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# Current status of the Northern Long-eared Myotis (*Myotis septentrionalis*) in northwestern Nebraska

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## Abstract

The Northern Long-eared Myotis (*Myotis septentrionalis*; Order: Chiroptera) occurs in eastern, southern, and northern Nebraska, but its current distribution in northwestern parts of the state is unclear due to its recent arrival to the region. We investigated the status of this species in the Pine Ridge via mist net (2011–2014) and acoustic surveys (2014). We documented nine species of bats in the region, including *M. septentrionalis*. Of 423 total bats, *M. septentrionalis* was represented by four individuals, the fewest of all species during our four-year survey. We only documented *M. septentrionalis* in Sheridan County; this county is where the species was first reported in the Pine Ridge. Possibly acoustic calls of *M. septentrionalis* were recorded along the White River in Dawes County, but they likely represented variant calls from other *Myotis* species, such as the Little Brown Myotis (*Myotis lucifugus*). Until more conclusive evidence is obtained from Dawes County, we do not consider *M. septentrionalis* as part of the bat fauna from the county. Captures of three lactating *M. septentrionalis* are the best evidence of a reproducing population in the Pine Ridge. We conclude that the Northern Long-eared Myotis currently is not widely distributed in northwestern Nebraska, especially during summer when females bear and raise young. During migratory periods, however, limited evidence suggests individuals occur across a broader area using more habitats while in route to and from hibernacula. Periodic surveys are warranted to monitor the status of this species in the region. Additional research to determine summer and winter roosts would promote and help to conserve habitats for this species in Nebraska as *M. septentrionalis* recently was listed as federally threatened in the United States.

**Keywords:** Northern Myotis, Northern Long-eared Myotis, *Myotis septentrionalis*, Nebraska, Pine Ridge, survey

## Introduction

In Nebraska, the Northern Long-eared Myotis (*Myotis septentrionalis*) occurs in eastern, southern, and northern parts of state (Czaplewski et al. 1979, Benedict 2004). In northwestern Nebraska, *M. septentrionalis* appears to be a recent addition to the local bat assemblage (Benedict et al. 2000, Benedict 2004), as prior publications did not report the species from the region (Jones 1964, Czaplewski et al. 1979, Hall 1981). The first record from the Pine Ridge consisted of an adult male captured in Sheridan County in 1993, with six additional males captured in 1998 from nearby localities (Benedict et al. 2000). Subsequent regional surveys in 2000 provided the first evidence of reproduction in the region with the capture of a post-lactating female and a volant young in Sheridan County (Benedict 2004). In northwestern Nebraska and other regions of the Great Plains, distribution of *M. septentrionalis* is suspected to have expanded in part due to changes in forested habitats (Benedict et al. 2000, Swier 2006, Sparks et al. 2011). In light of recent distributional expansions in the Great Plains and recent widespread population declines associated with white-nose syndrome in eastern North America (Moosman et al. 2013, USFWS 2013), we initiated a study to determine the current status of the Northern Long-eared Myotis in northwestern Nebraska. Such research will help to facilitate conservation strategies

and management in the region, as *M. septentrionalis* recently was listed as federally threatened in the United States (USFWS 2015).

## Study Sites

Our survey was conducted in Dawes, Sheridan, and Sioux counties in the Pine Ridge region of northwestern Nebraska. Habitats surveyed spanned from upland ponderosa pine (*Pinus ponderosa*) forests to open grasslands to lowland riparian forests dominated by eastern cottonwoods (*Populus deltoides*), willows (*Salix* spp.), and other deciduous trees. Ponderosa pine forests consisted of recently burned stands, older burned forests, and non-burned areas. The area also contains some cliffs and rocky outcroppings that occurred in upland pine forests and associated riparian habitats.

## Materials and Methods

From 2011–2013, we surveyed bats by deploying mist nets over water sources in Dawes and Sioux counties including stock tanks, ponds, streams, and small rivers. Many sites were situated in upland habitats, such as ponderosa pine forests and riparian areas associated with canyons and buttes. Although a number of upland riparian sites contained numerous deciduous trees, we questioned whether our lack of captures for *M. septentrionalis*

in those two counties reflected our bias towards upland habitats. In eastern Nebraska and eastern South Dakota, *M. septentrionalis* is considered a deciduous forest species, with captures commonly associated with lowland riparian habitats along streams and rivers (Czaplewski et al. 1979, Benedict 2004, Geluso et al. 2004, Swier 2006, Bales 2007); however, in the nearby Black Hills of South Dakota, Cryan et al. (2001) documented females in upland habitats dominated by ponderosa pine. In 2014, we changed field efforts by focusing surveys in mainly lowland riparian habitats to examine whether past netting surveys influenced our ability to detect and capture *M. septentrionalis* in the Pine Ridge. In 2014, we surveyed riparian forests in both uplands surrounded by ponderosa pine forests and lowlands surrounded by grasslands using acoustic and mist-net survey methods for bats in Dawes and Sheridan counties.

From April 2011 to July 2014, we periodically deployed mist nets (6–18 m in length, Avinet Inc. Dryden, NY, USA) across perennial and intermittent streams, small rivers, earthen ponds, and metal stock tanks to survey bats. For each individual captured, we recorded species, sex, age (adult or volant young), reproductive condition (pregnant, lactating, or post-lactating), and for many individuals we also recorded forearm length and weight. See Geluso et al. (2013) for methodology on determining age and pregnancy for bats released at capture sites. Most individuals were released at capture sites, but a few vouchers of each species were taken and deposited in the natural history collection in the Division of Zoology, University of Nebraska State Museum (UNSM), Lincoln, Nebraska, USA. Such vouchers serve to physically and permanently document the identity of individuals at localities of occurrence, and moreover, vouchers allow for future reassessment of species identification in light of new morphological and molecular information that update organismal identities and evolutionary relationships (Yates 1985). We also queried the UNSM for a complete list of specimens from Dawes, Sheridan, and Sioux counties to search for potential unpublished voucher specimens as well as ascertain an index of relative abundance based on collection of past specimens to compare to our mist-netting surveys. Specimens already housed in the museum were collected over a span of time from 1901 to 2004.

We recorded acoustic calls of bats with SM2Bat+ detectors and SMX-US microphones (Wildlife Acoustics, Inc., Maynard, MA, USA). We deployed microphones on poles 3 m above the ground mainly along perennial streams and small rivers. To enhance quality of calls, we placed acoustic detectors along edges of wooded areas with the least amount of overhead canopies or obstructions. Bat passes (i.e., a sequence of bat calls) were recorded as full-spectrum calls in WAC format and later converted to WAV format using Kaleidoscope software (version 2.0.7,

Wildlife Acoustics, Inc., Maynard, MA, USA). Bat passes were separated into files with a maximum duration of 5 seconds. We visually searched for calls of *M. septentrionalis* by comparing them to known calls from a library provided by SonoBat (version 3.2.0, SonoBat, Arcata, CA, USA) and calls from our acoustic encounters of this species from eastern Nebraska.

Coordinates for localities of occurrence were acquired via handheld global positioning systems (GPSs) using NAD1983 for mist-netting sites and WGS84 for acoustic sites. All capturing, handling, and euthanizing techniques were approved by the University of Nebraska at Kearney's Institutional Animal Care and Use Committee (protocol #060408 and #020614). Hereafter, a net night equals one net of any size deployed for varied lengths of time during an evening; most nets were open at least during the first few hours of evenings, with some open all night. Common and scientific names of bats used herein follow Bradley et al. (2014).

## Results

We documented nine species of bats in the region during four years of netting surveys (Table 1). Although we captured 423 total bats in Dawes, Sheridan, and Sioux counties, only four were *M. septentrionalis*, the fewest of all species captured during our survey (Table 1). Mist-netting surveys did not document *M. septentrionalis* in Dawes and Sioux counties, although most net nights were accumulated in those counties ( $n = 46$  in 2011–2013 and  $n = 4$  in 2014). A single night (14 July 2014) of effort along Larrabee Creek in Sheridan County with four net nights yielded three lactating female and one adult male *M. septentrionalis*. Relative abundance of species based on captures corresponded with total numbers of vouchers from the UNSM, with the exception of the Eastern Red Bat (*Lasiurus borealis*). Eastern red bats were more prevalent in our recent surveys compared to accumulated vouchers housed at UNSM from northwestern Nebraska (Table 1). Relative abundance of *M. septentrionalis* ranked at or near the bottom of both indices (Table 1).

Forearm lengths of three lactating female *M. septentrionalis* and one adult male were 35, 36.5, 37, and 36 mm, respectively. Weights of the three females and one male were 6, 7, 7, and 6 g, respectively. Times of capture were 2052, 2055, 2125, and 2128 h MDT, representing 26, 29, 59, and 62 min after sunset. All females were captured near large willow trees (*Salix* spp.) about 15 m from the creek, and the one male was captured over Larrabee Creek. Many large eastern cottonwoods also were in these narrow riparian habitats.

From 9–15 July 2014, we recorded acoustic calls of bats at 16 sites, with two sites having two nights of recordings, in Dawes and Sheridan counties (Table 2). Acoustic surveys in 2014 further confirmed the presence of *M.*

**Table 1.** Total numbers of captures during our netting survey for bats in the Pine Ridge region of northwestern Nebraska, 2011–2014, and total numbers of voucher specimens from the Pine Ridge housed at the University of Nebraska State Museum (UNSM). Note the similarity in rank of species between captures in our mist-nets survey and number of specimens previously deposited at the UNSM. The only species that does not follow the pattern is the Eastern Red Bat (*Lasiurus borealis*). During our survey, *L. borealis* was the 4<sup>th</sup> most common species captured whereas based on former voucher specimens at UNSM, the species was the second least frequent species suggesting a recent increase in abundance in the Pine Ridge.

Common name	Scientific name	Captures	UNSM
Big Brown Bat	<i>Eptesicus fuscus</i>	174	263
Little Brown Myotis	<i>Myotis lucifugus</i>	118	170
Hoary Bat	<i>Lasiurus cinereus</i>	66	103
Eastern Red Bat	<i>Lasiurus borealis</i>	19	7
Western Small-footed Myotis	<i>Myotis ciliolabrum</i>	18	86
Silver-haired Bat	<i>Lasionycteris noctivagans</i>	13	82
Long-legged Myotis	<i>Myotis volans</i>	6	39
Fringed Myotis	<i>Myotis thysanodes</i>	5	22
Northern Long-eared Myotis	<i>Myotis septentrionalis</i>	4	15
Townsend's Big-eared Bat	<i>Corynorhinus townsendii</i>	--	1
TOTAL		423	788

*septentrionalis* at four sites in Sheridan County (Larrabee Creek and White Clay Creek; Table 2). Acoustic surveys also recorded the potential calls of *M. septentrionalis* at one site along the White River in Fort Robinson State Park, Dawes County, on 11 July 2014. Another acoustic detector set 125 m away the same evening did not produce similar calls. Another two acoustic detectors along the White River within 2.4 km also did not record potential calls of *M. septentrionalis*.

## Discussion

We only documented *M. septentrionalis* in Sheridan County, the first county where the species was reported in northwestern Nebraska (Benedict et al. 2000, Benedict 2004). We documented *M. septentrionalis* along two creeks (Larrabee and White Clay), and both creeks were bordered by narrow bands of deciduous forest. Benedict (2004) documented this species along Larrabee and Patton creeks. All three creeks consisted of perennial water generally 2–3 m in width, with many areas of open water. Our sampling sites along these creeks were not immediately surrounded by ponderosa pine forests, but such forests were abundant in upland habitats in the general area. Use of small, riparian creeks with perennial water and deciduous trees is similar to other summer habitats used by *M. septentrionalis* farther east in Nebraska (Czaplewski et al. 1979; Benedict 2004; Geluso et al. 2004; Geluso unpublished data Harlan County; UNSM ZM#28915 Franklin County).

Our capture of three lactating females provides the best evidence of a reproductive population in northwestern Nebraska. Previously, a post-lactating female was collected on 4 August 2000 from Larrabee Creek (Benedict

2004). Based on the UNSM zoology database, this individual had visible nipples, no milk, and was probably post-lactating (UNSM ZM#30458). Additionally, a volant young was collected on 5 August 2000 from Patton Creek (Benedict 2004, UNSM ZM#30467). We agree with Benedict (2004) that such records represent evidence of reproduction in the Pine Ridge, but we also know that *M. septentrionalis* moves between summer habitats and hibernacula (Caire et al. 1979) with arrival at hibernacula beginning as early as late July (Whitaker and Rissler 1992). Thus, our new records provide additional evidence that females bear and raise young in the area, as lactating females return to feed young at summer roosts.

The Northern Long-eared Myotis is considered a recent arrival to the Pine Ridge region of northwestern Nebraska, most likely arriving from a population in the Black Hills of South Dakota rather than from a westward expanding population along the Niobrara River (Benedict et al. 2000). Those authors used gender composition of new records to base their conclusion regarding the species recent arrival. However, it is also relevant to examine whether past surveys have been conducted sufficiently in the region to determine whether the species is truly a recent arrival or whether it represents a formerly undetected population (see Frey 2009). If the area was not previously surveyed, then likelihood favors that the population in question always occurred in the area but went undetected (Frey 2009). Herein, we further examine the conclusion that *M. septentrionalis* is a recent arrival to the Pine Ridge on the basis of 1) whether prior surveys of bats were known from nearby areas where *M. septentrionalis* has now been documented, 2) how easy the species is

**Table 2.** Localities of acoustic surveys for the Northern Long-eared Myotis (*Myotis septentrionalis*; MYSE) in the Pine Ridge region of Nebraska, 9–14 July 2014. All sites were located in riparian areas with at least some deciduous trees; lowland riparian areas contained deciduous trees almost exclusively. “MYSE” represents whether acoustic call sequences of *M. septentrionalis* were observed at the site based on comparison with call libraries and experience with call sequences from eastern Nebraska. “Calls” represent the total number of bat call sequences detected via KaleidoscopePro. “Habitat” represents whether riparian areas were situated in canyon areas within ponderosa pine (*Pinus ponderosa*) forests or whether sites were situated in lowland areas with narrow bands of deciduous trees surrounded by mainly grasslands or agricultural fields. SWMA represents State Wildlife Management Areas, and USFS represents lands administered by the United States Forest Service.

Location	Latitude, Longitude	Date	MYSE	Calls	Habitat
<i>Dawes County</i>					
Bordeaux Creek, SWMA Site 1	42.81444°N, 102.92319°W	9 July	No	93	Lowland
Bordeaux Creek, SWMA Site 2	42.81508°N, 102.92436°W	9 July	No	140	Lowland
Bordeaux Creek, USFS, Pasture 35	42.74967°N, 102.91703°W	9 July	No	253	Lowland
Bordeaux Creek, USFS, Cliffs	42.71901°N, 102.93036°W	9 July	No	1610	Canyon
Chadron Creek, Schenbeck	42.80553°N, 103.05175°W	13 July	No	114	Lowland
Chadron Creek Ranch, East Pond	42.66930°N, 102.99106°W	13 July	No	175	Canyon
Chadron Creek Ranch, West Pond	42.67084°N, 103.00199°W	13 July	No	81	Canyon
Fort Robinson, Bike Trail, Bridge	42.66687°N, 103.45400°W	11 July	Yes <sup>a</sup>	1843	Lowland
Fort Robinson, Bike Trail, Willows	42.66595°N, 103.45517°W	11 July	No	972	Lowland
Fort Robinson, Bike Trail, Willows	42.66595°N, 103.45517°W	12 July	No	1215	Lowland
Fort Robinson, East of Tent Camp	42.65708°N, 103.46733°W	11 July	No	1438	Lowland
Fort Robinson, East of Tent Camp	42.65708°N, 103.46733°W	12 July	No	436	Lowland
Fort Robinson, Ice House Pond Area	42.65264°N, 103.47634°W	11 July	No	770	Lowland
West Ash Canyon, USFS	42.64363°N, 103.26048°W	12 July	No	513	Canyon
<i>Sheridan County</i>					
Larrabee Creek	42.92034°N, 102.50735°W	14 July	Yes	80	Lowland
Larrabee Creek	42.92080°N, 102.50844°W	14 July	Yes	52	Lowland
Larrabee Creek	42.93249°N, 102.52854°W	10 July	Yes	188	Lowland
White Clay Creek	42.93661°N, 102.56014°W	10 July	Yes	87	Lowland

a. Due to a lack of other Northern Long-eared Myotis calls on nearby detectors and no verification of species via captures, it is unclear whether such calls represent positive verification of calls from *M. septentrionalis*. Calls from *Myotis* species as a group are difficult to distinguish, as there can be overlapping variation among a number of species.

captured (relative capture rates) in mist nets, 3) observations on whether other bat species have experienced similar recent distributional expansions in the Great Plains, and 4) additional capture data on gender composition for *M. septentrionalis* in the area.

Examination of prior bat records from northern Sheridan County demonstrate that two common species, the Big Brown Bat (*Eptesicus fuscus*) and Western Small-footed Myotis (*Myotis ciliolabrum*), already were known from within 5 km of sites inhabited by *M. septentrionalis* (Czaplewski et al. 1979). Such records lend support that prior sampling efforts likely would have documented *M. septentrionalis* in the past if present, especially because *M. septentrionalis* is relatively easy to catch with mist nets in Nebraska. Benedict (2004) showed that *M. septentrionalis* had the 2<sup>nd</sup> highest success rate of capture (55%) within its known distribution in the state. The Big Brown Bat had

the highest capture rate of all species (62%) whereas *M. ciliolabrum* (48%) ranked 3<sup>rd</sup> for species occurring in western parts of the state. Moreover in eastern South Dakota, catchability of *M. septentrionalis* was greater than all other species known to occur in the area (Bales 2007).

Furthermore, evidence continues to build demonstrating that a number of eastern woodland bat species have expanded distributions in response to increasing woodlands and forest edges across the Great Plains. Such species include *M. septentrionalis* (Benedict et al. 2000, Sparks et al. 2011), American Perimyotis (*Perimyotis subflavus*; Sparks and Choate 1995, Benedict 2004, Geluso et al. 2005, Sparks et al. 2011), Evening Bat (*Nycticeius humeralis*; Sparks and Choate 1995, Benedict et al. 2000, Lane et al. 2003, Benedict 2004, Serbousek and Geluso 2009, Sparks et al. 2011), and *L. borealis* (Benedict et al. 2000, Geluso et al. 2013, this study Table 1).

Lastly, evidence from gender composition continues to support that *M. septentrionalis* has recently arrived to the Pine Ridge. In 1993, a single adult male was captured followed by six additional adult males in 1998 (Benedict et al. 2000). In 2000, besides the post-lactating female and volant young female (Benedict 2004), nine other adult males were captured at those sites (UNSM ZM#30451-30456, 30460, 30464, 30466). Our captures in 2014 add three additional females, moreover lactating females, and one adult male. Thus, the trend of a changing gender composition is supported with our recent data by the capture of additional females, especially reproductively active females, rather than all adult males. It is widely observed in mammals that dispersal of males from natal ranges is more common than females (Wolff 1994), even for *M. septentrionalis* (Arnold 2007). Based on the data at hand, it appears males first colonized the Pine Ridge (Benedict et al. 2000) and were followed by females (Benedict 2004, this study). Based on the multiple lines of evidence presented above, we are in agreement with conclusions drawn by Benedict et al. (2000) that data suggest that the Northern Long-eared Myotis is a recent addition to northwestern Nebraska.

Although *M. septentrionalis* appears to be a recent arrival to eastern parts of the Pine Ridge, our acoustic and mist netting surveys demonstrate it is presently absent (or limited) in abundance throughout the western portion of the region in Dawes and Sioux counties. Of 16 acoustic survey sites in some of the most well established riparian habitats along small rivers and perennial streams in those counties, we only recorded the potential calls of *M. septentrionalis* at one site along the White River at Fort Robinson State Park. We are cautious to state the positive occurrence of the species at this location at this time for two reasons. First, another acoustic detector only 125 m away the same evening did not produce similar calls as well as two other detectors 1.5 and 2.4 km away along the same reach of the White River. One possible explanation is that we recorded variant clutter calls from little brown bats (*Myotis lucifugus*), a species abundant in the area (Table 2; Fort Robinson sites) or another species of *Myotis*. We and other researchers have observed similar issues with variation in calls at localities associated with greater amounts of canopy cover or obstructions in the area (Broders et al. 2004). On the same evening with use of acoustic detectors, we captured 86 *M. lucifugus* in about 30 min 1.5 km away. Second, due to such variation in calls of many species of bats, we find it the best practice to confirm the identity of acoustic bat calls via mist-netting surveys, especially for species relatively easy to catch in mist nets, such as *M. septentrionalis* (see Benedict 2004). Future research is warranted to examine the plausibility of *M. septentrionalis* occurring on the White River at Fort Robinson State Park with both acoustic and netting surveys.

We found no conclusive data at this time to support the occurrence of *M. septentrionalis* in riparian habitats and upland habitats dominated by ponderosa pine forests in Dawes and Sioux counties. Our mist netting surveys were widespread, multi-year, and had many overall captures of all bat species known from those two counties (see Czaplewski et al. 1979). Limited acoustic data also support their absence in such habitats. Prior to initiating our surveys, we suspected that Soldier Creek (Sioux County) and Bordeaux Creek (Dawes County) had the greatest likelihood for documenting *M. septentrionalis* because of the presence of deciduous trees along permanent streams. We failed to detect this species during our surveys in those areas but predict such sites might represent some of the most likely upland riparian habitats for future occupancy, that is, besides the more developed deciduous riparian corridors in lowlands such as the White River. We based this hypothesis on habitat use of *M. septentrionalis* in Sheridan County and areas farther east in the state.

The only data that demonstrate ponderosa pine habitats are used by the species in northwestern Nebraska was by the capture of the first *M. septentrionalis* in Sheridan County (Benedict et al. 2000). On 21 September 1993, Benedict et al. (2000) reported a male individual captured over a stock tank on a hillside dominated by dry grasslands and open forests of ponderosa pine. Late September corresponds best with the movement periods for the species (Caceres and Barclay 2000), thus the individual possibly was in route between summer habitat and a winter hibernaculum. Such data suggest that *M. septentrionalis* potentially occurs across a larger area of the Pine Ridge during migratory movements and use additional habitat types not yet observed during summer months in the state. In the nearby Black Hills of South Dakota, however, Cryan et al. (2001) radio-tracked nine female *M. septentrionalis*, two non-reproductive, six pregnant, and one lactating, to roosts in ponderosa pine trees in upland habitats. Due to the proximity of reproducing populations in the Black Hills (Turner 1974, Cryan et al. 2001) and northern Sheridan County (Benedict 2004, this study), known ability for the species to colonize suitable habitats in the Great Plains (Benedict et al. 2000, Sparks et al. 2011), and use of upland ponderosa pine habitats <130 km away in the Black Hills (Cryan et al. 2001), we propose continued surveys should monitor the status of *M. septentrionalis* in the region, as the distribution of this species might continue to expand or shift. Isolated individuals or small groups might occur throughout the entire Pine Ridge in the future, if they do not inhabit some of these areas already in low abundances.

Due to major declines of this species in eastern North America (e.g., Ford et al. 2011, Moosman et al. 2013, USFWS 2013) and westward advancing front of white-nose

syndrome (Frick et al. 2010, USFWS 2013), additional research would aid in promoting conservation of *M. septentrionalis* in the Great Plains. We find that determining roosts used as hibernacula and maternity colonies in the Pine Ridge and throughout Nebraska would be important research topics to pursue. Research on distances traveled between summer and winter roost sites also is warranted as we only located a single paper in the literature with such data (Caire et al. 1979), although many other papers incorrectly cite such data (e.g., USFWS 2015) that actually refer to data on other species of bats or movements between hibernacula for *M. septentrionalis*. Additionally, examination of habitat suitability and composition of deciduous trees in eastern and western parts of the Pine Ridge along deciduous perennial water courses might elucidate the current lack of *M. septentrionalis* in western reaches of the Pine Ridge region during summer months. We predict that *M. septentrionalis* will colonize areas farther west in the Pine Ridge if suitable habitat exists and other factors are appropriate, such as food resources and if *M. septentrionalis* is not negatively affected by an abundance of *M. lucifugus* in riparian areas farther west in the Pine Ridge.

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