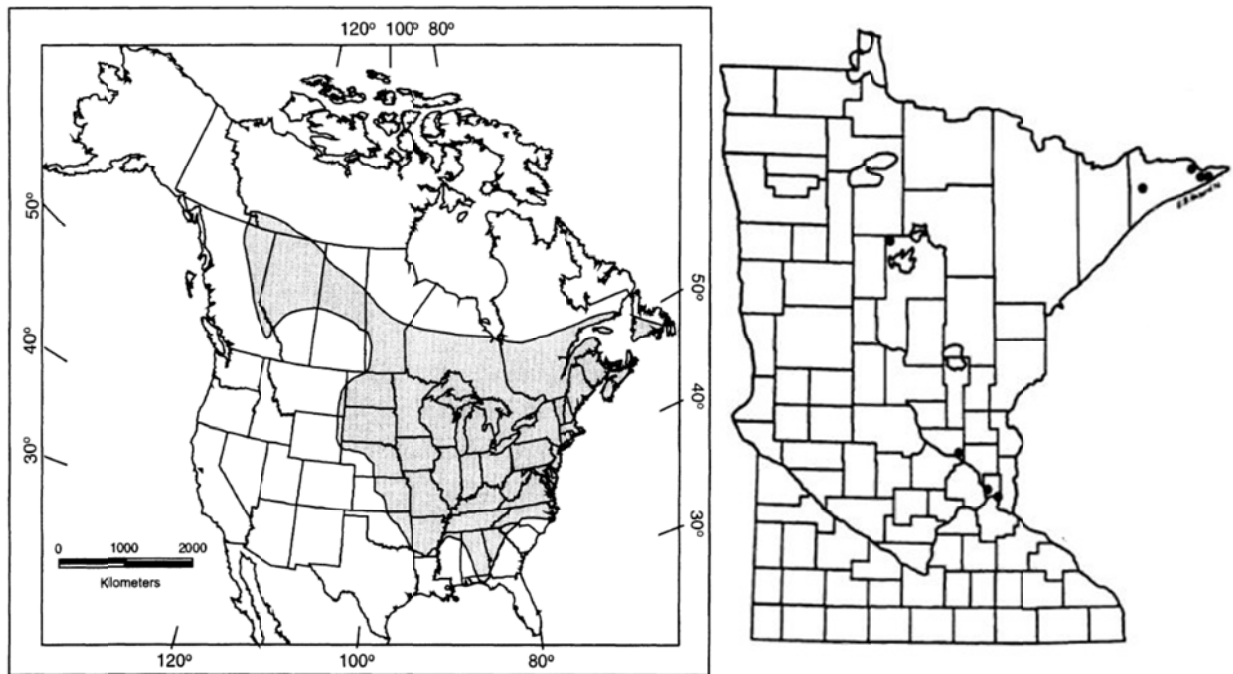
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Introduction

Northern long-eared bats (*Myotis septentrionalis*) are small bats that hibernate in caves and mines in the winter. Other names for the northern long-eared bat in the historical literature include *Vespertilio gryphus* var. *septentrionalis* and *Myotis keeni septentrionalis* (Caceres and Barclay 2000). In some older literature, the northern long-eared bat is referred to as *Myotis subulatus* (Jackson 1961). The northern long-eared bat ranges throughout much of eastern North America based on the species distribution map, although specimen records in Minnesota are relatively scarce (Fig. 1).

Figure 1. Distribution of northern long-eared bat in North America (Caceres and Barclay 2000) and in Minnesota (Hazard 1982). The North American distribution map was originally published in a Mammalian Species account, and the Minnesota map was created by the Bemidji State University Biology Department and originally published as Map 13 in *The Mammals of Minnesota* (Hazard 1982).



Older references often indicate that the northern long-eared bat is relatively common in Minnesota forests in the summer, although the little brown bat (*Myotis lucifugus*) appears to be the most common *Myotis* species in Minnesota. Occurrence records of *Myotis* species come from winter hibernacula records and from occasional specimens captured in the months when bats are not in hibernacula. The little brown bat has more historical records because it often roosts in buildings during the summer, while the northern long-eared bat usually roosts in trees and therefore is less likely to be encountered by humans.

The first publications on mammals in Minnesota did not list the northern long-eared bat as present. For example, Herrick (1892) listed only the little brown bat in the *Myotis* genus. The northern long-eared bat was likely present; this is probably another instance of the little brown bat being easier to find because it roosts in buildings in the summer.

The first published indication of the northern long-eared bat in Minnesota was in a list of Minnesota mammals compiled by University of Minnesota professor C.E. Johnson in 1916, in which the range of the northern long-eared bat was described as including the “entire state” (Johnson 1916). The northern long-eared bat was described as very common throughout Itasca County in north central Minnesota in 1919 (Cahn 1921), although Cahn called it *M. subulatus* in that publication. Cahn also listed the little brown bat as present but did not say that it was either common or very common.

In a second compilation of the Mammals of Minnesota, the little brown bat was considered the most common *Myotis* bat in the summer, although hibernacula locations appeared to be unknown because winter locations were not discussed (Surber 1932). The northern long-eared bat was described as having only a local distribution in Minnesota, although it could be found throughout the state. One known specimen from Elk River in Sherburne county was referenced.

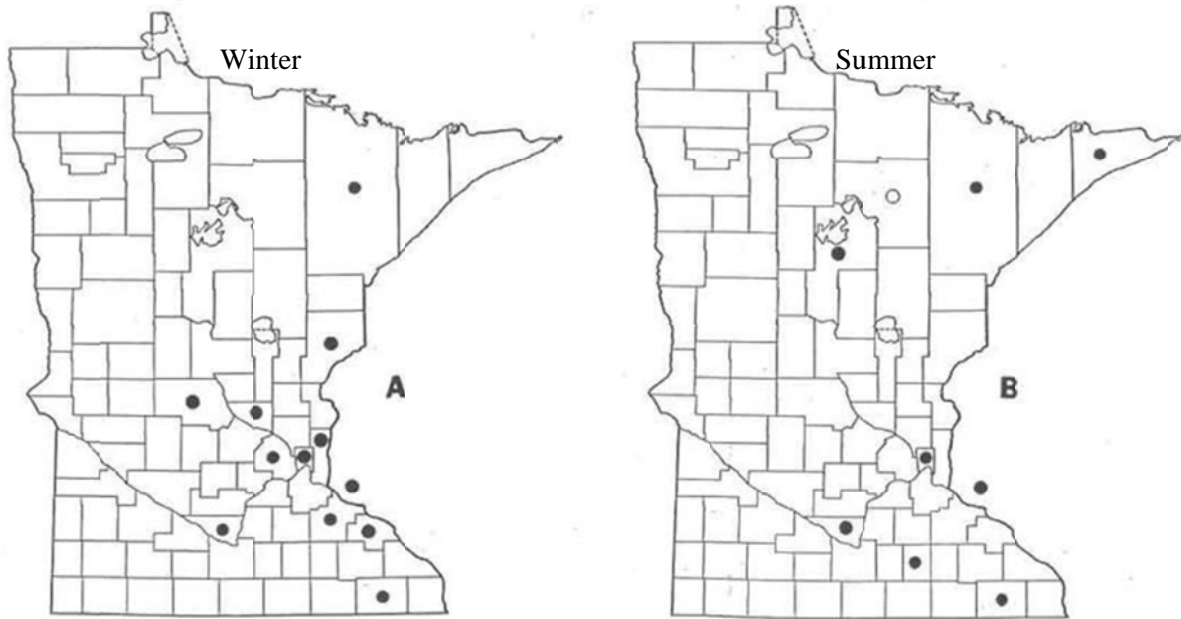
There are few published records of the northern long-eared bat from the mid 1900s. A few northern long-eared bats were found hibernating in caves during winter surveys in 1940–1941 in Nicollet, Goodhue, Fillmore, and Wabasha counties (Rysgaard 1942). Rysgaard indicates the northern long-eared bat is thought to be relatively common throughout Minnesota, although he also says that it is rarely found in hibernacula compared to other bat species. Other counties with documented presence of the northern long-eared bat included Clearwater, Itasca, St. Louis, Lake, Pine, Sherburne, and Stearns counties. Northern long-eared bats were found hibernating in sewers in St. Cloud, MN in 1952 (Goehring 1954).

In a third compilation of the mammals of Minnesota by Gunderson and Beer in 1953, the theme of the little brown bat being more common than the northern long-eared bat continues. The little brown bat was documented present in 19 counties in Minnesota, while the northern long-eared bat was listed as present in 7 counties in Gunderson and Beer’s Mammals of Minnesota. The authors again indicate that the northern long-eared bat is more common than specimen records indicate, although also saying that in hibernacula the little brown bat is much more common.

In 1982, Bemidji State University biology professor Evan B. Hazard published another compilation of the mammals of Minnesota, with maps based on specimen records at the township level (Fig. 1). Counties with northern long-eared bat presence in Fig. 1 include Cass, Cook, Sherburne, and Ramsey. Several of the counties listed in earlier references (e.g., Rysgaard 1942, Goehring 1954) are not included because specimens were not associated with those observations. As in Gunderson and Beer (1953), the little brown bat was listed as present in many more counties than the northern long-eared bat in Hazard’s book (30 counties for the little brown bat compared to 4 counties for the northern long-eared bat).

A literature review and additional surveys for Minnesota bat species were conducted by Gerda Nordquist and Elmer Birney in the early 1980s, leading to updated distribution maps which included known museum specimens, literature records, and observations from summer and winter field surveys (Fig. 2). In their literature review the little brown bat was documented in 55 counties, compared to 15 counties for the northern long-eared bat. Several hibernacula were identified, including the largest known hibernating populations of the little brown bat and the northern long-eared bat in Minnesota, at the Soudan Underground Mine in St. Louis County (Nordquist and Birney 1985).

Figure 2. Maps of known northern long-eared bat winter (left) and summer (right) distribution records in Minnesota as of 1985. Circles appear in counties for which records of northern long-eared bats occur, and do not indicate exact locations. Maps in Figure 2 were originally published as Figure 3 in the report “Distribution and Status of Bats in Minnesota” (Nordquist and Birney 1985).



Most of the earlier records of bat presence in Minnesota are from hibernacula, captures of bats in summer roosts, or specimens obtained incidentally. It became easier to document presence of bat species during the summer when the technology to record and identify the ultrasonic calls of bats became available to field biologists in the early 1980s (Fenton and Bell 1981). Acoustic surveys for bats were first conducted by the Minnesota Department of Natural Resources (MN DNR) in Minnesota in the early 2000s. Additional survey work has been conducted by state and federal agencies, universities, and private consulting companies. Some of these projects were published in peer-reviewed literature or as theses; others are only present in gray literature or are unavailable.

Ultrasonic recording technology has advanced greatly in the last decade, but even now not every call that is recorded can be identified to species. Early acoustic detectors recorded data in zero-crossing (ZC) format, a format which stored a limited amount of acoustic information compactly due to data storage limitations. More recently, acoustic detectors that record data in full-spectrum (FS) formats were developed. The FS format stores a greater amount of information about each call, which can make it easier to identify bat species.

The echolocation calls of bat species vary depending on their body size and foraging strategy. Minnesota’s seven bat species make either low-frequency calls (hoary bat (*Lasiurus cinereus*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*)) or high-frequency calls (northern long-eared bat, little brown bat, tricolored bat (*Pipistrellus subflavus*), eastern red bat (*Lasiurus borealis*)). Low-frequency calls and high-frequency calls are easily differentiated, but it can be difficult to assign calls to a species within either the low-frequency or the high-frequency group. As might be expected, the calls of some bats within the same genus, such as the northern long-eared bat and the little brown bat, can be difficult to assign to a species. Northern long-eared bats and little brown bats are particularly difficult to distinguish due to the overlapping range of many call

characteristics. In addition, for high frequency bats, some little brown bat and eastern red bat calls have similar characteristics. For low-frequency bats, big brown bat and silver-haired bat calls are very similar. Examples of the calls made by different species and additional discussion of identification of bat calls to species are in Swingen et al. (2018a).

Since 2006, cave-hibernating bat populations in the United States have declined sharply from white-nose syndrome (WNS). First documented in New York state, WNS has spread westward to 32 U.S. states and 7 Canadian provinces, killing millions of bats (U.S. Fish and Wildlife Service 2012). The northern long-eared bat is particularly susceptible to WNS, with declines of 90–100% in many eastern U.S. hibernacula (Turner et al. 2011). WNS was first confirmed in Minnesota in 2016, and subsequent winter surveys have confirmed decreasing numbers of bats (MN DNR 2016, 2017). When the northern long-eared bat was listed as Threatened under the Endangered Species Act in 2015, it became necessary to increase understanding of the distribution of this species in Minnesota. We used historic locations reviewed above, records downloaded from the Global Biodiversity Information Facility, the Minnesota Biodiversity Atlas, and available acoustic data to create an updated map of northern long-eared bat detections.

Methods

We compiled bat acoustic data collected in Minnesota by various entities prior to 2015. We attempted to identify all potential sources of bat acoustic data, including state agencies, federal agencies, universities, private consulting firms, and industry partners. If the original data was available, it was obtained in addition to a summary of the dataset and/or file identifications.

If the files were identified to species by the original source or author, we used the results of the original analysis. If the files were not identified by the original source or author, and the original recording data was available to us, we analyzed the files using the software program Kaleidoscope Pro (version 4.0.4). Data were processed in Kaleidoscope using the “Moderate” setting, with the “Minnesota” set of candidate species:

Big brown bat	<i>Eptesicus fuscus</i> (EPFU)
Eastern red bat	<i>Lasiurus borealis</i> (LABO)
Hoary bat	<i>Lasiurus cinereus</i> (LACI)
Silver-haired bat	<i>Lasionycteris noctivagans</i> (LANO)
Little brown bat	<i>Myotis lucifugus</i> (MYLU)
Northern long-eared bat	<i>Myotis septentrionalis</i> (MYSE)
Tricolored bat	<i>Perimyotis subflavus</i> (PESU)

We did not analyze any of the acoustic data using the Sonobat software program, because most of the existing data was from zero-crossing detectors, which cannot be analyzed by Sonobat.

There are some legal filings for wind turbine projects that can be found with an internet search. The acoustic data has been collected for these projects, but the data presentation in earlier projects is limited to high-frequency and low-frequency bat groups. Because the calls are not differentiated to species, the high-frequency bat calls could be from the northern long-eared bat, the little brown bat, or the eastern red bat. An example of this type of analysis is Derby and Dahl (2008).

Other legal filings that were done after the northern long-eared bat was listed as threatened under the ESA could be used. One example of this type of project is the Palmers Creek project in Yellow Medicine County (MDOC 2018), in which northern long-eared bats were not found.

Results

We compiled acoustic data and results from 2003–2014 from 10 sources (Table 1). Data were from 208 passive surveys, 47 active surveys, and 13 driving transects located in 21 Minnesota counties. Sources included the Minnesota Biological Survey, U.S. Forest Service, University of Minnesota, and WEST Inc. environmental consulting company. Acoustic records that are not publicly available, such as an acoustic study for the proposed new route for the Line 3 pipeline project by Enbridge, Inc. (<https://www.enbridge.com/Line3ReplacementProgram.aspx>), are not included in Table 1.

Table 1. Sources of bat acoustic data collected in Minnesota compiled for this analysis. For data type, ZC = zero-crossing and FS = full-spectrum.

Source	Years Data Collected	# Locations Data Collected	# Files Recorded	Type of Data	Files Identified by Source?
UMD – NRRI	2009–2014	106	52,790	ZC	Yes/No
Superior National Forest	2009–2014	7 ¹	4,554	ZC	Yes (WEST)
Chippewa National Forest	2011–2014	5 ¹	3,283	FS	Yes (WEST)
MN DNR – Biological Survey	2003–2014	Unknown ²	Unknown ²	ZC	Yes
MN DNR/ MN DOT	2014	16	25,547	ZC	Yes
National Park Service	2003	3	1,488	ZC	Yes
UPM Blandin	2014	3	790	ZC	Yes
Camp Ripley Training Center	2006–2014	11 ³	4,834	ZC	No
Dixon (2012)		47		ZC	Yes ⁴
Carlton County ⁵	2016	2	1,450	FS	Yes
Total		259			

¹ These locations are all driving transects.

² MBS data include confirmed MYSE calls. Call file data is not available.

³ One of these 11 locations is a driving transect.

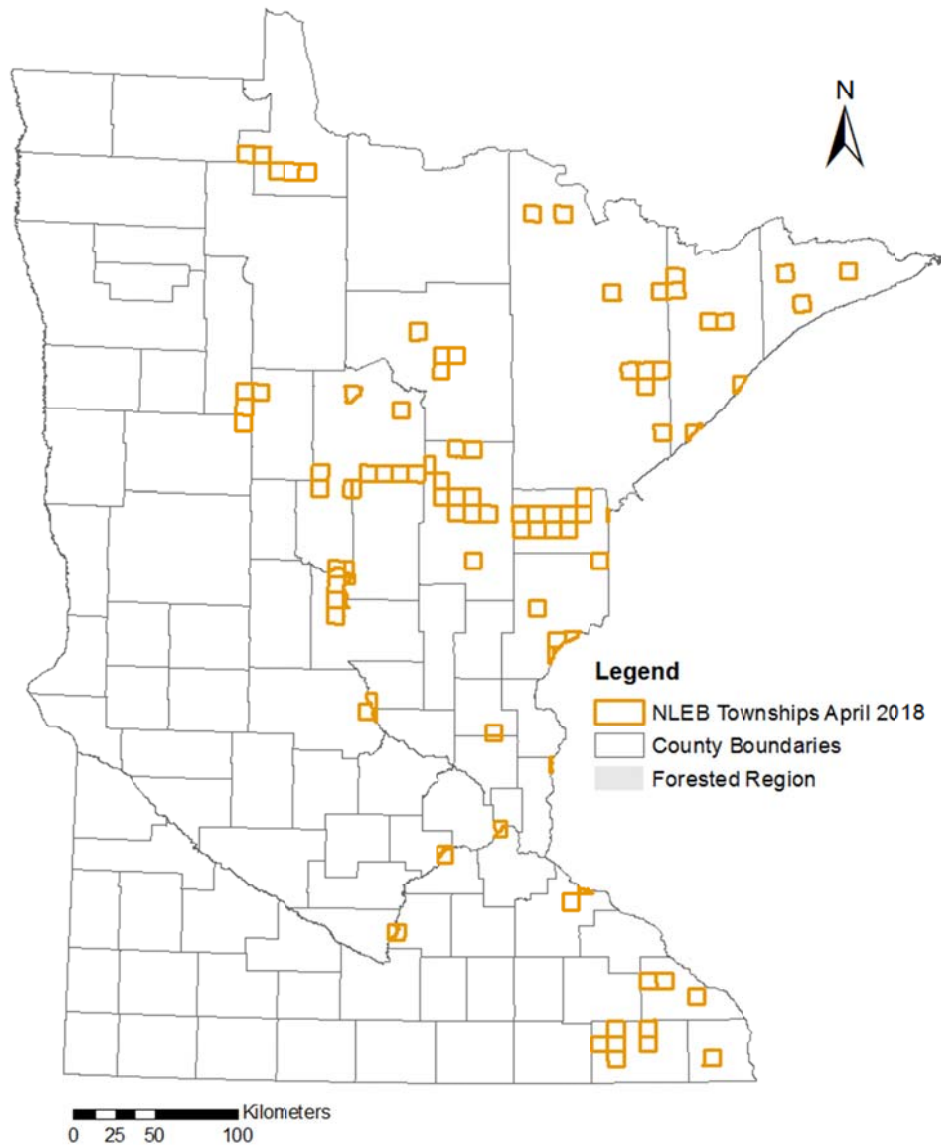
⁴ Did not differentiate between MYSE and MYLU.

⁵ Sichmeller and Hammond 2017.

There were 16 records for *Myotis septentrionalis* and *Myotis keenii* in the Global Biodiversity Information Facility (GBIF) and the Minnesota Biodiversity Atlas databases (GBIF.org 2018a, b). The GBIF database search for *Myotis septentrionalis* and *Myotis keenii* returned one record from Elk River and one record from St. Cloud (GBIF_1, GBIF_2). The Minnesota Biodiversity Atlas (MBA) of the Bell Museum of Natural History has 14 specimens from Minnesota that were collected from 1934 to 1983 (MBA 2018). Hazard, Gunderson and Beer, and Nordquist probably looked at some of these specimens from the Bell Museum to make their maps! Because the northern long-eared bat is listed as a threatened species, the location is only reported at the county level in the MBA. Counties included Cook, Goodhue, Hennepin, Nicollet, Ramsey, St. Louis, and Stearns, all of which had been reported in the earlier literature.

As a result of the northern long-eared bat being listed under the ESA, the MN DNR maintains records of locations of known roost trees. These records are currently located in 28 counties spread throughout the forested area of Minnesota. For all of these analyses of northern long-eared bat presence, an important consideration of this map is that absence of a record does not mean that northern long-eared bats are not present.

Figure 3. Records of northern long-eared bat roost trees by township stored in the database maintained by the MN DNR. Records are current as of April 2018.



Our review of the publications, museum records, and recent acoustic datasets resulted in documentation of northern long-eared bat presence in 38 of the 88 Minnesota Counties (Table 2). The main outcome of the synthesis of current knowledge of northern long-eared bat presence was to fill in some of the vacant spots present in earlier reviews.

Table 2. Counties in Minnesota with documented presence of northern long-eared bat. Column labels refer to publication date for Cahn (1921), Surber (1932), Rysgaard (1942), Goehring (1954), Gunderson and Beer (1953), Hazard (1982), Nordquist and Birney (1985). The column labelled “MNDNR” refers to known locations of northern long-eared bat roosts (Fig. 3), and the column labelled “T-1” refers to the sources compiled in Table 1. The column labelled “All” includes all counties in this table with northern long-eared bat presence documented.

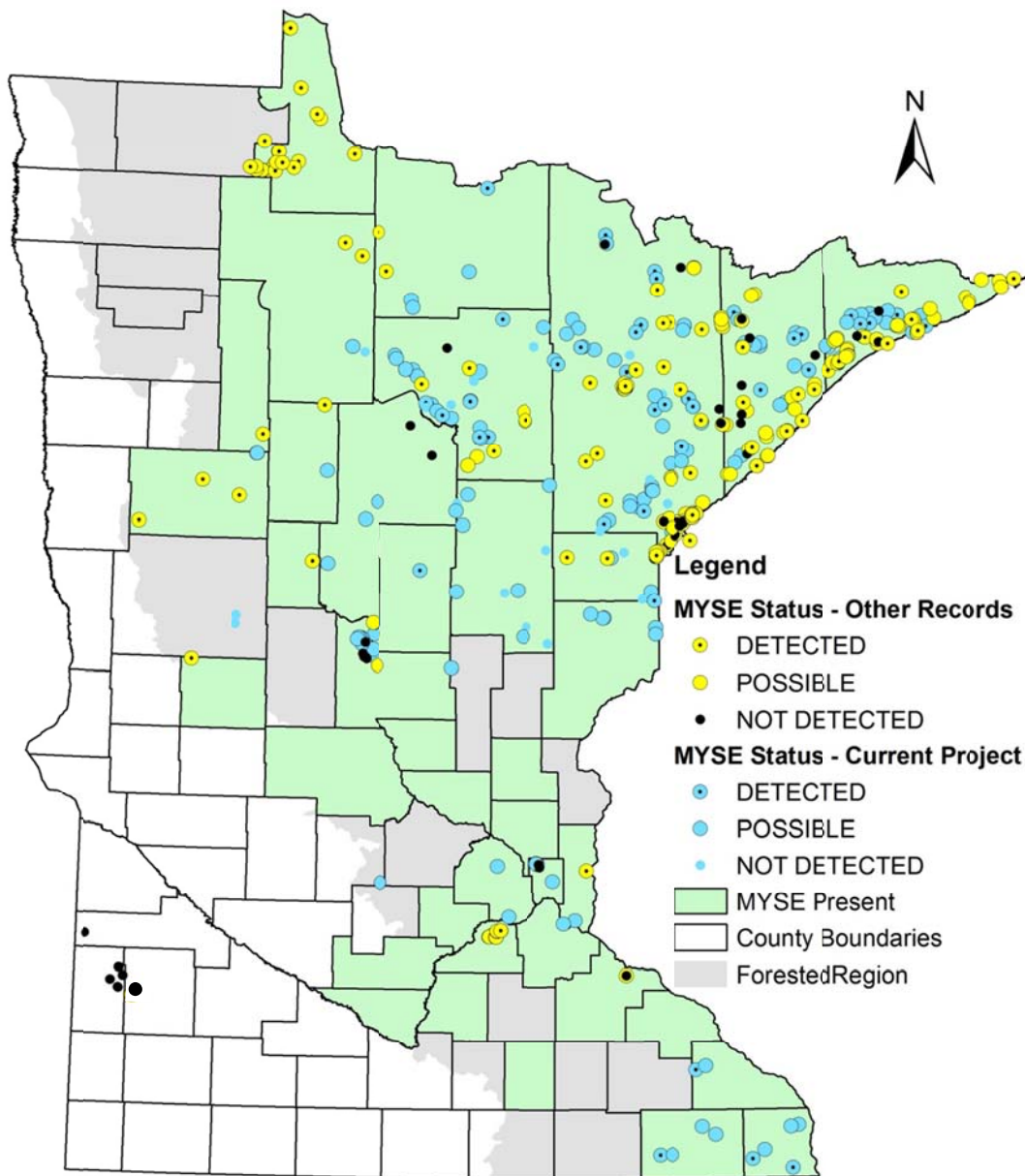
County	1921	1932	1942	1954	1953	1982	1985	MNDNR	T-1	All
Aitkin								1		1
Anoka								1		1
Becker								1	1	1
Beltrami									1	1
Benton								1		1
Big Stone										
Blue Earth										
Brown										
Carlton								1	1	1
Carver								1		1
Cass						1	1	1		1
Chippewa										
Chisago										
Clay										
Clearwater				1				1	1	1
Cook						1	1	1	1	1
Cottonwood										
Crow Wing								1		1
Dakota								1		1
Dodge										
Douglas									1	1
Faribault										
Fillmore			1				1	1		1
Freeborn										
Goodhue			1		1		1	1		1
Grant										
Hennepin							1			1
Houston								1		1
Hubbard								1	1	1
Isanti								1		1
Itasca	1			1			1	1	1	1
Jackson										
Kanabec										
Kandiyohi										
Kittson										
Koochiching									1	1
Lac qui Parle										
Lake				1				1	1	1
Lake of the Woods								1	1	1

Table 2, Continued.

County	1921	1932	1942	1954	1953	1982	1985	MNDNR	Fig. 3	All
Le Sueur								1		1
Lincoln										
Lyon										
Mahnomen										
Marshall										
Martin										
McLeod										
Meeker										
Mille Lacs										
Morrison								1		1
Mower										
Murray										
Nicollet			1		1		1			1
Nobles										
Norman										
Olmsted										
Otter Tail										
Pennington										
Pine				1	1		1	1		1
Pipestone										
Polk										
Pope										
Ramsey					1	1	1	1		1
Red Lake										
Redwood										
Renville										
Rice										
Rock										
Roseau										
Saint Louis				1	1		1	1	1	1
Scott								1	1	1
Sherburne		1		1	1	1				1
Sibley							1			1
Stearns				1	1			1		1
Steele							1			1
Stevens										
Swift										
Todd										
Traverse										
Wabasha			1		1		1			1
Wadena									1	1
Waseca										
Washington							1	1	1	1
Watonwan										
Wilkin										
Winona					1			1		1
Wright										
Yellow Medicine										

Combining pre-2015 acoustic survey data with other known locations shows that northern long-eared bats are distributed throughout the forested region of Minnesota (Fig. 4). Acoustic surveys and occurrence records have been focused on the northern half of Minnesota, around the Twin Cities metropolitan area, and in the southeastern corner of the state. However, based on the documented distribution of northern long-eared bats from recent research projects, it is likely that the species is present throughout the forested portion of the state, consistent with Johnson (1918), Surber (1932), Gunderson and Beer (1953), Hazard (1982), and Nordquist and Birney (1985).

Figure 4. Map of pre-2015 bat acoustic survey locations in Minnesota showing detection of northern long-eared bat (MYSE) calls. Sites marked with yellow are from past records, and sites marked with blue are from the current project (Swingen et al. 2018a). Counties with records are shaded green.



Discussion

Historically, northern long-eared bats were thought to be distributed across Minnesota, although this was originally based on relatively few documented specimen locations. Hibernacula sites were unknown in the early 1900s, and northern long-eared bats are less likely to be found because of the tendency of northern long-eared bats to roost in trees instead of buildings. Most references to abundance after the 1940s indicate that the little brown bat is the most common bat in Minnesota and that the northern long-eared bat is less common. Many of the references also indicate that the northern long-eared bat is more common than occurrence records indicate.

The several books that have been published on the Mammals of Minnesota generally indicate a summer range throughout the state, although there were few documented locations to support this (e.g., 8 specimens in Hazard (1982), 9 locations in Gunderson and Beer (1953)). Even as late as 1985, there were only 8 counties in Minnesota with documented locations of the northern long-eared bat in summer (Fig. 2, from Nordquist and Birney 1985). Thus, although specimens had been identified in counties distributed from north to south in Minnesota, the validity of the extent of summer range could have been challenged.

Acoustic detectors made it possible to more efficiently find northern long-eared bats in the summer, and the analysis of acoustic data has provided strong support for northern long-eared bats being distributed throughout at least the forested part of Minnesota. There were few deployments of acoustic detectors in the southern half of Minnesota prior to 2015 (Fig. 4), but deployments and mist-net captures from 2015 to 2018 provided additional support for presence of northern long-eared bats in the southern half of Minnesota (Swingen et al. 2018a, b).

One important aspect of acoustic data is that it provides evidence of distribution, but it is still not possible to use acoustic data to determine abundance of different species. As discussed in the Introduction (p. 6), while it is easy to differentiate high-frequency and low-frequency species from the bat calls, it can be difficult to differentiate species within each frequency group. Because of similarities of calls among species, relative abundance calculations must also be qualified with the identification criteria used. Human interpreters and software programs do not always agree when assigning species identifications to a call file (Lemen et al. 2015).

Although recording equipment and analysis software have made bat surveys more practical, acoustic file identifications are still less reliable than confirming species presence through mist-netting. The northern long-eared bat in particular is difficult to confirm positively from acoustic records because its calls are so similar to calls made by the closely related little brown bat. The automated programs appear to be more likely to identify a call to be from a little brown bat, because not every call made by a northern long-eared bat has the distinctive high-frequency part of the call present.

Another important aspect of both acoustic surveys and mist-netting is that it is difficult to impossible to prove absence. The only area of the state where northern long-eared bats have not been found during any survey is in the southwestern counties, where forested areas cover a small portion of the landscape. In all other areas that have been surveyed, at least some surveys have indicated presence of northern long-eared bats. It is probably a safe assumption that in the forested portion of Minnesota, even if one acoustic survey fails to detect northern long-eared bats, another acoustic survey in the area would detect their presence.

Overall, based on documented locations and acoustic surveys, the northern long-eared bat is present throughout the forested region of Minnesota. The mist-netting and acoustic detection parts of this project, conducted from 2015 to 2017, provided additional data on the distribution of the northern long-eared bat in Minnesota (Swingen et al. 2018a, b).

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