NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Hibernating Bats in North Dakota: Species Diversity, Habitat Use, and Potential Impacts of White-Nose Syndrome

Project T-35-R-1

August 1, 2012 – August 31, 2016

Terry Steinwand

Director

Submitted by Greg Link

Chief, Conservation and Communications Division

Bismarck, ND

November 2016

Hibernating Bats in North Dakota: Species Diversity, Habitat Use, and Potential Impacts of White-Nose Syndrome

Final Report

Prepared for the North Dakota Game and Fish Department

By

Dr. Erin Gillam
Dr. JJ Nelson
Dr. Paul Barnhart

Department of Biological Sciences
North Dakota State University
Fargo, ND

Species of Conservation Priority: Big brown bat (*Eptesicus fuscus*), Townsend's big-eared bat (*Corynhorinus townsendii*), Little brown bat (*Myotis lucifugus*), Northern long-eared bat (*Myotis septentrionalis*), Western small-footed bat (*Myotis ciliolabrum)*, Long-eared bat (*Myotis evotis*), Long-legged bat (*Myotis volans*), and Fringed bat (*Myotis thysanodes).*

Contact Information:

Erin Gillam
Dept. 2715, P.O. Box 6050
Fargo, ND 58108-6050
(701) 231-9401 (phone)
(701) 231-7149 (FAX)
Erin.Gillam@ndsu.edu

Activity Period: September 1, 2012 – August 31, 2016

Location: South Unit of Theodore Roosevelt National Park, Medora, ND (referred to as TRNP-SU throughout)

Table of Contents

I. EXECUTIVE SUMMARY

The continuing spread of the deadly fungal pathogen that causes White-Nose Syndrome has prompted wildlife management agencies in the US and Canada to rapidly develop action plans for effectively managing local populations of hibernating bats. While White-Nose Syndrome has not yet reached North Dakota, the disease is now advancing on two geographic fronts, with confirmed infection sites in eastern Minnesota and western Washington State. Prior to 2011, it was assumed that all bats in North Dakota migrated out of state during the winter months; this was shown to be inaccurate when the Gillam lab at NDSU collected pilot data suggesting that bats overwinter in the badlands habitat of western ND. The objective of this project was to expand our understanding of the hibernating bat community of North Dakota, with goals to identify what species are present during the Winter and to assess characteristics of selected hibernacula. Over three Fall-Winter-Spring field seasons, overwintering bats in Theodore Roosevelt National Park were studied via a combination of passive acoustic monitoring and physical capture with mistnets. Acoustic monitoring led to identification of the following winter residents: Big brown bats, *Eptesicus fuscus*, Silver-haired bats, *Lasionycteris noctivigans*, and bats of the genus *Myotis*. Physical capture in late Fall or Winter confirmed the presence of big brown bats and one *Myotis* species, the western small-footed bat, *Myotis ciliolabrum*. Further captures in early Fall suggest that two additional species, the long eared bat (*Myotis evotis*) and Townsend's big eared bat (*Corynorhinus townsendii*) may also be Winter residents. Three hibernacula (one cave, two rock crevices) were identified; temperature and relative humidity information collected indicate that climactic conditions in selected hibernacula are not ideal for the growth of *Pseudogymnoascus destructans*, the fungus that causes White-Nose Syndrome. Hence, if White-Nose Syndrome reaches the badlands of western ND, the spread of the disease is likely to be slow, particularly since data suggest that bats in the area roost singly or in small groups while hibernating. In the final year of this project, focus was shifted to assess the use of buildings as hibernacula by bats in eastern and Central ND, an area devoid of natural hibernation sites. Of eight potential building roosts that were identified and surveyed, the presence of big brown bats, *E. fuscus,* was confirmed at three of these sites. In summary, the results of this study confirm the presence of multiple bat species hibernating in the state of North Dakota. Future work aimed at additional characterization of this overwintering bat community would be valuable. Further, strategies for surveying known and potential hibernacula for the presence of *P. destructrans* are needed so that managers and biologists can effectively detect this pathogen if or when it arrives in North Dakota.

II. INTRODUCTION

White-nose syndrome (WNS) is a disease caused by a fungal pathogen, *Pseudogymnoascus destructans*, that has had devastating effects on hibernating bat populations in much of the eastern United States and Canada. Originally discovered in upstate New York in 2007, the disease has rapidly spread South and West, with the most recent confirmed cases in eastern Minnesota and western Washington in March 2016 (Figure 1). Mortality rates at hibernacula are generally greater than 75% and often reach 100% (Hicks 2008), with the estimated death toll from WNS in North America at more than 5.7 million bats (USFWS 2016). It is predicted that several bat populations in the eastern US will collapse in the coming decades (Frick *et al.* 2010), and one species, the northern long-eared bat, *Myotis septentrionalis,* has already been listed as threatened under the Endangered Species Act due to extensive mortality from this disease (Blehert et al. 2009, Langwig et al. 2015).

Figure 1. Bat White-Nose Syndrome occurrence map by county, as of 8/2/2016

In the 9 years since the discovery of this disease, there have been major breakthroughs in understanding transmission pathways, characteristics of the pathogen, and epidemiology of WNS. Alternatively, the primary conservation measures employed to fight the spread of WNS have changed little. These include: 1) strict decontamination protocols for individuals and equipment entering WNS-infected sites, 2) regular monitoring of known hibernacula for the presence of the fungal pathogen on bats or in the soil (Lindner et al. 2011), and 3) limiting human access to cave systems (Castle & Cryan 2010; Coleman et al. 2015; USFWS 2016). Once the pathogen has reached an area, management efforts have focused on documenting impacts to local bat populations, which is based on examining shifts from population data collected during the pre-infection period (Dzal et al. 2011). Such comparative data can provide critical information for developing effective conservation plans and determining which species are being hit hardest in a given region.

In North Dakota, there is no record of bats occupying natural hibernacula in the state and it has generally been thought that all bats undergo short or long-distance migrations to other states during the Winter months (Seabloom 2012). Hence, there was originally little concern about potential impacts of WNS infection in the state. Yet, documentation of hibernacula at more northern latitudes (Alberta, Canada; Lausen & Barclay 2006) suggested that bats could potentially overwinter in North Dakota. Specifically, the badlands of western North Dakota contain rock crevices and cave systems that could provide bats with the stable environmental conditions needed for effective hibernation.

During Winter 2011-2012, the Gillam laboratory at NDSU conducted an acoustic survey for bats in the South Unit of Theodore Roosevelt National Park, placing ultrasonic detectors at a variety of sites throughout the park where bats might pass by during periods of arousal. In that season, low levels of bat activity were recorded throughout the Winter months, indicating that bats were hibernating in the region. Note that very low levels of activity during the Winter is not necessarily indicative of very few bats being present in the area. Acoustic detection during the Winter is limited to bats that have aroused from hibernation and are actively flying in the recording area; given that animals are primarily in deep torpor within their hibernacula (presumably > 90% of the time), the chance of detecting a flying bat during such an infrequent and short-lived arousal period is unlikely. In addition to acoustic monitoring, we also captured two bats in early March 2012 during a period of arousal and tracked them to rock crevices and one large cave; at the same time, we documented additional hibernating individuals in the cave.

These preliminary findings suggested that rapid action was needed to learn more about the population of hibernating bats in western North Dakota. Working with the North Dakota Game and Fish Department, the Gillam lab began a multi-year study in 2012 to characterize the overwintering bat populations of western ND. The primary goal of the study was to use a combination of passive acoustic monitoring and radio telemetry to determine what species are overwintering in the region, and assess characteristics of occupied caves and rock crevices to determine what climactic and/or geological features are associated with occupied hibernacula. As is detailed later in the report, we had limited success tracking bats to hibernation sites for a variety of reasons. As a result, we worked with NDGF to reallocate remaining funds in our final year to an additional objective, aimed at documenting use of artificial hibernating sites (i.e. buildings) by bats in central and eastern North Dakota. Since these areas of the state lack natural sites for hibernation, any animals overwintering in the area will be dependent upon man-made structures. Information about use of such structures may be valuable in understanding potential invasion dynamics of WNS into North Dakota.

III. METHODS

III. A. Natural Hibernacula

III. A. 1. Passive acoustic monitoring

Passive acoustic monitoring is a process by which ultrasonic microphones coupled with recording devices, known as bat detectors, are deployed at sites and left unmonitored for days to weeks at a time. The unit automatically becomes active during a pre-set time period (i.e., sunset to sunrise) and recording is triggered when an amplitude threshold is crossed. In this study, units were used to detect the calls of bats that had temporarily aroused from hibernation and had left their hibernacula in search of water or other resources.

Detector units were deployed from September to May for the three years of the study (see Results for specific date ranges). Three types of bat detectors were used: 1) Anabat SD-2 units, 2) Anabat Roost Logger units, and 3) Pettersson D500X units. Both the Anabat SD-2 and Roost Logger units are frequency-division, zero-crossing bat detectors. Anabat SD-2 units were deployed at locations containing features that should have been attractive to active bats, such as near water sources or tree cover. These sites were also chosen based on their accessibility, as many parts of the study area were not accessible during the Winter months due to deep snow. Alternatively, Anabat Roost Loggers are designed to be placed within caves to record echolocation calls of bats after they arouse from hibernation. These devices were used to determine presence/absence of bats within specific cave sites during the Winter hibernation period. Unlike the Anabat Units, the Pettersson D500X records full-spectrum acoustic data, preserving all call information (zero-crossing units like the Anabat convert call data into a series of dots). While bat species identification can be successfully conducted on Anabat recordings, full spectrum data is valuable for further confirming such IDs. Pettersson D500X units were deployed at locations similar to those selected for Anabat SD-2 units.

The number and type of detectors deployed varied throughout the three years of the study. Table 1 lists the number of sites sampled with each detector type during each Winter sampling season. Most passive acoustic monitoring designs involve moving detectors to new locations every 2-4 days, although this design is based on Summer sampling when bats are active each night. The low amount of activity that is inherently detected in a Winter study led us to conclude that such regular movement of detectors would not be valuable, as a small number of sampling nights would not necessarily reveal information about general patterns of activity at a given site. Further, despite our efforts to place units at sites that were accessible during the Winter, heavy snow and road closures still served as a problem for some sampling locations; hence, moving units regularly was not always feasible.

Recording data was collected from the Anabat SD-2 and Petterson D500X units every 3-4 weeks, while the Roost Logger units deployed at known or potential hibernacula were able to remain powered and gather data for up to four months at a time. Recorded echolocation calls were analyzed using either Kaleidoscope Pro 3.0 (zero- crossing files) or Sonobat 3.0 (full spectrum files). Both analysis programs use automatic identification algorithms built from extensive call libraries that contain recordings from known individuals. Further, the species identified can be tailored to fit only those found in the region of study. For both programs, recorded files were first filtered to remove those containing sounds produced by blowing wind and rain, as well as call sequences of sufficiently poor signal-to-noise ratio as to preclude an accurate identification. The remaining call sequences were then classified. Classifying an entire sequence provides more reliable results than just analyzing single calls alone, as this method combines information within the sequence and avoids any issues of pseudoreplication. As a note, while data collection often continued until late May, we only analyzed calls through April 30th of each field season; calls recorded later than this may be from southerly migrants entering the region for the Summer months.

Table 1. Passive acoustic monitoring effort by year of study. Note that due to irregular patterns of arousal of bats from hibernation, as well as issues with regular access to sites experiencing heavy snow, units were not moved on a regular basis.

Winter	*Number of Sampling Locations*		
	Anabat SD1/SD2	*Anabat Roost Logger*	*Pettersson D500X*
2012 - 2013	8	0	0
2013 - 2014	7	6	0
2014 - 2015	6	0	4

III. A. 2. Physical Capture and Radio Telemetry

Capture of bats during the Winter months is particularly difficult, since the probability of capturing an animal that has aroused from hibernation is extremely low. Seasonal warm-ups during the Winter are the best chance to capture bats, as such increases in temperature often trigger many bats to arouse at once. Sampling during the Spring or Fall is also valuable; at these times, bats are possibly occupying their Winter hibernacula sites, but have still not entered a state of deep torpor in which they are inactive for weeks at a time. As a result, we primarily conducted mistnetting to capture bats during either the Spring or Fall months, or during occasional spikes in temperature during the Winter.

At a given mistnetting site, a total of two to five nets were deployed each night. Capture site locations were logged into a GPS and the primary vegetation dominating the landscape (i.e. mixed ponderosa pine/juniper woodlands) was characterized. Mistnet configurations and climactic data were also recorded. Mistnets were opened each night just before sunset and closed shortly before sunrise, or 120 minutes after the last capture of a bat. Upon capture, we assessed the following for each individual: species, sex, age, mass, forearm length, and reproductive condition.

After basic measurements were made, captured bats were fitted with a radiotelemetry tag. The fur between the scapulae was clipped and a 0.37 g radio transmitter (Holohil Systems, Model: LB-2N) was attached using surgical glue to the exposed skin. Radio transmitters should have minimally affected the maneuverability of bats, as we abided by the standard rule that tags should be <5% of total body mass (Aldridge and Brigham 1988). Bats were held with the radio transmitter in place for five minutes to allow time for the adhesive to dry, and then immediately released in the vicinity of the capture site. All bats were released within two hours of capture. The radio tags used have a battery life of ~ 11 days, and tags generally fall off within two weeks.

On subsequent days after release, bats were tracked using a directional antenna and an R-1000 receiver (Communication Specialists). Once a tagged bat was successfully located, characteristics of the rock crevice or cave were gathered. Temperature was assessed at the roost entrance, as well as within the roost if this was possible to do without disturbing the bats. Relative humidity was also assessed within the roost, when possible. A combination of Ibutton and Hobo climactic data collection devices were used.

III. A. 3. Scouting for Potential Hibernacula

Due to a paucity of information about the location of caves in the badlands of Western North Dakota, several scouting trips on foot were made during the first two field seasons of the study into the backcountry of TRNP-SU in search of potential hibernacula. While scouting on foot is not an efficient manner to cover large amounts of ground, the inaccessibility of most of the park via vehicle during the Winter season left this as our only option for further exploration. Potential hibernacula were identified based on slope face, size of the opening of the cave/crevice and the level of protection from wind and other elements. Some potential hibernacula were subsequently monitored for bat activity using Anabat Roost Loggers.

Based on the location of the potential hibernacula that we identified via scouting, we developed a habitat suitability map. The analysis included a digital elevation map (DEM) obtained through the USGS. The DEM was then converted into two separate raster datasets, slope and aspect, using ArcGIS. We then placed these two raster datasets and the locations of known and potential hibernacula into the MaxEnt software to develop a habitat suitability map for TRNP-SU. The resulting map depicted areas of high and low suitability in which new potential hibernacula might be found. This map was developed to guide future scouting trips so that efforts can be focused on areas of the park identified as having the potential for highly suitable hibernacula habitat.

III. B. Artificial Hibernacula

In Winter 2015-2016, the focus of the project was shifted from locating natural hibernacula in western ND to identifying artificial hibernacula in eastern and central ND. These regions of the state have no cave systems that could provide natural overwintering sites for bats. Yet, the presence of many human communities throughout the region opens up the possibility that bats are overwintering in man-made structures. Essentially no work has focused on understanding the vulnerability of bat populations that overwinter in anthropogenic structures to WNS, and the importance of such artificial hibernacula may potentially impact disease dynamics. For example, if WNS reaches the northern Great Plains, it may jump directly from cave systems in Minnesota or Manitoba to western ND, or it may spread via hibernating populations of bats in buildings throughout the eastern and central regions of the state. Hence, determining if bats are using man-made structures as hibernacula should be of management value.

To locate building hibernacula sites in eastern and central North Dakota, it was necessary to engage the public. A "media blitz" was conducted through the NDSU Office of Research and Creative Activities to alert the public that the Gillam lab and NDGF were in search of Winter bat roosts in buildings throughout the state. The press release was sent to more than 70 media outlets throughout North Dakota, South Dakota and Minnesota. This resulted in new stories being run in ~20 print/internet news sources, as well as two radio interviews and one TV media interview. Other strategies for reaching the public included: 1) emailing NDSU students and posting fliers around campus asking students to inquire with their families during the Thanksgiving and Winter holiday breaks about potential bat hibernacula in buildings, and 2) sending fliers to local post offices throughout the study area, with a request that fliers be hung on public information boards (these are often located in the post office in small towns).

Once a potential site was located, a Pettersson D500X unit was deployed at the site. Placement of the unit was dependent upon the characteristics of each building site; for most locations, detectors were placed within the building in question, while a few sites required that detectors be deployed directly outside of the building. Detectors were deployed with sufficient battery power and memory to monitor for 3-4 weeks, after which data was removed from the units. All units were permanently removed from sites by mid-May 2016

IV. RESULTS

IV. A. Natural Hibernacula

IV.A.1. Passive Acoustic Monitoring

Sampling locations for the three types of detectors deployed are listed in Appendix 1. Sampling occurred from September 1, 2012 to April 24, 2013, September 28, 2013 to May 31, 2014, and September 27, 2014 to May 24, 2015. As noted above, calls recorded after April 30th of each year were not analyzed, as these could be from southerly migrants that had entered the area. After filtering out noise and low-quality call sequences, we conducted species classification on 740 call sequences in Winter 2012-2013, 856 sequences from Winter 2013-2014, and 384 sequences from Winter 2014-2015. An example of a high-quality call sequence is shown in Figure 2.

In addition to the Anabat SD-2 units used in every field season, we deployed Anabat Roost Loggers in Winter 2013-2014 and Pettersson D500X units in Winter 2014-2015. Six Anabat Roost Loggers were placed within caves that had previously been identified as potential hibernacula. Unfortunately, three of the Roost Logger units were disturbed in Spring 2014 by visitors – two had components removed and stolen, while a third was turned into the NPS office. From the collected data, we found evidence of bat activity in two caves, with two call sequences recorded at RL Site 1 on 10/20/2013 and 2/13/2014, and one call sequence recorded at RL Site 4 on 4/20/2014. Given the low number of call sequences collected from the two Roost Logger units, we were not able to definitively conclude if these sites were regularly occupied by bats during the Winter months. Interestingly, the Anabat Roost Loggers were not collected until early June in this season, and more substantive bat activity was found at Roost Logger sites 3 and 4 from late May onward. This suggests that at least some of these sites may be used as Summer roosts by bats in the badlands.

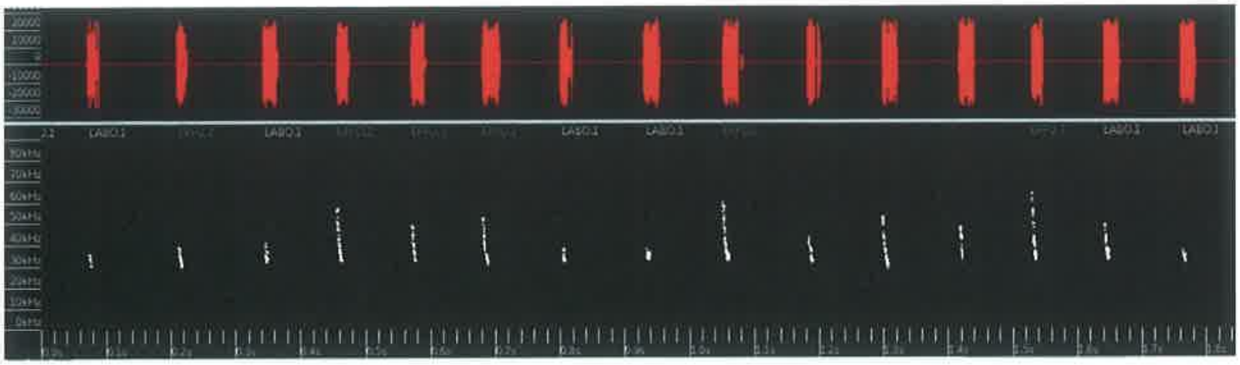


Figure 2. An example waveform (amplitude x time representation) and spectrogram (frequency x time representation) of a high-quality sequence of bat calls recorded from an AnaBat SD-2 unit in Theodore Roosevelt National Park – South Unit.

Deployment of four Pettersson D500X units in Winter 2014-2015 led to collection of 3,857 files, yet none of these contained classifiable echolocation call data when assessed by both analysis programs. The Pettersson units were plagued with power problems, as they use a lower voltage battery compared to the AnaBat units, which led to issues with maintaining reliable power over the 3-4 weeks between each visit to the study area. This problem was not foreseen because it was related to low winter temperatures, as these same units could easily maintain power for one month during Summer sampling for other projects. Since this time, we have worked with the company to determine an alternate powering system, which involves special-order 6V batteries with high enough amperage to power the system for one month or longer in below freezing temperatures.

Species ID results are reported in Table 2. The most common species identified was the eastern/western red bat (*Lasiurus borealis/Lasiurus blossevillii*). Yet, these call sequences were almost exclusively limited to the Fall months (September and October), suggesting that a migratory pathway of this species goes through North Dakota. This aligns with the biology of this species, as well as the hoary bat, *Lasiurus cinereus*, as these species are long distant migrants that are not known to regularly hibernate, although some cases of *L. borealis* hibernating in leaf litter have been reported in the eastern United States (Moorman et al. 2009).

All six *Myotis* species found in the region were identified in our acoustical analysis. While these results are broken down by species in Table 2, our confidence in the ability of the software to tease apart these species, which have very similar echolocation calls, is limited. Hence, it is preferable to interpret the results as all six *Myotis* being lumped into one "*Myotis species*" group. Additional interpretation of acoustic results is presented in Section V.

Table 2. Call ID results for all three sampling years, broken down by detector type. Species abbreviations are as follows: EPFU = Eptesicus fuscus, LABO = Lasiurus borealis, LABL = Lasiurus blossevillii, LANO = Lasionycteris noctivigans, MYCI = Myotis ciliolabrum, MYEV = Myotis evotis, MYLU = Myotis lucifugus, MYSE = Myotis septentrionalis, MYTH = Myotis thysanodes, MYVO = Myotis Volans

	2012-2013	2013-2014		2014-2015	
SPECIES	**SD-2**	**SD-2**	**RL**	**SD-2**	**D500X**
EPFU	46	16	0	9	0
LABO/LABL	283	302	2	55	0
LACI	9	236	0	26	0
LANO	319	108	0	96	0
MYCI	0	0	0	10	0
MYEV	0	2	0	0	0
MYLU	15	10	0	13	0
MYSE	2	13	1	1	0
MYTH	0	0	0	1	0
MYVO	0	1	0	1	0
No ID	66	165	0	172	0
TOTAL	740	853	3	384	0

IV.A.2. Physical Capture and Radio Telemetry

In all three sampling seasons, mistnets were deployed at a variety of sites within TRNP-SU, including: 1) habitats that would potentially be attractive to bats that have aroused from hibernation, such as sites near an open water source, and 2) in front of known or potential hibernacula. Mistnetting for bats during the Winter months is especially difficult due to the low numbers of bats that are active at any given time. As a result, much of our mistnetting focused on either the Fall (Fall 2012, 2014) or Spring (Spring 2013) months. In the Fall, bats may have begun to move into their hibernacula, but still be active on a regular basis, increasing our chance of capturing individuals. The same is true in the Spring, when bats may not have yet moved to their Summer roosts, but daily activity has increased substantially compared to the Winter.

As a reference point, information about our Winter 2011-2012 data are included here. On 11 March 2011, one big brown bat, *Eptesicus fuscus*, was tracked to a large cave, referred to as HIB 1 throughout this report. A visual inspection of the cave revealed two hibernating big brown bats ~12m from the entrance.

In the 2012-2013 season, mistnets were deployed on 14 nights throughout the sampling period. From 12-14 September 2012 a mistnet was deployed in front of the entrance to HIB 1 to determine if other species were using this site. During this time, one long-eared bat, *Myotis evotis*, and one big brown bat were caught emerging from HIB 1 and one Townsend's big-eared bat, *Corynorhinus townsendii*, was caught entering the cave. Emergence or entrance was noted by the side of the mistnet in which the bat was captured.

On October 9, 2012 one western small-footed bat, *Myotis ciliolabrum,* was captured near a water source. We tracked the bat to two hibernacula, the first of which it remained in for one night (HIB 2) and the second of which it remained in for eight nights (HIB 3), after which the transmitter failed. Both of these hibernacula were considerably smaller in size than HIB 1. HIB 2 and 3 were thin rock crevices, hence it was not possible to assess how deep the crevices ran or if they opened up into larger spaces.

In the 2013-2014 season, mistnets were deployed on 21 nights, primarily in March and April 2014. Nets were deployed near open water sources as well as near the entrance to HIB 1-3. Spring sampling was selected because higher temperature bouts often occur during this time period; during such warmer periods, bats are more likely to arouse from hibernation and fly outside, increasing the chance of mistnetting success. Unfortunately, the weather was not favorable for bat activity during this period, with unseasonably low ambient temperatures and/or high winds.

In the 2014-2015 season, mistnets were deployed on 18 nights, mostly in September and October 2014. Despite the fact that temperatures had not yet fallen to particularly low values as is typical in the Winter months, no bats were captured. Further, echolocation calls were only heard once on a bat detector kept active at mistnetting sites.

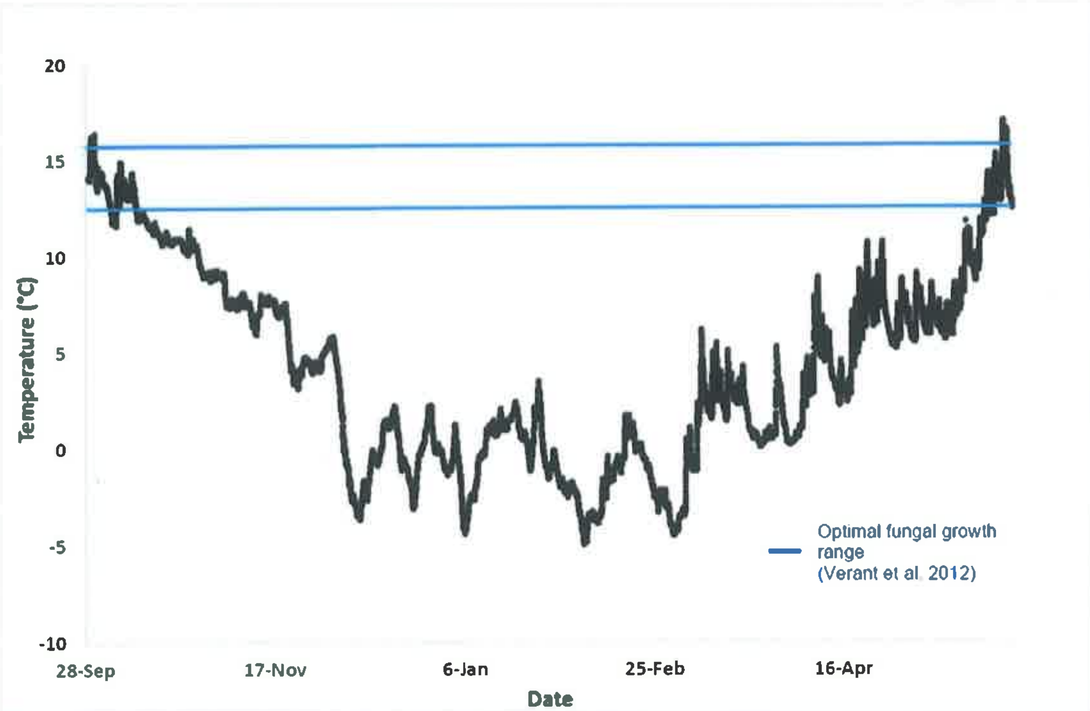
IV.A.3. Hibernacula Characteristics

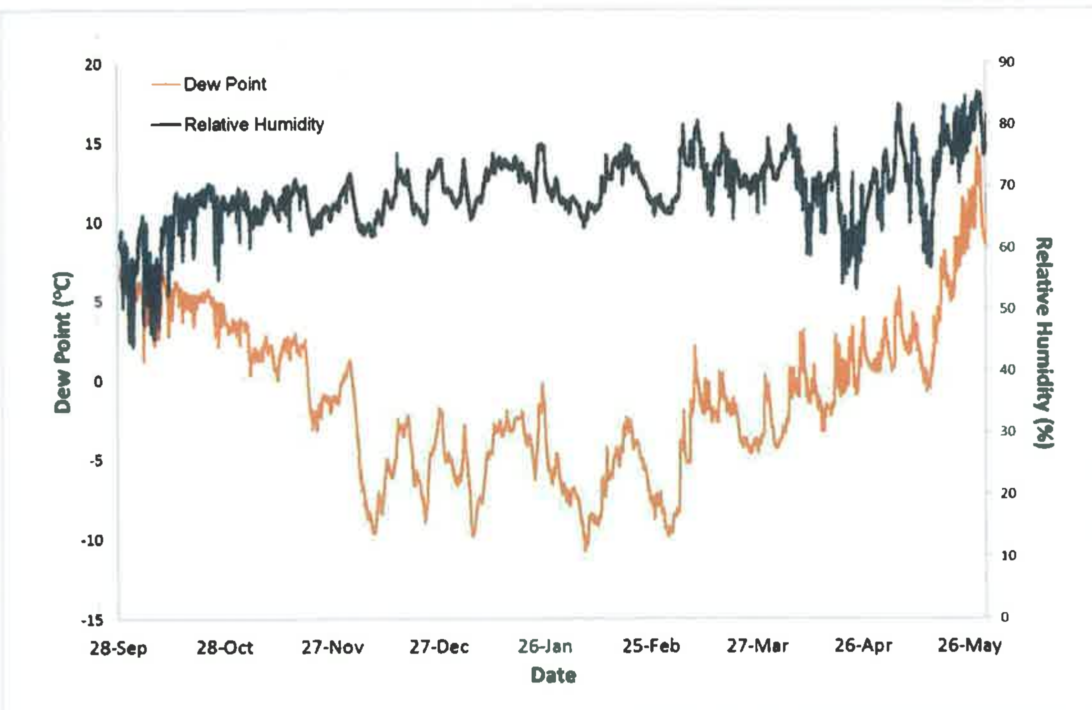
In Winters 2012-2013, information about the climactic conditions within the three known hibernacula were gathered. Data from HIB 1 was collected from March 12-14 at 60 sec intervals using a Hobo Weather Station, which measures temperature, relative humidity and dew point. The Hobo unit was placed ~12 m within the roost near the area that a single bat had been seen hibernating, although it is likely that more bats were located in a further chamber that was not accessible to the researchers. In addition, two Ibuttons were deployed from March 14-15 at different locations within the roost. During both Ibutton deployments, similar temperature information was collected (Table 3). Temperature data was also collected in HIB 2 (October 10, 2012) and HIB 3 (October 11-19, 2012; Table 3). In general, temperatures were more stable in the larger HIB 1 compared to the two smaller HIB 2 and 3 (Table 3). Further, average temperatures were lower in HIB 1 (5.21°C across all Ibuttons) compared to HIB 2 (8.62°C) and HIB 3 (7.84°C).

Table 3. Temperature information collected from Ibuttons in Hibernacula 1-3 in Winter 2012-2013. Temperatures are shown in C°

Hibernacula	*HIB 1*				*HIB 2*	*HIB 3*
Ibutton	1	2	3	4	5	6
AVG	5.37	5.36	4.91	5.21	8.62	7.84
SD	1.09	1.18	0.89	1.08	3.19	4.05
MIN	4	4	4	4	1	-2
MAX	7	7.5	8	8.5	13	16.5

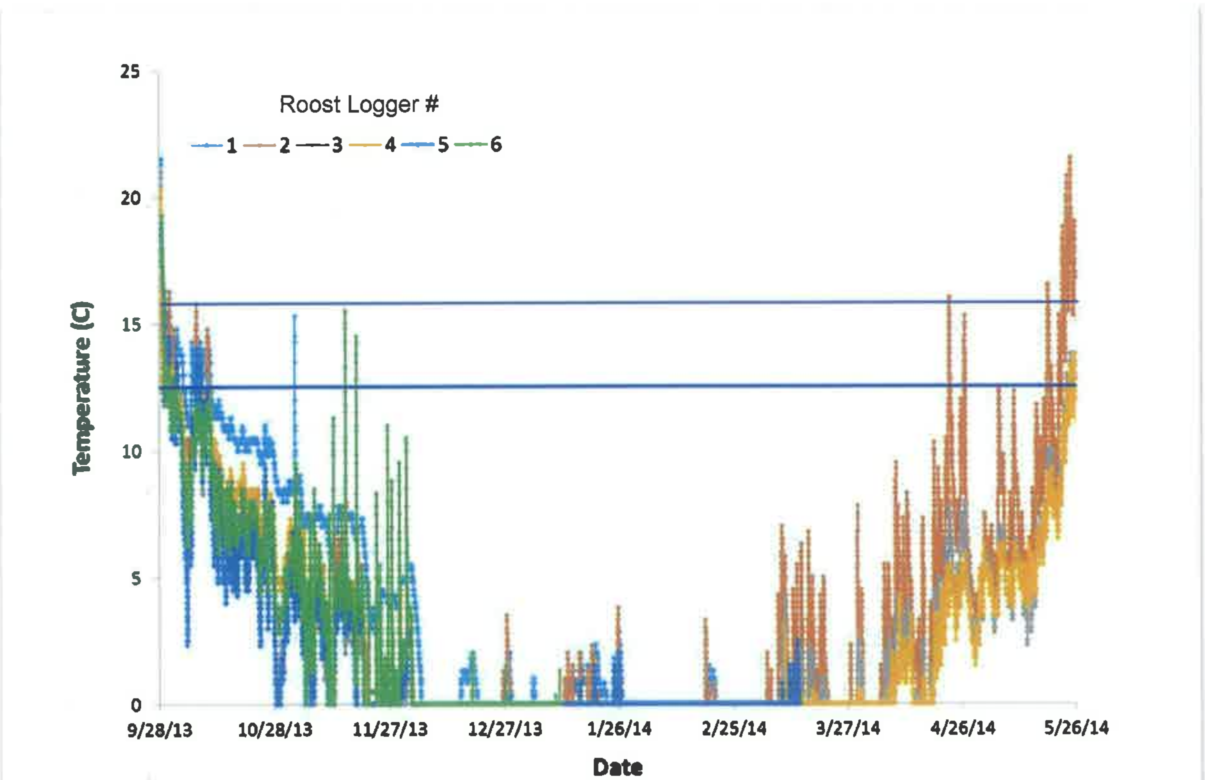
Figure 3. Climactic data from HIB 1 during Winter 2013-2014: a) temperature data and b) relative humidity and dew point data. Data points were logged every 10 seconds. Logger was placed ~12m within the roost in the vicinity of a site where bats had been previously observed roosting.





In Winter 2013-2014, sampling of HIB1 was expanded, with deployment of a Hobo Weather station across the entire sampling season (Figure 3). Temperature data was also collected by the six Anabat Roost Loggers deployed at a variety of potential hibernacula (Figure 4). Temperature data indicate that Winter cave temperatures are generally outside of the ideal temperatures for growth of *Pseudogymnoascus destructans*, the fungus that causes WNS (optimal growth range highlighted in blue in Figures 3 and 4). Further, relative humidity values from HIB 1 are substantially than those of hibernacula that have been impacted by WNS in the eastern United States (10-15% RH vs 70+% RH), although recent laboratory work suggests that *P. destructans* can survive for long periods of time at 30-40% RH (Hoyt et al 2015).

Figure 4. Temperature data from Anabat Roost Logger devices. The minimum readable temperature for these devices is 0°C – the flattening of the data lines at 0°C represents a limit of the equipment, not the actual temperature. Each roost logger is labeled with a different color.



IV.A.4. Scouting for Potential Hibernacula

We identified 18 potential hibernacula via scouting. This includes sites identified by extensive scouting via vehicle (i.e. sites that could be seen from the road) that was done in the first season of the study. Appendix 2 includes a list of the geospatial information about these potential hibernacula. Approximately 1/3rd of these sites were surveyed for bat activity using Anabat Roost Loggers. While two of the surveyed sites led to a handful of echolocation call recordings, further data is needed to determine if these sites are actually occupied by bats. Other surveyed locations had either no echolocation calls recorded or data was not collected due to equipment vandalism (see above).

Based on the location of the potential hibernacula we found via scouting, we developed a habitat suitability map. The resulting map depicts areas of high and low suitability in which new potential hibernacula can be found (Figure 2). This map should be useful in guiding future scouting trips, as we can focus our efforts on areas of the park with patches identified as having highly suitable hibernacula habitat.

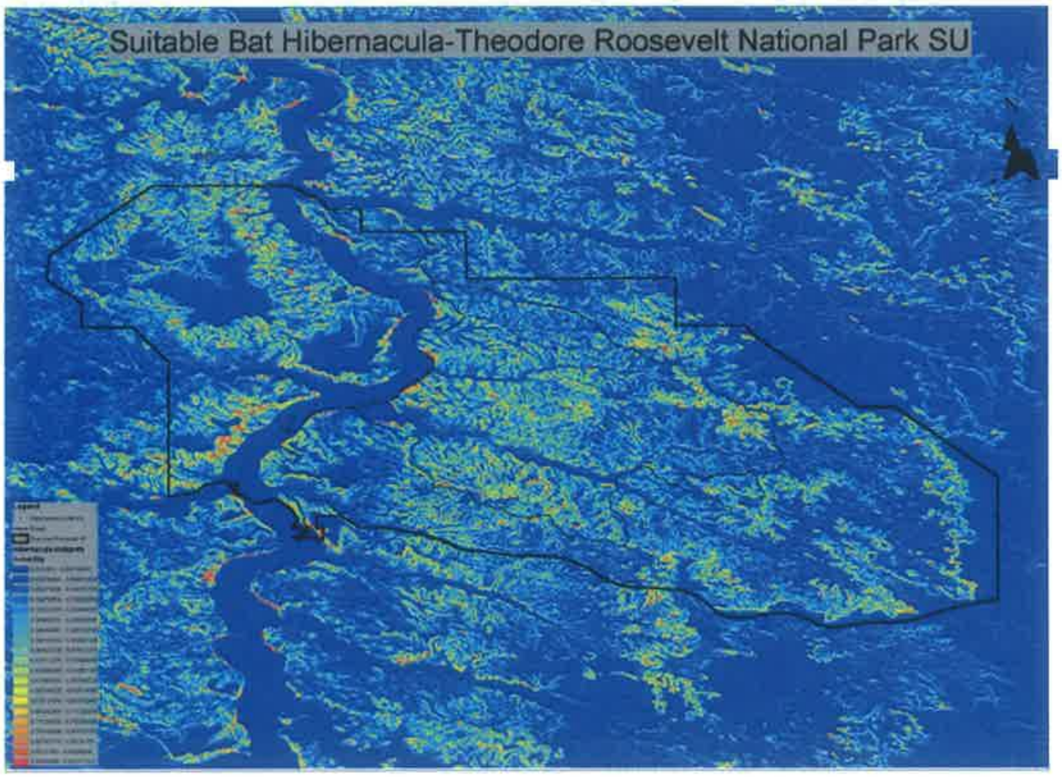


Figure 5. Habitat suitability map built from known and potential hibernacula sites. Red areas indicate areas of high suitability, while blue indicates an area of low suitability. The border of the South Unit of Theodore Roosevelt National Park is outlined in black.

IV. B. Artificial Hibernacula

IV.B.II. Comparison of Roost vs. Random Trees

The media blitz and associated efforts to reach the public were of limited success, with only 13 leads from eastern and central ND. After further discussion or inspection, it was determined that only 8 of these sites were viable leads. Pettersson D500X bat detectors were deployed at each of these sites, which are described in Table 4. Note that one sampling site was located in Ada, Minnesota; despite the fact that this was clearly not in ND, a unit was placed to survey the area since the town of Ada is <30 miles from the ND border.

Bats were detected at three of the eight building sites sampled during Winter 2015-2016. In Wahpeton, ND in the Old Main Building of the ND State College of Science, calls of big brown bats were manually identified. Calls were atypical in shape and frequency for this species, but this is not surprising given that animals were flying in the relatively small space of an attic. At a building on the campus of United Tribes Technical College in Mandan, ND, big brown bats were also confirmed to be roosting, through acoustic identification and visual inspection. At the First Methodist Church in Fargo, ND, a variety of species were acoustically identified, although it is likely that this location is strictly inhabited by big brown bats. Big brown bats were physically captured at this site during the Winter months. Further, bats were flying in an enclosed space, so the same issue of deviation from typical call structure holds true at this site as well. Such calls can then be misclassified as bats that use higher frequency, broadband calls, such as red bats and little brown bats. Further study of this site is necessary to determine if silver-haired bats or little brown bats are actually present in the Winter months.

Table 4. Acoustic identification data for seven surveyed building sites in Winter 2015-2016.

Location	Start	*End*	*Type*	*EPFU*	*LABO*	*LACI*	*LANO*	*MYLU*	*No ID*
Ada (MN)	28-Dec	2-May	Residence	0	0	0	0	0	0
Northwood	23-Nov	21-Jan	Storage warehouse	0	0	0	0	0	0
Sheldon*	23-Nov	11-May	Residence	120	0	3	96	0	14
Wahpeton	21-Jan	11-May	College building attic	28	0	0	0	0	0
Fargo	21-Jan	11-May	Church attic	167	85	30	98	37	309
Hague	22-Dec	12-May	Residence	0	0	0	0	0	0
Selfridge	22-Dec	12-May	Residence	0	0	0	0	0	0
Mandan	22-Dec	12-May	College building attic		0	0	0	0	0

** While bats were recorded at the Sheldon, ND site, these were exclusively after April 30; hence this activity can be considered from Summer residents.*

V. DISCUSSION

V. A. What Species Overwinter in Western ND?

The goal of this study was to gather basic information about the populations of bats that overwinter in western North Dakota, an area that has an abundance of rock crevices and small caves that could potentially be used as hibernacula. Although the study experienced some logistical problems, the data gathered provides a more comprehensive picture of what types of bats are using this region for hibernation. Predictions can also be made about *how P. destructans*, the fungus that causes WNS, will fare under the typical weather conditions experienced in the badlands of ND during the Winter months.

V.A.i. Acoustic monitoring

Data from acoustic monitoring indicate the presence of bats in the study region throughout the Fall, Winter, and Spring months. As mentioned above, the prevalence of red bat (*Lasiurus borealis/blossevillii*) and hoary bat (*Lasiurus cinereus*) call sequences in our dataset does not indicate that these tree-roosting species are hibernating in ND. Given that almost all call sequences identified to these species were recorded in the Fall, it is likely that that western North Dakota is part of a migratory corridor used by these species to reach southerly wintering grounds in the southern United States. Future work focused on better characterizing this migratory corridor will be of value to conservation efforts focused on these species.

A substantial number of call sequences were also classified as big brown bats (*Eptesicus fuscus*) or silver-haired bats (*Lasionycteris noctivigans*). While *E. fuscus* was physically captured during the Winter months, we have yet to similarly confirm the presence of *L. noctivigans* in the state during the Winter. Silver-haired bats are generally considered migratory and are typically not found overwintering in caves; yet, migration in this species is poorly understood and may differ between populations (Cryan 2003, McGuire et al. 2012). Availability of suitable hibernacula may be a key factor influencing migration in these bats and the boundaries of their Winter distribution are poorly known (Izor 1979). In North Dakota, multiple acoustic detections of these bats in the badlands across Winters suggest that the species is a Winter resident. Yet, these calls are similar in structure to those of big brown bats; while the analysis software appears to effectively differentiate between these species, it is not clear if some sequences of both species are being misclassified as the other. A detailed analysis in which captured animals (with species ID confirmed) are released and recorded to use as voucher call sequences would be valuable. While this has been done in other regions of the United States, geographic variation in call structure does occur; such local data would help improve the accuracy of the classification functions used by the sound analysis software.

The remaining species classifications are divided amongst the six *Myotis* species known to be Summer residents of western ND. While these have been broken down by species in Table 2, it is important to stress that there are known issues with separating the echolocation calls of these species. In general, bats of the genus *Myotis* are difficult to tease apart using acoustic information alone due to heavy overlap between species in their typical call structure (Schnitzler and Kalko 2001, Lundy et al 2011). Hence, it is most appropriate to group all of the calls classified as *Myotis* species into one group (MYSP) and only state that a species is definitively present in the Winter months if this is further confirmed with a physical capture. As a result, it is only possible at this time to definitively conclude that *Myotis ciliolabrum* is a Winter resident of ND, as this species was captured in 2012. It is likely that other *Myotis* species are roosting in the region; *Myotis evotis* was captured in early Fall 2012, and all six *Myotis* species for which calls were identified are found in the study area during the Summer months. Of special interest is whether the northern long-eared bat, *Myotis septentrionalis*, is overwintering in North Dakota; this has not been documented via physical capture, but given the short migratory distance of this species in other regions, hibernation in the badlands by ND Summer residents is plausible.

V.A.ii. Physical capture

Ultimately, it was more difficult than expected to capture bats during the Winter months, primarily for two reasons. First, western ND does not regularly experience seasonal warm-up periods during the Winter, which are known as "chinooks" in western regions of North America. The only other study that has definitively documented overwintering bat activity in the northern Great Plains occurred in western Canada (Lausen and Barclay 2006), where bats were primarily captured when they arose from hibernation and temporarily become active during these warm periods. The steady cold during the North Dakota Winter means that animals likely arouse based on internal signals rather than external temperature cues – as a result, there is unlikely to be any synchronization in arousals, such as what is seen with chinook events. The second challenge related to effectively capturing bats is that North Dakota is essentially devoid of permanent caves, with relatively ephemeral sinkholes and rock crevices serving as hibernacula for bats. Data presented in this report show that at least some bats will hibernate in rock crevices, which means that there are countless potential overwintering locations in the ND badlands. This not only makes identifying hibernacula much more difficult, but also capturing bats, as mistnetting efforts cannot be focused on areas near large cave systems where bats are likely to be hibernating.

Despite these setbacks, the presented radio tracking data provide important information about hibernating bats in North Dakota, including the first identification of two species definitively overwintering in the state (*E. fuscus* and *M. ciliolabrum*) and evidence suggesting that two additional species may also be hibernating in the area (early Fall captures of *Myotis evotis* and *Corynorhinus townsendii*). One large cave and two rock crevices were identified as hibernacula. While our ability to access most of HIB 1 was limited due to a narrow entranceway into the back chamber, multiple species were found at this location, suggesting that it is an important overwintering site for local bats. Further, the documentation of rock crevices being used as hibernation sites suggests that bats are often roosting in small groups, or possibly even alone. This is an exciting finding from the perspective of WNS, as bat-to-bat transmission is a key factor in disease spread, and it has been suggested that one reason this pathogen is less deadly in Europe and has slowed in the Midwest US is because bats form smaller hibernation groups compared to eastern US populations (Verant et al. 2012). If bats are roosting separately or in small groups in North Dakota, this may lessen the impact of *P. destructans* on hibernating bat populations if the pathogen arrives in the state.

V. B. What are the Characteristics of Hibernacula Used by Bats in Western ND?

Temperature data gathered from the three known hibernation sites in western ND indicate that Winter cave temperatures are generally outside of the ideal temperatures for growth of *P. destructans*, the fungus that causes WNS. Verant et al. (2012) studied growth patterns of several strains of the fungus across a wide temperature range, and found the thermal optima for growth to occur between 12.5 and 15.8°C. While growth can still occur at lower temperatures, it is not as rapid.

One piece of information that is not currently reported in the literature is the lower critical temperature for survival of the fungus (i.e. the temperature at which no growth occurs). Hoyt et al. (2015) report that the fungus can persist for five years in the absence of bats at 5°C. While the temperature data reported in our study suggest hibernacula sites in ND regularly reach temperatures well below freezing, it is important to note that only accessible locations were sampled and that these are not necessarily the exact spots where bats were hibernating. Microclimactic differences within caves and crevices can be substantial over short distances, and it is likely that exact locations selected for hibernation do not fall much below 5°C. Hence, it is probable that if *P. destructans* infiltrates caves and crevices in western ND, that it may be able to persist for long periods at specific hibernations sites, although the much colder temps experienced in other parts of a cave/crevice may greatly hamper the spread of the fungus.

Hoyt et al (2015) also examined how long-term persistence of *P. destructans* was impacted by low relative humidity (30%), finding that the species could persist at this RH value for 5 years in soil samples (no hibernating bats present). This is relevant for understanding WNS in North Dakota, as data presented here show that hibernacula sites have low RH, with averages around 10-15%. Similar to the temperature data, we cannot confirm that microclimactic differences within a hibernaculum mean that RH values may be much higher at the specific locations that bats are hibernating. Overall, climactic data suggest that while *P. destructans* should be able to become established in western ND, the conditions are not ideal for growth, so spread will likely be slow. Such spread is likely to be further slowed if, as suggested above, bats primarily roost alone or with a small number of bats.

V. C. Are Bats Overwintering in Buildings in North Dakota?

Our preliminary findings suggest that at least one species of bat (*E. fuscus*) is overwintering in man-made structures in North Dakota. When searching for building hibernacula, we received relatively few leads despite our attempts to reach a large amount of people in the state. This may indicate that either few building hibernacula exist in ND or that people are often unaware of the presence of hibernating bats in occupied buildings. While the latter is certainly possible, we will note that at all three sites in which Winter bat activity was confirmed, building managers had problems with big brown bats periodically entering lower floors of the building where people work during the Winter months. Given that big brown bats typically select areas of a roost that are between -1°C and 13°C (Brack and Twente 1985), and that temperatures in ND regularly dip to -20°C in the deep Winter months, it is unlikely that these bats overwinter in unheated structures, such as detached garages or abandoned farm buildings. While we cannot rule out the possibility that there are a large number of bats living in man-made structures during the Winter in the state, our work suggests that this is not the case. Given the low temperatures that can occur even in attics of heated buildings, it is also not surprising that big brown bats are the species that have been found hibernating in these structures. Their larger body size compared to smaller *Myotis* species means that they should have a tolerance for lower roost temperatures when in deep torpor (Brack and Twente 1985).

V. D. Future Research and Conservation Objectives

As the spread of White-Nose Syndrome has advanced westward, the likelihood of the pathogen reaching North Dakota continued to increase. This probability was further heightened with the 2016 discovery of bats having died of WNS in Washington State; now the disease is approaching the northern Great Plains from two fronts. Although we have a better understanding of hibernating bat populations in North Dakota than we did four years ago, there are still many questions that remain open, many of which are important for building an effective plan for managing this disease.

First among these is an understanding of how to best monitor for this disease in North Dakota. As previously noted, the only available natural hibernacula come in the form of caves and rock crevices found in the badlands region of western ND. Unfortunately, there is essentially no mapping of known caves in this area, and the rugged terrain prevents extensive exploration and scouting even in the Summer months without a large team dedicated to the work. In South Dakota and Montana, state agencies have been able to employ the help of recreational spelunkers to monitor bats at known cave sites and inform them of previously undocumented hibernacula. No such spelunking community exists in North Dakota, so this is not a resource that can be used. Yet, there is extensive backcountry hiking that occurs in TRNP during the Summer months. One possibility might be to develop a program in which hikers use their smartphones to record the GPS locations of any caves they encounter during their forays into the backcountry and report this data to the National Park Service. Acoustic monitoring devices such as Anabat Roost Loggers could then be deployed at these locations in the Fall to monitor for bat activity. Any sites with confirmed bat activity in the Winter could then be regularly monitored for *P. destructans*. Yet, this is only one possible solution and it depends heavily on public participation; it would be worthwhile to work with managers and biologists to brainstorm additional ways that we may be able to monitor for this disease in North Dakota.

It is also not clear if there are additional species hibernating in the state, beyond those documented in this project. Given the problems faced in capturing animals during the Winter, it would be best for future work to involve dedicated personnel that live on site and regularly net throughout the Fall, Winter, and Spring months. While this study involved three month-long sampling bouts, we were unable to have a researcher present during the entire sampling season due to time commitments at NDSU (classes and teaching). Although our sampling covered all parts of the Fall-Winter-Spring season, dedicated personnel would have more time to test out new mistnetting sites and scout more of the landscape.

VI. ACKNOWLEDGMENTS

We would like to thank the North Dakota Game and Fish Department and the US Fish and Wildlife Service for providing funding for this research through the State Wildlife Grant program. We would also like to thank the managers at the North Dakota Game and Fish Department (especially Patrick Isakson and Steve Dyke), National Park Service, National Forest Service, US Fish and Wildlife Service, and the North Dakota Parks and Recreation Department who helped us with the logistics of this project, such as access to lands.

VII. REFERENCES CITED

Aldridge, H.D. & Brigham, R.M. (1988). Load carrying and maneuverability in an insectivorous bat: a test of the 5% "rule" of radio telemetry. *Journal of Mammalogy* 69: 379–383.

Blehert, D.S., Hicks, A.C., Behr, M., Meteyer, C.U., Berlowski-Zier, B.M., Buckles, E.L., Coleman, J.T.H., Darling, S.R., Gargas, A., Niver, R., Okoniewski, J.C., Rudd, R.J., & Stone, W.B. (2009). Bat White-Nose Syndrome: an emerging fungal pathogen? *Science* 323: 227

Brack Jr, V., & Twente, J. W. (1985). The duration of the period of hibernation of three species of vespertilionid bats. I. Field studies. *Canadian journal of Zoology* 63(12): 2952-2954.

Castle, K.T., & Cryan, P.M. (2010). White-nose syndrome in bats: a primer for resource managers. *Park Science* 27(1): 20-25.

Cryan, P. M. (2003). Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. *Journal of Mammalogy*, 84(2): 579-593.

Dzal, Y., McGuire, L.P., Veselka, N., & Fenton, M.B. (2011). Going, going, gone: the impact of white-nose syndrome on the summer activity of the little brown bat (*Myotis lucifugus*). *Biology Letters* 7(3): 392-394.

Frick, W.F., Pollock, J.F., Hicks, A.C., Langwig, K.E., Reynolds, D.S., Turner, G.G., Butchkoski, C.M. & Kunz, T.H. (2010) An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. *Science* 329: 679-682.

Hoyt, J.R., Langwig, K.E., Okoniewski, J., Frick, W.F., Stone, W.B., & Kilpatrick, A.M. (2015). Long-term persistence of Pseudogymnoascus destructans, the causative agent of white-nose syndrome, in the absence of bats. *EcoHealth* 12(2): 330-333.

Izor, R. J. (1979). Winter range of the silver-haired bat. *Journal of Mammalogy* 60: 641-643.

Langwig, K.E., Hoyt, J.R., Parise, K.L., Kath, J., Kirk, D., Frick, W.F., & Kilpatrick, A.M. (2015). Invasion dynamics of white-nose syndrome fungus, Midwestern United States, 2012–2014. *Emerging infectious diseases* 21(6): 1023-1026.

Lausen, C.L. & Barclay, R.M.R. (2006) Winter bat activity in the Canadian prairies. *Canadian Journal of Zoology-Revue Canadienne De Zoologie* 84: 1079-1086.

Lindner, D.L., Gargas, A., Lorch, J.M., Banik, M.T., Glaeser, J., Kunz, T.H., & Blehert, D.S. (2011). DNA-based detection of the fungal pathogen *Geomyces destructans* in soils from bat hibernacula. *Mycologia* 103(2): 241-246.

Lundy, M., Teeling, E., Boston, E., Scott, D., Buckley, D., Prodohl, P., & Montgomery, I. (2011). The shape of sound: elliptic fourier descriptors (Efd) discriminate the echolocation calls of Myotis bats (*M. daubentonii, M. nattereri* and *M. mystacinus*). *Bioacoustics* 20(2): 101-115.

McGuire, L.P., Guglielmo, C.G., Mackenzie, S.A., & Taylor, P.D. (2012). Migratory stopover in the long-distance migrant silver-haired bat, Lasionycteris noctivagans. *Journal of Animal Ecology* 81(2): 377-385.

Moorman, C. E., Russell, K. R., Menzel, M. A., Lohr, S. M., Ellenberger, J. E., & Van Lear, D. H. (1999). Bats roosting in deciduous leaf litter. *Bat Research News* 40(3): 74-75.

Schnitzler, H.U., & Kalko, E.K. (2001). Echolocation by insect-eating bats. *Bioscience* 51(7): 557-569.

Seabloom, R.W. (2012) Mammals of North Dakota. North Dakota Institute for Regional Studies, Fargo, ND. ISBN-13: 9780911042740.

USFWS (2016) White-Nose Syndrome: A devastating disease of North American bats. (ed. USFWS). https://www.whitenosesyndrome.org/. Accessed 1 Nov 2016.

Verant ML, Boyles JG, Waldrep W Jr, Wibbelt G, Blehert DS (2012) Temperature-sependent growth of *Geomyces destructans*, the fungus that causes bat White-Nose Syndrome. *PLoS ONE* 7(9): e46280.

Appendix 1. GPS locations of passive acoustic monitoring sites, broken down by year

Year	System	Site	Latitude	Longitude
2012-2013	SD-2	1	46.94489	-103.53194
2012-2013	SD-2	2	46.95481	-103.51772
2012-2013	SD-2	3	46.95956	-103.50236
2012-2013	SD-2	4	46.95533	-103.49958
2012-2013	SD-2	5	46.95194	-103.49508
2012-2013	SD-2	6	46.96383	-103.49022
2012-2013	SD-2	7	46.96972	-103.48669
2012-2013	SD-2	8	46.97164	-103.49097
2013-2014	SD-2	1	46.95194	-103.49508
2013-2014	SD-2	2	46.95530	-103.49955
2013-2014	SD-2	3	46.95958	-103.50105
2013-2014	SD-2	4	46.95952	-103.50583
2013-2014	SD-2	5	46.95900	-103.50486
2013-2014	SD-2	6	46.96005	-103.50722
2013-2014	SD-2	7	46.95541	-103.50822
2013-2014	RstLggr	1	46.92200	-103.45505
2013-2014	RstLggr	2	46.917778	-103.44658
2013-2014	RstLggr	3	46.917778	-103.44647
2013-2014	RstLggr	4	46.919417	-103.44772
2013-2014	RstLggr	5	46.973722	-103.42627
2013-2014	RstLggr	6	46.973528	-103.42463
2014-2015	SD-2	1	46.95958	-103.50106
2014-2015	SD-2	2	46.95948	-103.50265
2014-2015	SD-2	3	46.95898	-103.50489
2014-2015	SD-2	4	46.95535	-103.50823
2014-2015	SD-2	5	46.95240	-103.50873
2014-2015	SD-2	6	46.95197	-103.49491
2014-2015	D500X	7	46.95939	-103.50583
2014-2015	D500X	8	46.95533	-103.49951
2014-2015	D500X	9	46.95958	-103.50106
2014-2015	D500X	10	46.95898	-103.50489

Appendix 2: GPS coordinates for known hibernacula and potential hibernacula.

[redacted]

NORTH DAKOTA STATE BAT MANAGEMENT PLAN

ERIN GILLAM[1], J.J. NELSON[1] AND PAUL BARNHART[2]

NORTH DAKOTA STATE UNIVERSITY, FARGO, ND[1]
DICKINSON STATE UNIVERSITY, DICKINSON, ND[2]

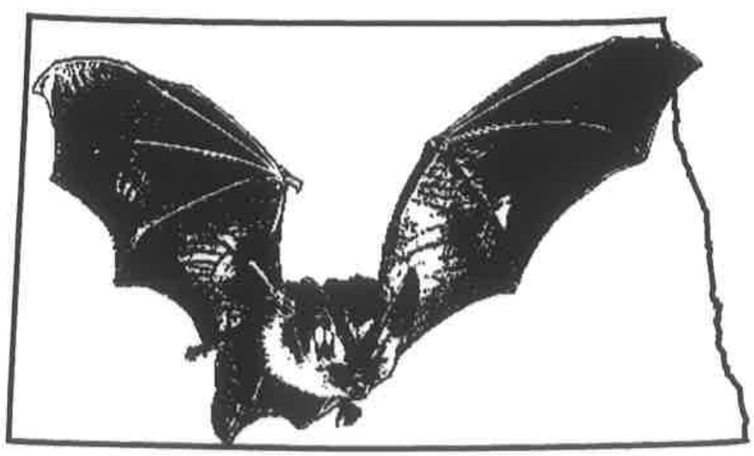


TABLE OF CONTENTS

I. ACKNOWLEDGMENTS

We would like to thank the North Dakota Game and Fish Department for their continual financial and logistical support, not only during the development of this management plan, but also during the five previous years that we have conducted research on bats in the state of North Dakota. We thank the Department of Biological Sciences and College of Science and Mathematics at North Dakota State University for funding bat research in the Gillam lab, as well as supporting our research program. Finally, we wish to thank the managers from the state and federal wildlife agencies across North Dakota that have allowed us to gather critical information about bats in the state; without their input and logistical assistance, this work would not have been possible.

II. EXECUTIVE SUMMARY

Bats are an integral part of a healthy ecosystem, providing key ecological and economic benefits. As the threats to bat populations from factors such as anthropogenic development and emerging infectious disease continue to rise, a concerted effort at appropriate conservation and management is needed. The North Dakota Bat Management Plan represents the first step in that effort for our state, identifying what we already know about local and regional bat populations, as well as key objectives that should be met in coming years.

The first part of the ND Bat Management Plan provides basic information on the natural history of bats for those that may be unfamiliar with this group of mammals. This includes a discussion of basic life history characteristics, foraging and roosting ecology, and other pertinent biological information. We also discuss topics related to the interactions between humans and bats, such as the economic importance of bat populations and the threat of rabies transfer from bats to humans. This section ends with a brief description of the species comprising the ND bat community and an overview of previous bat research that has been conducted in the state.

The second part of the document addresses the primary goal of the plan, which is to outline the major threats to bats in the Great Plains region and provide direction about specific needs in the area of management, research and education. For each of these areas, we include: 1) an explanation for why more information is needed, 2) a list of objectives, and 3) an outline of strategies for meeting these goals. We encourage managers to adapt these objectives and strategies to their local ecosystems and information needs.

Finally, we provide managers and researchers with tools for studying the bats of North Dakota, including: 1) detailed species accounts, 2) a taxonomic key for identifying captured bats, 3) an acoustic key summarizing five years of monitoring in the state, 4) the USFWS WNS decontamination protocol, and 5) habitat suitability maps for eight of the eleven bats species resident in the state.

Our long-term goal is that the ND Bat Management Plan be a living document that is regularly updated as the conservation and management needs of bats within the state change over time. Regular input from NDGF employees, as well as managers and scientists from federal agencies, tribal agencies, colleges/universities, and the general public will be valuable for identifying which strategies have been effective and for setting future goals and objectives. While such a scenario would make this a fluid document that slowly changes over time, we recommend a full assessment and appropriate revision occur at least every five years.

IV. INTRODUCTION TO BATS

The Order Chiroptera contains more than 1,200 species of bats, making up roughly 20% of all known mammals (Nowak, 1994). The unique feature of bats that sets them apart from other mammals is their capacity for true, powered flight (other mammals can glide, but only bats can fly). While often compared to rodents, bats are actually more closely related to primates. Bats are an incredibly successful group, as evidenced not only by the large number of species, but also by their colonization of all areas of the world, except the Arctic and Antarctic regions. Across the Order Chiroptera, extensive variation is seen in foraging ecology, with different bats specializing on insect prey, nectar, pollen, fruit, blood, fish, birds or even other bats. Bats are also found occupying a wide diversity of roosts, including caves, trees, man-made structures, and leaves, among others.

Below, we describe key ecological and life history traits of bats, with particular focus on species found in the United States. Where possible, we provide information about the eleven species known to reside in North Dakota.

General Life History

Bats are unique among mammals in their patterns of reproduction and longevity. For their body size, bats have very low reproductive rates, with most temperate species producing only one pup per year (Barclay & Harder, 2003). Comparatively, the North American house mouse, *Mus musculus,* which is similar in size to many temperate bats, produces an average of 30-80 pups a year. A low reproductive rate means that bats are particularly susceptible to extinction events, since populations experiencing mass mortalities from disturbances do not quickly rebound. A prime example is the spread of white-nose syndrome, a fungal disease of hibernating bats that has decimated bat populations in the northeastern United States (Blehert et al., 2009). Eight years after the 2006 introduction of this fungus, caves that previously contained tens of thousands of bats still stand nearly or completely empty (Service, 2014).

Bats have incredibly long lifespans for their body size, greatly exceeding that of other similar-sized mammals. Longevity records for bats range from 6-38 years (Wilkinson & South, 2002); the North American record is 34 years for the little brown bat, *Myotis lucifugus*. Comparatively, the house mouse, *M. musculus*, has an average lifespan of one year. The high longevity of bats is thought to be due to decreased mortality risks from factors such as predation and disease (Austad & Fischer, 1991). Interestingly, hibernating bats live, on average, six years longer than non-hibernating species, suggesting that reducing body temperature and restricting activity for long periods of time has a positive impact on lifespan in bats (Austad & Fischer, 1991).

Bats and birds represent the only examples of powered vertebrate flight, with bats being the only flying mammals. Chiroptera (the taxonomic order to which bats belong) literally means "hand wing", relating to the fact that the wing of a bat is composed of the arm bones and greatly elongated digits of the vertebrate hand. Strong links are observed between the foraging ecology of a species and it's wing morphology; typically bats with short, broad wings forage in cluttered environments, while those with long, narrow wings feed on insects in open areas (Norberg & Rayner, 1987). Flight is one of the most energetically expensive forms of locomotion (Norberg, 1990; Norberg, 1996), resulting in high energetic demands of bats. Juvenile bats cannot initially fly and rely on crawling within a roost or attachment to their mother for any movement. Volancy typically occurs within a few weeks after birth, although the length of the pre-volancy period varies between species.

Foraging Ecology

Bats exploit a wide diversity of food sources, but 43 of the 47 species found in the United States are strictly insectivorous. The most common prey are insects from the order Lepidopteridae (moths) and Coleopteridae (beetles), although most species are generalists, opportunistically foraging on a diverse selection of insects. An exception to this pattern is the eastern red bat, *Lasiurus borealis*, which is reported to be a moth specialist (Acharya & Fenton, 1999). Two foraging strategies are commonly used by bat species resident in the United States – aerial hawking and gleaning. Aerial hawking species actively pursue and capture prey in the air. The classic examples of bats flying erratically to capture insects (and insects doing the same to avoid the bats) come from aerial hawkers. The little brown bat, *M. lucifugus*, is a species commonly observed foraging for insects that fly above bodies of water. Some species, such as Townsend's big-eared bat, *Corynorhinus townsendii,* and the northern long-eared myotis, *Myotis septentrionalis*, instead capture insects by gleaning them from the ground or the surface of leaves, often relying on prey-generated sounds for final localization of prey targets.

In North Dakota, the most important foraging habitats to bats appear to be riparian areas and woodlands. Forest/woodland edges are often particularly rich in species numbers and diversity, serving as ideal foraging locations for bats. Water is an important resource, not only because bats regularly drink water (i.e. preformed water from their prey is not sufficient), but also because bodies of water are home to a diverse community of insects that can be readily exploited by bats.

Echolocation is a form of biological sonar in which calls emitted by an animal are reflected off objects in the environment and return to the sender as echoes. By comparing the echo to the original signal, the calling animal obtains information about the surrounding environment (Griffin, 1958). While some large fruit-eating bats from the Old World do not echolocate, and others produce rudimentary echolocation clicks (Roberts, 1975), the vast majority of bats use a complex laryngeal echolocation system. Such echolocation involves the use of highly structured signals and sophisticated neural processing to allow extraction of detailed information about target range and identity (Thomas et al., 2004).

Considerable differences exist between bat species in the temporal and spectral structure of echolocation calls. As a result, calls recorded from free-flying, unidentified individuals can be analyzed with sophisticated software programs and classified to species (Britzke et al., 2013). While the accuracy of classifications based on echolocation calls was previously questioned, modern programs use large call libraries and sophisticated algorithms, both of which greatly increase confidence in the identifications made. Despite this, it is important to note that echolocation structure is not a fixed character of a species or individual – differences in call structure related to age, sex, body size and reproductive condition have been reported (see Jones and Siemers (2011) for a review). Bats have also been shown to adjust their call structure in reference to conditions at a foraging site, including the proximity of insect prey (Griffin, 1958), the amount of vegetative clutter (Obrist, 1995), and the presence of nearby conspecifics (Gillam et al., 2007).

Roosting Ecology

As a taxonomic group, bats exhibit extensive diversity in their roosting ecology (Kunz & Fenton, 2006), especially in terms of roost permanency, ranging from permanent sites, like caves, to use of highly ephemeral structures, such as leaves. Roosts are critical resources, as they provide bats with protection from harsh environmental conditions, concealment from predators, and opportunities for social interactions, including mating (Kunz, 1982). The vast majority of bats species live colonially, although some species roost alone including two species found in North Dakota (*L. borealis* and *L. cinereus*)

In North Dakota, the most common roosting resources used by bats during the summer months are trees, rock crevices and buildings. Trees are key summer roosting resources for several species, with some bats living in previously excavated (or naturally occurring) cavities or under loose bark (i.e. *E. fuscus*, *M. septentrionalis*), while others hang individually in trees among leaves and needles (*L. borealis* and *L. cinereus*). Research conducted on temperate, tree-roosting species in the United States repeatedly highlight the importance of dead or dying trees, known as snags, as key roosting resources for bats (Barclay & Kurta, 2007) and researchers have urged foresters to retain these trees when harvesting occurs.

In western North Dakota, the buttes of the badlands offer ample roosting resources in the forms of caves and rock crevices. Unlike many other states, North Dakota has a paucity of permanent cave systems; instead, the caves and crevices of the badlands are primarily composed of bentonite clay, which easily crumbles, leading to changes in the geological landscape over relatively short periods of time. Regardless, caves and crevices can be sufficiently deep to offer adequate temperature and humidity conditions for bats roosting during the winter or summer months.

While bats are certainly present in anthropogenic structures in North Dakota, no research has focused on characterizing colonies of bats living in buildings. It is assumed that in the Drift Prairie and Missouri Coteau ecosystems of North Dakota, where trees are particularly scarce, that buildings serve as the primary roosting resource for bats. Research focused on better understanding the reliance of bats on buildings in the state would be valuable.

Winter habitat use by bats is, to our knowledge, restricted to anthropogenic structures and the caves and rock crevices of western North Dakota. While occurrence of overwintering bat populations in buildings has been reported to EHG at different sites throughout the state, the presence of winter colonies has not been confirmed at these sites. Work by the authors in the South Unit of Theodore Roosevelt National Park has documented the presence of bats throughout the winter months, indicating that a population of hibernating bats is present in the region (Barnhart and Gillam, under review). One identified hibernacula is a large site that appears to harbor multiple species during the winter; two smaller rock crevice hibernacula have also been identified (see Section 5.C for more details).

Torpor and Hibernation

Many temperate bat species are heterothermic, having the ability to substantially reduce metabolic rate, heart rate and body temperature. Heterothermy is an energy-conservation strategy generally used during periods of reduced resource availability or low energetic needs. While it is commonly known that many bats undergo deep bouts of torpor for extended periods during the winter months, known as hibernation, bats often use torpor on a daily basis during the warmer seasons as well. Torpor use is related to reproductive state, as pregnant and lactating females have been shown to reduce the amount of time spent in torpor, presumably as periods of reduced temperature and metabolic rate negatively impact fetal development and (Geiser (1996), although see Willis et al. (2006)).

Distribution and Seasonality

Documentation of a species' distribution provides the baseline information needed for assessing key questions related to conservation and habitat management. Of the eleven species known to occupy North Dakota, seven reach a range limit within the state (See Appendix A for detailed range maps). From a biogeographical perspective, this indicates that many bat populations in North Dakota are peripheral in nature, even potentially fragmented and isolated from the main distribution. As a result, patterns of habitat use may differ from studies conducted on more centrally located populations. Peripheral populations, especially those at or near the leading-edge of a distribution, often experience more challenging environmental conditions (Brussard, 1984), are more vulnerable to decline (Peterman et al., 2013), and are of significant importance for conservation and management.

Bat populations in North Dakota exhibit marked patterns of seasonality. Species diversity and total number of individuals is highest during the summer months. In late Summer or early Fall, most bats migrate to other locations. While some species, such as the red bat and hoary bat, undergo long distance migrations to the southern United States (Cryan et al., 2004), most bats are believed to migrate relatively short distances to overwintering sites in Minnesota or western South Dakota (Seabloom, 2011). Yet, recent research by Barnhart and Gillam (under review) has documented overwintering populations of at least three species in the badlands habitat of western North Dakota (see Section V for more details). Some bats are also known to overwinter in man-made structures throughout the state (EHG personal observation), although these populations have not been studied.

Ecological and Economic Importance

Bats play a variety of key roles related to ecosystem health and the interface between humans and natural systems. From an ecological perspective, bats are primary predators of a diverse array of insect prey. While some insectivorous bat species are considered specialists, most are opportunistic foragers that eat many different types of insects. In tropical systems, bats also play key roles as the primary pollinators and seed dispersers of a large number of plants. The economic benefits of bats stem directly from these key ecological roles. For example, many of the primary insect prey eaten by bats are also crop pests. Cleveland et al. (2006) estimated the agro-economic value of the ~1.5 million Brazilian free-tailed bats, *Tadarida brasiliensis*, living in an eight-county region of South Central Texas, determining that bats save cotton growers an average of $741,000 per year in pest control services (annual cotton harvest profits are ~$5 million). In addition, experimental evidence suggests that bats can actively suppress mosquito populations (Reiskind & Wund, 2009). As biological systems continue to be impacted by anthropogenic effects, bats can also play a key role as ecosystem bioindicators (Jones et al., 2009), providing managers with early warning signs that whole communities of species are at risk. For a detailed review of the ecological and economic benefits of bats, see Kasso and Balakrishnan (2013).

Bats and Public Health

Bats have been at the center of a variety of public health issues (Schountz, 2013), the most extensive of which relates to bats and rabies. While bats are not the largest wildlife reservoir of rabies in the United States, they are the most common group to transmit the rabies virus to humans (although rabies in humans is extremely rare in the United States). This is primarily driven by the small size of bat bites, which are often not easily visible or thought to be unimportant; as a result, individuals who have been bitten often do not seek appropriate medical care (De Serres et al., 2009), specifically a vaccination series that can prevent development of the disease. In recent years, bats have been identified as biologically significant reservoirs of other disease agents, including SARS, Hendra, Marburg, and Nipah viruses (Calisher et al., 2008).

Another public health concern relates to large accumulations of guano in bat roosts, which can harbor the fungus *Histoplasma capsulatum*. This fungus grows in the droppings of birds and bats; airborne fungal spores breathed in by humans can cause a condition known as histoplasmiosis. Although most cases of this disease are asymptomatic or mild, under certain conditions in which feces are concentrated in especially large amounts, the condition can be much more serious, potentially even fatal.

Although the public health risks associated with bats should not be understated, there is often highly negative reactions when media stories cover bat exposures, leading to irrational fear among the public and backlash on colonies of bats (i.e. killing all the bats in a building), even though such actions do not impact disease exposure rates (Huot et al., 2008). Media should be encouraged to not sensationalize the health risk associated with bats, in an effort to avoid such wasteful destruction of animals by the general public.

V. BATS OF NORTH DAKOTA

Species List

The following species are known to occur in North Dakota. See Appendix A for detailed species accounts that provide further information about the ecology of each species.

Species (common name)	Species (Latin name)
Big-eared bat	*Corynorhinus townsendii*
Big brown bat	*Eptesicus fuscus*
Silver-haired bat	*Lasionycteris noctivagans*
Red bat	*Lasiurus borealis*
Hoary bat	*Lasiurus cinereus*
Western small-footed myotis	*Myotis ciliolabrum*
Long-eared myotis	*Myotis evotis*
Little brown bat	*Myotis lucifugus*
Northern long-eared myotis	*Myotis septentrionalis*
Fringed myotis	*Myotis thysanodes*
Long-legged myotis	*Myotis volans*

Conservation Status

Four species of bats are currently listed as Level I Conservation Priority by the North Dakota Game and Fish Department. Level I species are described by NDGF as "species having a high level of conservation priority because of declining status either in North Dakota or across their range; or a high rate of occurrence in North Dakota constituting the core of the species' breeding range, but are at-risk rangewide, and funding other than State Wildlife Grants is not readily available to them". Bat species classified as Level I include: 3) Big-eared bat, *Corynorhinus townsendii*, 2) Big brown bat, *Eptesicus fuscus*, 3) Little brown bat, *Myotis lucifugus,* and 4) Northern long-eared bat, *Myotis septentrionalis*. Currently, the northern long-eared bat is being considered for addition to the USFWS Endangered Species List.

Three species of bats are currently listed as Level III Conservation Priority by the North Dakota Game and Fish Department. Level III species are described by NDGF as " species having a moderate level of conservation priority, but are believed to be peripheral or do not breed in North Dakota". Bat species listed as Level III include: 1) Western small-footed myotis, *Myotis ciliolabrum*, 2) Long-eared myotis, *Myotis evotis*, and 3) Long-legged myotis, *Myotis volans*.

Overview of Research Findings

Prior to 2009, little research had focused on the bats of North Dakota. The work that had been conducted involved limited sampling over small areas and generally included few capture records (see Species Account section for more detail about these studies). With funding from the North Dakota Game and Fish Department State Wildlife Grant program, the Gillam lab at North Dakota State University began investigating the distribution and ecology of bats in North Dakota in Summer 2009.

North Dakota was divided into 5 ecologically and geographically distinct sampling regions: The Red River Valley, Pembina Gorge, Turtle Mountains, Missouri River Valley, and the Badlands of southwestern North Dakota. The only regions of the state that have not been well sampled are the Drift Plains and Missouri Coteau, as previous sampling found that activity is particularly low in these regions and that there is a severe lack of natural roosting structures available. Sampling included: 1) direct capture of bats via mist netting, 2) recording calls from captured, light-tagged bats, 3) radiotagging and tracking via telemetry of select captured individuals, and 4) active and passive ultrasonic recording of echolocation calls from free-flying bats.

The presence of eleven species was confirmed in the state, with an increase in diversity moving westward (five species in the Red River Valley to eleven species in the badlands of western ND). The silver-haired bat was the most commonly encountered bat across the state, with both physical and acoustic captures in all five habitat regions. The big brown bat and the hoary bat were also documented in all five regions, although they were not physically captured in all regions. The little brown bat was the most abundantly captured bat, although this was mostly driven by the presence of large maternity colonies near some sampling sites. The fringed myotis and long-legged myotis were the least commonly encountered bats, suggesting that these species are rare in the state.

Of the eleven species documented in the state, five species were captured or recorded outside of their known IUCN distribution (*C. townsendii, M. thysanodes, M. septentrionalis, M. ciliolabrum,* and *L. borealis*). Based on field data (physical capture and acoustic monitoring), maximum entropy habitat suitability maps were generated for six species (*C. townsendii, M. lucifugus, M. thysanodes, M. septentrionalis, M. ciliolabrum,* and *L. borealis*; see Appendix E). All maps showed habitat areas of high suitability outside of each species' known distribution, suggesting that further exploration of undersampled areas of the state may further alter our knowledge of bat range limits in ND.

A radiotelemetry study conducted in Summers 2011 and 2012 involved the tagging of 29 bats, 14 of which were successfully tracked to roost locations. *E. fuscus* (n=4) were found exclusively in mature cottonwoods, *Populus deltoides* along riparian corridors. *L. noctivagans* (n=5) were found to roost in cottonwoods, green ash, *Fraxinus pennsylvanica*, and bur oak, *Quercus macrocarpa*. *L. borealis* (n=2) roosted in trembling aspen, *Populus tremuloides*, American basswood, *Tilia Americana*, and a beaked hazel shrub, *Corylus cornuta*. *M. lucifugus* (n=2) were tracked to man-made bat houses affixed to cottonwood trees, although it is likely that cottonwoods are commonly used as natural roost sites by this species. *M. septentrionalis* (n=1) roosted in cottonwoods, green ash, and boxelder, *Acer negundo*. *Myotis ciliolabrum* (n=1), *M. evotis* (n=1), and *M. thysanodes* (n=1) were all found to roost in rock and soil strata crevices and hydrologically eroded pipes/sink holes.

Bats have historically not been reported to overwinter in North Dakota, with summer residents supposedly migrating to sites in Minnesota and South Dakota. The badlands of western ND provide ideal habitat for hibernacula, and similar habitats at more northern locations have been known to support hibernating bat populations; hence it is plausible that bats are overwintering in the state. Between the winters of 2010-2013, mist netting, radio telemetry, and ultrasonic detection were used to determine if the western ND badlands supported winter bat populations. Three species were positively identified via ultrasonic detection (*Eptesicus fuscus*, *Lasionycteris noctivagans* and *Myotis lucifugus*) and two species via physical capture (*E. fuscus* and *Myotis ciliolabrum*). Two additional species, *Corynorhinus townsendii* and *Myotis evotis,* were also captured, although these may have been late-season summer residents that had not yet migrated. Radio telemetry resulted in the documentation of 3 confirmed hibernacula, and scouting trips guided by a maximum entropy habitat suitability model resulted in the identification of 18 potential hibernacula. Temperature data showed that all known hibernacula were within the growing range (although not often within the optimal growing range) of *Pseudogymnoacsus destructans*, the fungus that causes white-nose syndrome.

VI. BAT MANAGEMENT PLAN

VI. A. Overall Goal

The overall goal of the bat management plan is to outline the major threats to bats in the Great Plains region and provide direction about specific needs in the area of management, research and education. For each of these areas, we include: 1) an explanation for why more information is needed, 2) a list of objectives, and 3) an outline of strategies for meeting these goals. We encourage managers to adapt these objectives and strategies to their local ecosystems and information needs. The ultimate objective is to develop a long-term conservation plan for the bat species found in North Dakota.

VI. B. Threats to Bat Populations of North Dakota

Habitat Loss

Like most vertebrates, bats face threats due to extensive conversion of natural landscapes for anthropogenic use. The primary threats come from agricultural development, increasing use of land for urban (and suburban) expansion, and fragmentation of forested habitat. In particular, habitat fragmentation has been shown to have negative impacts on bat species diversity in both tropical (Cosson et al., 1999) and temperate (Medlin et al., 2010) ecosystems.

From a roosting perspective, the conversion of natural lands limits the availability of suitable roosts for bats, particularly when forested and/or riparian areas are impacted. Trees within forested areas (i.e. not singular trees or shelterbelts) are an important roosting resource for many bat species (Lacki et al., 2007). Within forested areas, large diameter trees that are dead or dying, known as snags, have been shown to be particularly important roosting resources for a variety of bat species (i.e (Kalcounis & Brigham, 1998; Brigham et al., 2007). While modern silvicultural practices often call for the preservation of some snags in areas of harvest, research suggests that often too few trees are retained given the roosting needs of local bat populations (Pierson, 1998).

From a foraging perspective, habitat modification also alters the distribution of insect prey. With ~70% of bat species worldwide primarily eating insects, changes to insect distributions and densities can potentially have widespread impacts on bat populations. The insect community over conventional agricultural plots generally differs substantially from that of organic agricultural plots or natural areas, even over short distances (Wickramasinghe et al., 2004). The tendency for farms to take the form of large monocultures further reduces the diversity and/or abundance of insects available as prey to bats.

In North Dakota, riparian corridors are key habitats for bats, providing roosting resources as well as rich prey patches. Habitat suitability maps for 8 of the 11 resident species in the state emphasize the importance of these riparian corridors (see Appendix E). The badlands of western North Dakota also consistently score as highly suitable habitat for a wide variety of bat species. Interestingly, it is possible that the settlement of the Great Plains by humans led to an expansion of some bat ranges, as large areas with few or no trees in central and eastern ND were replaced by human settlements that contained buildings, which often offer suitable roosting conditions.

Wind Energy Development
Wind energy has quickly become a critical technology for providing Americans with renewable energy. However, bats have been found to be susceptible to injury and fatality near wind turbines (Baerwald et al., 2008; Horn et al., 2008) and impacts have been extensively documented. The first wind energy–related bat fatalities in the United States were recorded during avian fatality searches (e.g., Orloff et al. (1992)). Since then, bat deaths at wind energy facilities have been documented at many sites across the country, with fatality rates ranging from relatively low (1.2 bats/turbine/year, Klondike Wind Farm, OR; Johnson et al. (2003)) to alarmingly high (20.82 bats/turbine/year, Buffalo Mountain Wind Farm, TN; (Fiedler, 2004)).

Research has shown that the species experiencing the highest number of fatalities at turbines are hoary bats, *Lasiurus cinereus*, silver-haired bats, *Lasionycteris noctivagans,* and eastern red bats, *Lasiurus borealis* (Johnson, 2005; Cryan & Brown, 2007). These tree-dwelling species exhibit fall migratory behavior (Koehler & Barclay, 2000; Cryan, 2003) and fatalities at wind facilities have been consistently highest during the fall migration period of late summer and fall (Arnett et al., 2008).

While it was originally thought that most bat deaths were due to direct strikes with turbine blades, (Baerwald et al., 2008) reported that barotrauma is a significant factor in wind facility-related bat fatalities. Barotrauma occurs as a result of sudden or extreme changes in pressure. This sudden change in pressure causes an expansion of the air in the lungs, resulting in internal hemorrhaging. It is believed that bats experience such barotraumas when they enter undetectable areas of low pressure found at blade vortices. At a wind energy facility in southwestern Alberta, Canada, evidence of pulmonary barotrauma was found in 90% of fatalities, while only half of the fatalities demonstrated signs of having been directly struck by turbine blades (Baerwald et al., 2008).

Despite progress toward understanding how bats are killed at wind energy facilities, little is known about why these bats even approach turbines. One hypothesis is that fall migratory behavior increases the likelihood of interaction with turbines. Prior to fall migration, bats may exhibit increased flying activity while mating or feeding, which may result in higher mortality rates. The fact that migratory tree-roosting bats are the most susceptible to turbine-related mortality also suggests the possibility that individuals are attracted to turbines as they seek out the tallest tree on the landscape (Cryan & Barclay, 2009). It has also been hypothesized that the migratory or spatial patterns of the insects upon which bats prey may be a factor in fatality rates (Rydell et al., 2010).

While several potential mitigation methods have been tested, the most effective to date appears to be reduction of turbine cut-in speed on low-wind nights. Bat activity is higher during low-wind nights and a positive relationship between fatalities and low wind speeds has been consistently demonstrated (Redell et al., 2006; Arnett et al., 2008). Turbines typically begin operating when the wind reaches a speed of 4 m/second (cut-in speed). Increasing cut-in speeds mean that the rotors will not begin to turn and will not start generating electricity until the wind reaches the selected speed. Arnett et al. (2010) found that by increasing the cut-in speed to 5 m/second, average nightly fatalities were reduced by 53 - 87%, with minimal loss to power production. In Alberta, Canada, Baerwald and Barclay (2009) found similar results, with reductions from 50 - 70%. As power production is already reduced on low-wind nights, increasing the cut-in speeds at that time could significantly reduce bat fatalities without causing great economic loss to power companies.

As of January 2015, North Dakota ranks 12th in the United States with 1,681 MW of installed wind-generating capacity, and proposed projects exceeding 11,000 MW (AWEA, 2013). This rapid increase in wind energy development, coupled with our knowledge of bat fatalities at other wind facilities, suggests a need to assess potential risks to local bat populations.

Spread of White Nose Syndrome

White-nose syndrome (WNS) is an emerging infectious disease that is having devastating effects on hibernating bat populations in the northeastern United States. Originally discovered in upstate New York in 2007, the disease has rapidly spread South and West, with the most recent confirmed cases in eastern Minnesota (USFWS, 2014). Mortality rates are greater than 75% and often reach 100%, with the estimated death toll from WNS in North America at more than 5.7 million bats (USFWS 2014). Predictive modeling indicates the likely collapse of some bat populations in the northeastern US in the next two decades (Frick et al., 2010).

White-nose syndrome is caused by a psychrophilic fungus, *Pseudogymnoascus destructans* (Chaturvedi et al., 2010; Rajkumar et al., 2011). Fungal hyphae invade the tissues of hibernating bats, especially areas around the face and wing membranes (Blehert et al., 2009; Courtin et al., 2010). Infected bats also exhibit: 1) an increased number of arousals and increased length of arousals during the hibernation period (Boyles & Willis, 2010), 2) significantly reduced fat stores, and 3) abnormal flight behavior near hibernacula entrances during late winter (Blehert et al., 2009). Excessive arousals are hypothesized to be due to irritation from the fungus or excessive evaporative water loss, which is linked to the health of wing membranes (Cryan et al., 2010; Willis et al., 2011). Overall, increased periods of homeothermy and disruption of key physiological processes are believed to be the primary cause of death (Willis et al., 2011; Warnecke et al., 2012).

To date, the primary conservation measures to fight the spread of WNS are strict decontamination protocols for individuals and equipment entering WNS-infected sites, regular monitoring of known hibernacula for the presence of *P. destructans* on bats or in the soil (Lindner et al., 2011) and limiting human access to cave systems (Castle & Cryan, 2010). Modeling indicates that culling is an ineffective method for curbing the spread of WNS (Hallam & McCracken, 2011), and while other potential solutions have been proposed (Boyles & Willis, 2010), none have been effectively implemented. Despite these efforts, WNS continues to spread, and predictive modeling estimates that the disease will reach areas of the western United States within the next 10-20 years (Maher et al., 2012).

VI. C. Management Needs

Issue 1: Key Habitat Assessment and Protection on State Lands

In North Dakota, permanent cave systems are scarce and are not believed to be of importance for summer or winter resident bat populations. Alternatively, the rock crevices and ephemeral caves of the badlands are key roosting habitats for bats throughout the year. Forested and/or riparian areas are also key habitats, providing tree roosts for a variety of bat species found in the state. Badlands, forested and riparian areas also offer key foraging resources to insectivorous bats. Hence, protection and preservation of these areas is of primary importance for bat conservation in North Dakota. The importance of buildings as roosting resources to bats has not been adequately studied, but is likely significant in areas of the state lacking extensive tree cover (i.e. the Drift Plains of ND). One of the primary threats to bats occupying buildings is culling of bats for exclusion, which is an ineffective method of control.

A significant percentage of the badlands/grasslands of western North Dakota are publicly owned, either as part of Theodore Roosevelt National Park (NPS) or the Little Missouri Grasslands (USFS). This is ideal, as disturbance to bat populations should be minimized in these publicly-owned and managed areas. Yet, extensive oil development on surrounding private lands threatens the integrity of these landscapes. This is of particular concern given that: 1) bat diversity peaks in this region of the state (11 species), including all bats listed as Species of Conservation Priority by NDGF, and 2) the crevices and temporary caves of the badlands offer the only known natural hibernacula sites for bats in ND (Gillam, 2014).

In forested areas, the primary action taken for management of bats is retention of snags, which are key roosting resources for bats (Brigham et al., 2007). While we have limited knowledge about the effects of forest fragmentation on temperate bat populations, evidence points towards negative effects (Pierson, 1998). Hence, efforts to preserve larger forest fragments, especially along rivers and waterways, would be beneficial to bat species. This is particularly important given the potential impending addition of the northern long-eared bat, *Myotis septentrionalis*, to the USFWS Endangered Species List. This bat is primarily associated with forested areas, so preservation of the state's riparian zones and limited forested areas will likely have positive impacts on this species. Unfortunately, specifics about the minimum forest fragment size that can support *M. septentrionalis* are not currently known, so the best potential action is to maximize conserved fragment size within the limits of the specific development/harvest project. Although the ND timber industry is relatively small compared to other states, there are multiple processing mills throughout the state, and in 2009, > 134,000 cubic feet of industrial roundwood was harvested from the state (Haugen & Harsel, 2013).

Preservation of riparian areas not only involves conservation of the woodland corridors that flank rivers, but also maintenance and preservation of the river itself. Limited access of livestock to riparian areas, especially those that are in a well-preserved state, is critical for minimizing vegetation disturbance and soil erosion. Any additional activities that lead to erosion or modification of the river's geology should be avoided or minimized.

Objective 1.1: develop guidelines for management of bats within the Bakken Shale formation.

Strategy 1.1A: Conduct research that estimates the impact thresholds of oil on bat populations. Impact thresholds are defined as "levels of development and disturbance that impair key habitat functions by directly eliminating habitat, by disrupting wildlife access to, or use of habitat, or by causing avoidance and stress". (WYGFD, 2010). Specifically, it would be valuable to assess how the establishment of oil infrastructure (fracking equipment, derricks, etc.) impact activity of bats at foraging sites. Such assessment would ideally involve a combination of acoustic monitoring and, to a lesser extent, physical capture via mist netting before, during and after establishment of an oil extraction site.

Strategy 1.1B: Work with oil companies, as well as state, federal and tribal management agencies to identify key management actions that can be taken to reduce the impacts of oil development on bat populations. For example, ponds that contain oily wastes should be netted to prevent bats from foraging over and/or drinking from these contaminated water sources (Esmoil & Anderson, 1995).

Objective 1.2: develop guidelines for management of bat habitats in forested areas and riparian areas in ND.

Strategy 1.2A: Work with state, federal and tribal agencies, as well as private foresters to develop bat-friendly guidelines for managing the forests, woodlands and riparian areas of North Dakota. Key recommendations include: 1) maintenance of a minimum of 8.5 snags of 12" DBH or greater per acre in forested areas (Mattson et al., 1994). This guideline should be especially emphasized in riparian areas and large fragments or unfragmented forested areas, which are most likely important foraging and roosting sites for multiple bat species; and 2) minimal disturbance of rivers and streams, particularly in relation to soil erosion and hydrology (i.e. river shape and flow).

Strategy 1.2B: Develop a document that outlines general information about bats in forested landscapes, as well as information about basic methods for assessing the presence of bats on forested lands, identifying bat roosts for retention and protection, and general silviculture practices for enhancing forest stands and riparian areas for bat populations. Distribute this document to state, federal and tribal agencies, as well as private foresters.

Strategy 1.3B: Invest state and federal capital, such as USFWS State Wildlife Grant funds, into purchasing lands that are of high quality for bat communities, such as those with intact forests and relatively undisturbed riparian zones. Active preservation of such lands will benefit not only bat species, but also the many other taxa associated with these ecosystems.

Objective 1.3: Assess the importance of buildings to bats throughout the state and develop guidelines for managing bat populations in buildings.

Strategy 1.3A: Assess the use of buildings by bats throughout the state. Implementation of a written survey distributed to selected homeowners would be an effective tool for such an assessment. A research study involving acoustic monitoring and mist netting at a subset of identified sites would be also be valuable (see Section VI.D, Issue 5).

Strategy 1.3B: Determine the practices used for bat removal by professional excluders in the state. Identify all practitioners that remove/exclude bats in the state and determine which use bat-friendly exclusion methods (see Strategy 1.3C). When requested, provide homeowners with a list of the bat-friendly excluders. Update the list every 2-3 years.

Strategy 1.3C: Develop a document providing details about bat-friendly exclusion procedures that can be distributed to practitioners. Key information to highlight includes: 1) appropriate times during which to conduct exclusions (i.e. when bats are absent from the roost), and 2) appropriate methods for exclusion (i.e. sealing entrance points to a roost, rather than culling).

Objective 1.4: Monitor for the spread of white-nose syndrome to North Dakota.

Strategy 1.4A: Work with USFWS White-Nose Syndrome coordinators and academic researchers to develop a plan for regularly conducting soil surveys at known hibernacula in western North Dakota. Such soil surveys are the easiest way to monitor for the arrival of *P. destructans* to a new location. Soil samples can often be analyzed for free by nationally-funded efforts, such as the work being conducted by Dr. Winifred Frick at UC Santa Cruz (wfrick@ucsc.edu).

Objective 1.5: Place appropriate signage at known hibernacula and at appropriate park visitor centers that explain the details of white-nose syndrome and why individuals should not enter caves.

Strategy 1.5A: Collaborate with employees of the National Park Service and National Forest Service to appropriately place signs about white-nose syndrome and the negative effects of entering cave sights. A sign created by the Washington Department of Fish and Wildlife is an excellent model, as it provides information about the disease and proper precautions to avoid spreading the fungus, such as not entering structures where bats may roost and decontaminating items if you do enter such a site.

Issue 2: Integration of Management with Local, Regional and National Objectives

While state managers certainly interact with other managers in neighboring states, as well as those in federal agencies, a concerted effort to discuss unifying and aligning bat conservations efforts would be valuable. Such coordination could involve not only wildlife managers, but also conservation organizations and public citizen groups.

Objective 2.1: Increase interaction with other bat interest groups, such as the SD Bat Working Group, Western Bat Working Group, the North American Society for Bat Research and the North American Bat Conservation Partnership.

Strategy 2.1A: Send an NDGF representative to the annual meetings of the Western Bat Working Group and the North American Society for Bat Research at least once every two years. Such attendance is valuable for not only conveying the challenges and objectives of bat conservation in ND, but also gaining knowledge of current research and management practices in other areas of the country.

Objective 2.2: Interact with city, county and tribal government agencies to provide resources about bat conservation and determine local research and management needs.

Strategy 2.2A: Conduct a workshop about bat conservation and management practices at three locations in North Dakota (Williston/Dickinson, Bismarck, and Fargo) at least once every three years. Invite government officials, managers, pest control practitioners, educators, and members of the general public. Workshops can begin with basic information about bats (see Educational Needs section); the main focus of the workshops should be planned breakout discussions about management/conservation problems and objectives. By gathering such information from different stakeholders, problems related to bats that NDGF is unaware of may come to light; such sessions may also be helpful for identifying future management objectives.

Issue 3: Regulations Impacting Bat Populations

A variety of federal and state laws set the basis for how bat species are managed in the United States. While some of these are well-established laws that are enforced nationwide (i.e. Endangered Species Act), others are only applicable at the state or local level, and may have not been crafted with extensive thought towards bats and other wildlife populations. In addition, key legislation that may aid in meeting bat management objectives may be missing; identifying such gaps is key so that new legislation can be drafted and proposed.

Objective 3.1: Summarize state and federal regulations that impact bat populations.

Strategy 3.1A: Conduct a broad assessment of regulations that impact bat populations and bat habitats. While federal regulations impacting wildlife are likely summarized in other sources, it is unlikely that any such catalog exists for ND-specific laws.

Objective 3.2: Identify key regulations that can be modified to align with bat management objectives and/or new regulations that can be proposed to meet the same goal.

Strategy 3.2A: Based on the compilation from Objective 3.1, identify regulations that potentially have negative impacts on bat populations and/or habitats. At the federal level, contact the local USFWS office to gain further information about such policies and any ongoing efforts towards revision. For state-level laws, directly interact with members of the state legislature and discuss how policies could potentially be modified to better protect bat species in the state. Invite state politicians to attend bat informational/brainstorming workshops (Strategy 2.2A).

Strategy 3.2B: Identify gaps in federal and state laws where additional legislation would be useful for protecting bat populations and their associated habitats. Work with state and federal legislators to develop proposed legislation to fill in these regulatory gaps.

VI. D. Research Needs

Issue 1: Migratory Pathways

Two species of bats in North Dakota - *Lasiurus borealis* and *Lasiurus cinereus* - are known to migrate long distances out of state in the winter months. The remaining species are all thought to either make relatively shorter migrations to suitable hibernacula, potentially to the Black Hills of South Dakota, or they may be winter residents of North Dakota. While some recent work has documented bat presence in the badlands region of ND, hibernacula identification and confirmation of species has proven difficult.

Objective 1.1: Conduct studies to identify migratory pathways of ND bat species.

Strategy 1.1A: Efforts to capture bats and use radio telemetry to identify hibernacula and surveys of potential hibernacula for bats have yielded little rewards given ND's harsh winters and the inaccessibility of potential hibernacula of the badlands. However, such work is necessary to confirm over-winter species presence. As an alternative approach, banding studies coordinated with out of state management and conservation entities could potentially document ND summer resident bats in out of state hibernacula in places such as the Black Hills. The feasibility of such work will strongly depend on the spread and impacts of white-nose syndrome in the region.

Strategy 1.1B: Acoustic surveys in the Fall and Spring months to document peaks and cessation of species activity across geographic gradients could be demonstrative of migratory activity. Surveys should focus on likely migratory corridors, such as major rivers and tributaries.

Issue 2: Impacts of Wind Energy

As of January 2012, North Dakota ranks 10th in the United States with 1,469 MW of installed wind-generating capacity, and proposed projects exceeding 11,000MW (American Wind Energy Association 2012). This rapid increase in wind energy development, coupled with our knowledge of bat fatalities at other wind facilities, suggests a need to assess potential risks to local bat populations. The extensive presence, and alarming predicted growth rate, of the wind industry in North Dakota points to the potential for a large impact on regional bat populations. Bicknell and Gillam (2013) conducted a post-construction survey at a wind energy facility in south-central North Dakota; although the study involved a limited survey (12 turbines checked weekly over a ten-week period), nine bat carcasses were found. Although these data did not assess fatality rates, they point to a need for future research on the impacts of the growing wind-energy industry in North Dakota. While EIS guidelines often require wind farms to perform pre-construction acoustic surveys, we are unaware of any post-construction surveys other than that conducted by Bicknell and Gillam (2013).

Objective 2.1: Determine fatality rates of bats at select wind energy facilities in North Dakota.

Strategy 2.1A: Conduct post-construction fatality surveys at select wind-energy facilities around North Dakota, with a focus on larger facilities. Fatality rates are calculated by not only conducting regular surveys of areas surrounding turbines for bat carcasses, but also by calculating searcher efficiency and scavenger removal rates.

Strategy 2.1B: Conduct a written/phone survey of wind energy facilities in North Dakota to determine current practices for reducing negative impacts of wind turbines on bat populations. The most common practice is to reduce cut-in speeds on low-wind nights (see Section VI. B). Results of this survey could be used by state managers to discuss the potential addition of reduced cut-in speed policies to facilities that do not currently employ such practices.

Issue 3: Genetic Assessment of ND Populations

As the ease of using genetic tools has increased in recent decades, an increasing number of studies have investigated the phylogeographic structure of animal populations across their distribution. For North American bats, this has been done for a few species, although these species are either not found in North Dakota (i.e *Tadarida brasiliensis*; Russell et al. (2005)) or the studies have not included samples from the state (i.e. *Eptesicus fuscus*; Turmelle et al. (2011)). As a result, nothing is known about the phylogeographic structure of bat populations in North Dakota, nor how these populations compare to other populations throughout North America. Such information can be key for setting management goals. For example, the concept of Evolutionary Significant Units (ESUs), which incorporates spatial patterns of genetic diversity, is commonly used for deciding how to manage plant and animal populations (Moritz, 1994). Such information will be especially valuable for the northern long-eared bat, *Myotis septentrionalis*, which will potentially be added to the Endangered Species List in 2015.

Objective 3.1: Assess patterns of genetic diversity in bat species of North Dakota, with particular focus on the northern long-eared bat, *Myotis septentrionalis.*

Strategy 3.1A: Collect tissue samples in the form of wing punches from *all* bats captured in the state; specifically, tissue samples should be taken from bats collected during studies or surveys with different objectives, assuming the sampling process does not interfere with the primary purpose of the study/survey. Wing punches are a standard method of sampling skin tissue in bats, and holes from the biopsy generally heal quickly (Simmons et al., 2009).

Strategy 3.1B: Collaborate with other researchers in North America that are conducting phylogenetic analyses of bats across their range. Samples from Strategy 3.1A can be submitted to such researchers and included in larger projects. This is advantageous, as information is obtained with little cost to the state.

Strategy 3.1C: Conduct a study specifically focused on assessing phylogeographic patterns of *M. septentrionalis* populations in North Dakota. This could be combined with a study of the general ecology of the northern long-eared bat (See Issue 4 below). Analyze tissue samples using mitochondrial and nuclear markers to determine the patterns of genetic diversity of this species in North Dakota. Compare patterns of genetic diversity in ND to larger scale phylogeographic assessments from other parts of the species' range, either by collaborating with other researchers or referencing previous research published in the peer-reviewed literature.

Issue 4: Habitat Use of the Northern Long-Eared Bat (*Myotis septentrionalis*)

In response to the rapid nationwide declines of certain population due to white-nose syndrome, it is vital that managers take necessary steps to protect impacted species. The northern long-eared bat, *M. septentrionalis*, is currently being considered for listing under the Endangered Species Act (USFWS, 2015). While it is not clear if or when the disease will reach North Dakota or what impacts it will have on regional *M. septentrionalis* populations, it is obvious that more basic ecological information about this species in the Great Plains is required. The habitat use of *M. septentrionalis* in ND has not been thoroughly documented and it is unknown whether these bats are over-winter residents. In-depth ecological studies of these bats are needed to better assess threats to *M. septentrionalis* in ND.

Previous work on M. septentrionalis in the region reveals a strong roosting association with riparian zones. A single *M. septentrionalis* radiotracked in ND was found to roost in cottonwoods, green ash, and boxelder trees, In South Dakota, this species has been commonly found in the Black Hills, where they roost in decaying Pinus ponderosa (Cryan et al., 2000; Tigner et al., 2003). In eastern SD, Swier (2003) found *M. septentrionalis* roosting in cottonwoods.

Objective 4.1: Study *M. septentrionalis* summer habitat use.

Strategy 4.1A: Assess the roosting habitat preferences of *M. septentrionalis*. A combination of physical capture and subsequent radiotracking of individuals would be valuable for better understanding the tree species used by these bats, as well as the general roost characteristics that are preferred.

Strategy 4.1B: Assess the foraging habitat preferences of *M. septentrionalis*. One survey method is deployment of passive acoustic monitoring units; another option is to physically capture individuals and use coded radiotags to track animals throughout the night while foraging. Such information can then be brought into a GIS environment to study habitat associations.

Objective 4.2: Study the winter ecology of *M. septentrionalis*.

Strategy 4.2A: Winter acoustic surveys should be continued to identify over-winter species presence and possible migration patterns of *M. septentrionalis* in ND.

Strategy 4.2B: In line with Section V.D.1., studies focusing on the possible migratory patterns of *M. septentrionalis* should be conducted to identify key habitats for conservation, as well as to better understand continuity in the species' distribution, as this could influence the spread of white-nose syndrome. Hibernacula of *M. septentrionalis* have been documented in the Black Hills (Tigner & Stukel, 2003) and it is possible that tributaries of the Missouri River may act as migration corridors influencing the species' distribution (Swier, 2006); see map included in *M. septentrionalis* species account).

Issue 5: Use of Artificial Roosting Habitats

Currently, little information is known about bat populations in North Dakota that primarily reside in buildings. There are several resident bat species that occupy buildings in other parts of their distribution (*Eptesicus fuscus*, *Myotis ciliolabrum,* etc.), hence it would be expected that anthropogenic structures serve as important roosting resources for some bat populations. This may be especially true in the Drift Prairie and Missouri Coteau ecosystems of North Dakota, where few natural roosting structures (i.e. trees, caves) are available. Studying colonies of bats that reside in buildings will not only provide more detailed and complete information about the presence and distribution of bat species across the state, it will also allow for interesting ecological and behavioral comparisons between animals living in natural and artificial structures.

Objective 5.1: Study the use of buildings as roosts by bats in North Dakota.

Strategy 5.1A: Based upon the results of the survey proposed under Management Needs (Section VI.C Objective 1.3), identify a selection of sites for a monitoring study. Use of passive acoustic monitoring and physical capture techniques (Section VI.F) would be valuable for determining: 1) if bats are actually present at a site, and 2) the species occupying the site. Where possible, further assessment of the actual roosting area would be valuable. Specifically, deploying temperature and humidity data loggers within roosts will provide information about the characteristics of roost microhabitats.

Issue 6: Bats of Eastern ND

Minimal research has focused on characterizing the bat populations of eastern North Dakota, especially directly along the Red River where large amounts of high quality bat habitat is present. The primary hurdle to conducting research in this region is the tendency for most land near the river to be privately owned. Networking with landowners and making appropriate connections before the summer sampling period would be ideal for gaining access to many areas within the Red River Valley. In addition to the Red River Valley, many other riparian areas in eastern North Dakota potentially offer high quality foraging habitat for bats; assessment of such sites would be valuable for better understanding habitat use in the eastern half of the state.

Objective 6.1: Conduct a foraging habitat study focused on bat populations of eastern North Dakota, with particular focus on riparian areas

Strategy 6.1A: Use a combination of passive acoustic monitoring and physical capture (Section VI.F) to assess habitat use of bats within the Red River Valley and other substantial river areas of eastern ND (i.e. Sheyenne River, Pembina River).

VI. E. Education Needs

Issue 1: Public Attitudes and Misconceptions of Bats

Misconceptions stemming from myth, ignorance, and fear of bats, as well as inaccurate knowledge of public health issues related to bats, seriously impede public support for bat conservation. Such public attitudes can be countered by providing educational resources to the general public and other key audiences, such as teachers, public health officials, wildlife managers, landowners, and political leaders. Some of the educational objectives and strategies detailed here overlap with the management objectives in Section VI.C, since some management needs are inextricably related to education.

Objective 1.1: Develop educational resources for the general public.

Strategy 1.1A: Develop resources for the general public that provide accurate information about the basic biology of bats. Resources may include information on the natural history and ecology of bats, benefits of bats to humans, threats to bats, as well as data about the diversity of North Dakota's bat species and regional conservation needs. Outreach materials such as posters, brochures, and short videos can be developed and distributed across the state. Resources can also be made available on agency and non-government organization websites, as well as via social media. Several excellent models for educational materials are available through national bat conservation organizations, as well as other state wildlife agencies.

Strategy 1.1B: Dissemination of accurate information about public health issues related to bats is key for limiting negative human-bat interactions. Efforts should be made to work with public health authorities to disseminate factual information about bats and rabies, as well as instructions on appropriate actions to take when encountering grounded bats. A pamphlet/brochure/handout with such details could be distributed to public health offices across the state, as well as on the NDGF website.

Objective 1.2: Develop educational resources for specific audiences.

Strategy 1.2A: Provide educators with resources on bats designed for classroom settings at all educational levels, including resources that can be incorporated into existing curricula. Groups such as Bat Conservation International and the Organization for Bat Conservation have a multitude of educational materials online that are available for free or purchase.

Strategy 1.2B: Work in collaboration with veterinarian and public health organizations to provide public health officials with resources on nuisance and health issues involving bats. Resources should include factual information and statistics on rabies occurrences in bats, guidelines for safe human-bat interactions, and proper protocols for handling individuals and animals that have potentially been exposed to the rabies virus.

Strategy 1.2C: Provide property owners with information on non-lethal exclusion methods from homes or other buildings, as well as contact information for trained wildlife control specialists who use bat-friendly exclusion methods (see Section VI. C. Objective 1.3). Other resources could include information on bat houses as a means of coexistence and promoting bats as bio control agents of insect pests on properties.

Strategy 1.2D: Provide farmers and ranchers with information on the potential economic value of bats in agriculture as insect pest predators. Information should also include the habitat requirements and conservation needs of bat species. Collaboration with organizations such as NDSU Extension Service could prove valuable as a means for distributing such information to farmers and landowners.

Strategy 1.2E: Develop and distribute informational resources about bats to lawmakers, industrial and agricultural commissions, and other political leaders. These resources should highlight the economic and ecological importance of bats, as well as bats as a part of North Dakota's heritage. Such materials could be disseminated during workshops (see Section VI.C Objective 1.2) as well as at other appropriate venues.

Objective 1.3: Integrate bat education materials into other successful programs and materials

Strategy 1.3A: Integrate bat education resources into NDGF sponsored class and workshop programs. Classes and workshops should target both the general public as well as specialized groups (see Section VI. C. Objective 1.2).

Strategy 1.3B: Integrate education resources about bats into current North Dakota Game and Fish outreach programs. Modification of existing programs would be relatively simple and cost-effective.

Strategy 1.3C: While bats are more cryptic than most of North Dakota's more charismatic fauna, they can still be promoted as Watchable Wildlife. Foraging bats may be viewable in evening twilight or around artificial light sources such as streetlights. Also, relatively inexpensive hand-held acoustic bat detectors could be purchased for use in after-dark nature walks and educational programs. A program similar to the NDGF Birding Backpack education tool could be made available for bats with simple bat detectors.

Strategy 1.3D: Conduct surveys every 3-5 years to assess the efficacy of education materials and the exposure/level of use these materials are receiving. Update educational materials accordingly.

Issue 2: Professional Training for Bat Conservation

Successful bat conservation in North Dakota requires wildlife professionals to have knowledge of bat ecology and conservation strategies, as well as increased collaboration and coordination with wildlife management and conservation entities. Partnerships are vital for effective surveys, research, white-nose syndrome surveillance, data exchange, and public outreach. Collaboration may also assist with securing funding for bat conservation and outreach efforts from both government and non-government sources. Key entities include the NDGF, NPS, USFS, USFWS, BLM, USDA, ND Dept of Agriculture, ND Parks and Recreation, ND Department of Health, The Nature Conservancy, state universities, tribal colleges, and others.

Objective 2.1: Train biologists and naturalists in bat conservation

Strategy 2.1A: Conduct a workshop in Bismarck every 3-5 years aimed at training wildlife biologists in bat identification, survey methods, data collection, and reporting. The objective of such training is to assist in survey efforts for species occurrence as well as monitoring for white-nose syndrome.

Strategy 2.1B: Develop collaborative programs to train citizen conservation groups, naturalists, and volunteers to assist or conduct public outreach and education efforts such as nature walks, lectures, or school presentations. Potential methods of training individuals could be an in-person workshop or an online training course followed by a quiz that must be passed for course completion.

Objective 2.2: Formation of a state/regional bat working group

Strategy 2.2A: Develop either a stand-alone bat working group for North Dakota, or partner with researchers and managers in South Dakota to develop a larger Dakota Bat Working Group (this would be an expansion of the current South Dakota Bat Working Group). Previous contact with SD bat researchers, such as Dr. Scott Pederson (SDSU), has indicated a strong interest in creating a collaborative group that covers both states. Such a group would enhance all bat conservation efforts by providing a cohesive entity through which wildlife professionals, volunteer naturalists, and students could work together in bat conservation and outreach efforts.

Strategy 2.2B: Develop and maintain a bat working group website as well as a state database of people and organizations with bat training and make this accessible to the public.

Objective 2.3: Foster collaboration

Strategy 2.3A: Collaboration of state and federal agencies with non-government organizations could provide invaluable resources for extending bat conservation efforts. Groups such as Bat Conservation International specialize in bat conservation, outreach, and education. Conservation-minded student organizations such as the NDSU and UND chapters of The Wildlife Society could provide enthusiastic volunteers for both research assistance and public outreach.

VI. F. Tools for Implementing Proposed Actions

Provided below is a sampling protocol for surveying bats in North Dakota, using a combination of mist nets for direct capture and ultrasonic detectors for passive acoustic monitoring. The sampling protocol makes a series of assumptions. If any of the listed assumptions are not met, further consultation is required with NDGF personnel or individuals with expertise in bat sampling. These assumptions are:

1) The researcher has obtained a Scientific Collection Permit from ND Game and Fish. An additional permit is required if research is occurring in Theodore Roosevelt National Park (this permit can be applied for through the NPS online permitting system) or state parks within North Dakota. Research occurring on USFS land (i.e. national grasslands in ND) may not require a permit, although consultation with regional USFS personnel is recommended.

2) The researcher has received appropriate pre-exposure vaccinations against rabies. This consists of a series of 3 shots administered over a 21-day period. These shots can generally be ordered and administered at county health facilities.

3) The researcher has previous experience handling bats, especially removing bats from mist nets, OR the researcher is working with an individual who has this experience. Removing bats from mist nets is a process that requires time and supervision for an individual to become proficient at, and should never be attempted alone or without supervision if you do not have direct handling experience with bats in mist nets.

4) The researcher is able to identify the different bat species found in the region of the state being sampled. Species ID in the eastern part of ND is relatively easy due to the unique size/coloring of the five species found there. Moving further west, the diversity of myotids substantially increases, making species identification of bats in the hand more difficult. See Appendix B for details on identification of bats in the hand and Appendix C for details on acoustic identification. Books such as "The Mammals of North Dakota" by Robert Seabloom and "The Handbook of Canadian Mammals: Bats" by C.G. van Zyll de Jong are excellent resources for identifying the bats of the Great Plains.

5) Researchers are following the federal protocol for sanitization of equipment, with the express purpose of avoiding the spread of White-Nose Syndrome, a fungus that is rapidly spreading across the eastern United States and threatens westerly populations in upcoming years. See Appendix D for the details of the USFWS White Nose Syndrome decontamination protocol.

VI. F.1. Survey Methods (Physical Capture)

Mist Net Placement

Mist net placement is very site-specific, but generally an ideal site is one where bats are funneled through a relatively small space. For example, bats regularly use waterways, trails, and roads as flyways; placing mist nets along these passageways can lead to effective capture. Often, good sites have closed canopies that limit the vertical movements of bats and restrict easy flight to 10 feet or less above the ground (i.e. the area where the mist net is deployed). Further, it is ideal to select locations where the bat has minimal time to respond to the presence of the net. For example, it would be better to place a mist net across a bend in a river rather in the middle of a long, straight section of the same waterway.

The number of mist nets deployed at a specific site should depend upon: 1) the characteristics of the sampling area, and 2) the number of researchers available to monitor nets. In general, mist nets should NEVER go unchecked for more than 10 minutes. Individuals captured by the net regularly become more tangled the longer they are left in the net. Such tangling can greatly increase the amount of time required for removal, and the amount of stress placed on the animal. If two researchers are monitoring nets, it is generally feasible to simultaneously deploy 2-5 mist nets. Netting sites should be recorded in a GPS and characteristics of the site should be described. It is often valuable to sketch the configuration of the different mist nets on the back of a datasheet, especially if you are identifying the net and shelf where each bat was captured. Mist nets are easy to deploy using a set of 10 foot poles (or shorter, stackable poles). In addition, guide lines tied to nearby vegetation help ensure that sufficient tension is placed on the net, as drooping nets are much less effective at capturing bats and lead to more extensive tangling if an animal is caught.

Mist nets are generally opened just before sunset and closed shortly before sunrise, or 120 minutes after the last capture of a bat. This cutoff is based upon extensive observations by many researchers that bat activity peaks in the first two hours after sunset, after which it drops off substantially until the few hours before sunrise. Hence, if no bats are captured after two hours, it is unlikely that any will be captured in the coming hours due to the drop-off in activity.

Animal Handling and Assessment
Upon capture and removal from the net, the following characteristics are generally assessed for each individual: species, sex, age, mass, forearm length, and reproductive condition. Here, I briefly describe how to take these measurements, although the reader is strongly encouraged to read "Ecological and Behavioral Methods for the Study of Bats" by Thomas Kunz and Stuart Parsons. The key in Appendix B should be regularly consulted, especially when multiple *Myotis* species are found in a study area. Sex can be easily identified in bats by inspecting the genitalia. Mass is generally measured using a spring scale (weight of bag + bat – weight of bag = weight of bat). Forearm length is assessed by selecting one of the wings and using calipers to measure the length of the humerus.

Male reproductive condition refers to the presence or absence of descended testes; in general, males in the United States are not reproductively active, and do not have descended testes, during the summer months. Female reproductive condition refers to whether a female is pregnant, lactating, post-lactating, or non-reproductive. Pregnancy can be determined by palpating the abdomen in search of a fetus. This is especially difficult early in pregnancy, but closer to parturition, the female's abdomen is quite large. Lactation can be determined by palpating the nipples to see if milk can be expressed. If no milk is expressed, the female can be categorized as post-lactating. In both lactating and post-lactating females, the nipples are enlarged and fur directly around the nipple is absent. Non-reproductive females exhibit none of the bodily changes described above.

Age general refers to separating sub-adults from adults. Early in life, the epiphyseal joints of young bats have not fused and appear as a long hollow tube. Alternatively, older subadults/juveniles and adults have calcified joints, which appear as knobby structures. This difference can be easily observed by extending the bats' wing and shining a flashlight behind the joints of the phalanges.

Light tagging

Recordings of the echolocation calls of captured bats, which have been identified in the hand to the species level, are generally used to build a call library for analysis of unknown calls. To obtain these calls, captured bats should be housed in clean cloth bags and transported to an open release site within 2 miles of the capture site. A 1.5" chemoluminescent tag (available from Rod-N-Bobb's Inc. and several other companies) is attached between the scapulae of the bat using non-toxic Elmer's glue. This light adhesive ensures that the tag will rapidly fall from the bat, an ideal situation since the researchers will only be recording the bat in the first few minutes after release.

The release site should be continually monitored for bat activity; when no bats have been detected for >60 seconds, one individual, light-tagged bat should be released and visually tracked with a bat detector. The light tag allows the researcher to follow the bat with the detector as it flies in the vicinity of the release are. Researchers should be wary about including the first 30-60 sec of post-release recordings in call libraries; during this period, bats often do not produce typical echolocation calls, presumably as they are orienting in their new environment. After the focal bat has left the area, the process can be repeated until all captured bats have been light tagged and released. Ideally, all bats should be released within 2 hours of capture, as to prevent excessive stress on the animals and disruption of nocturnal foraging.

VI.F.2. Survey Methods (Acoustic Monitoring)

Passive Acoustic Monitoring

For an extensive discussion of different ultrasonic monitoring methods for bats, see Britzke et al (2013). While many different bat detectors can be deployed for passive acoustic monitoring, here we focus on three systems: 1) time expansion, 2) frequency division, and 3) full spectrum, real-time. Time-expansion detectors, such as the Pettersson D240X (Pettersson Elektronik, Sweden) record full call data (i.e. full spectrum) for a short period of time (1.7 or 3.4 sec) and then broadcast the recorded signal at one-tenth the original speed. Time-expanded signals are then stored as an MP3 file on a digital recorder, such as an IRiver, attached to the detector. Frequency division detectors, such as the Anabat SD2 (Titley Electronic, Australia) divide the frequency by a set factor (usually 10), bringing recorded signals into the sonic range without manipulating the temporal structure of the signal. The Anabat system is a stand-alone unit, including both the detector and storage device in one machine. Full spectrum systems, such as the Pettersson D500X, are superior to either time expansion or frequency division detectors because: 1) no data is lost due to use of the zero-crossing method of AnaBat (which reduces the complex full spectrum information in a call to a series of dots), and 2) no data is lost due to the time needed to play back a time-expanded call (for time expansion systems, a 1.7sec recording takes 17 sec to play back, during which additional sampling is not possible). That said, all three systems could effectively be used for species identification given correct deployment of equipment and an adequate call library.

Due to the sensitive nature of bat detectors and the potential for damage during inclement weather, any acoustic recording system must be housed in a protective casing. A common housing for detectors is a small tub with a 90° PVC elbow caulked into a hole cut from the side of the tub. In addition, a hole can be drilled at the bottom of the elbow to permit draining of any accumulated water. The microphone/detector is placed inside the tub and oriented towards the PVC elbow, which permits sounds to be recorded through the opening while excluding rain or other materials from entering the tub and damaging the equipment. See Britzke et al. (2010) for more details about housing of passive acoustic monitoring equipment.

Sound Analysis and Species Identification
Recorded echolocation calls can be analyzed using a wide variety of sound programs. SonoBat 3 (SonoBat, Arcata, CA) and BatSound (Pettersson Elektronik, Sweden) are two commonly used programs for analysis and classification of full spectrum recordings (time-expansion or real time). Commonly used programs for analyzing frequency-division, zero crossing AnaBat recordings are AnaLook (Titley Electronic, Australia) and more recently, EchoClass (Eric Britzke, USACE) and Kaleidoscope Pro (Wildlife Acoustics, USA). All analysis programs conduct species identifications by comparing unknown calls to an extensive library of calls recorded from known individuals. Variation in call structure between geographic locations is common; hence it is wise to include recordings made from light tagging of local bats in these larger reference databases, when possible. These analysis programs are also able to extract a variety of parameter measurements from calls, such as duration and peak frequency, which can be valuable when answering research questions addressing the fine-scale structure of echolocation calls.

VI.F.3. Predictive Habitat Modeling

Ecological niche modeling, also known as habitat suitability modeling, has a wide variety of potential applications. It is commonly used to determine areas of high habitat suitability for a given species across a spatial landscape, known as species distribution models (see Appendix E for examples). Unlike other modeling methods, ecological niche modeling only relies on presence data; such presence-only modeling has been shown to be very reliable and competitive with other high performing modeling techniques (Elith et al., 2010). In bats, presence data can be most easily gathered using a combination of acoustic monitoring and physical capture at the site(s) of interest. Maps are produced by combining presence data with geospatial data, such as

Bioclim climactic variables (Hijmans et al. (2005); http://www.worldclim.org), which consists of temperature and precipitation information summarized geographically in a grid form. Information about land cover (i.e. NLCD 2006; http://www.nd.gov/gis/data-portal.html) is also generally used for building habitat suitability maps. Due to landscape heterogeneity, it is best to use the highest resolution datasets available for all climactic modeling analysis.

The most commonly used program for developing species distribution models is MaxEnt (Phillips et al., 2006). The program produces probability density maps, where species presence is scored across small geographic areas as likely (score near 1) or unlikely (score near 0) (Phillips & Dudík, 2008). The program can also test the likelihood of different models (which are combinations of climactic and land cover variables) correctly distinguishing between presence and random locations. A fundamental assumption of MaxEnt is that the entire geographic area of interest has been sampled (Kramer□ Schadt et al., 2013), yet this is typically not the case. MaxEnt can be used to select background pseudo-absence locations within the same study area (i.e. counties); creation of such a pseudo-absence file has the same bias as the presence locations (Young et al., 2011), ensuring that substantial biases in model production due to uneven sampling do not occur. For more details about model testing in MaxEnt, see (Phillips et al., 2006) and (P Anderson et al., 2006).

VI.F.4. Identification and Characterization of Potential Hibernacula

Locating Hibernacula

Potential hibernacula are most efficiently located by physically capturing bats (see above) and radio tagging individuals for subsequent tracking to hibernation sites. Once captured, fur should be clipped between the scapula and a radio transmitter attached to the exposed skin using Skin Bond adhesive (or a similar surgical skin glue). The radio transmitters used should be appropriate for the body size of the species being tagged; the standard rule is that radio transmitters placed on bats should be <5% of total body mass (Aldridge & Brigham, 1988). Once applied, the radio transmitter should be held in place for five minutes to allow time for the adhesive to dry, after which the animal should be immediately released. On subsequent days, the bat can be tracked to their roosting location using an antenna and receiver setup, such as the R-100 telemetry receiver (Wildlife Specialists, USA) attached to a three-element antenna. Radio transmitters typically fall off within two weeks, although bats often groom off the device in a shorter period of time. Use of radiotelemetry for tracking the movements of bats is common practice (see Amelon et al. (2009) for more details) and minimal mortality is associated with this method.

An alternative, but much less efficient method is to scout the landscape on foot for caves that may be occupied by bats. Once a potential site is located, a passive acoustic monitoring station can be deployed at the site during the winter months to monitor for the presence of bats. An excellent option for such acoustic surveys is the AnaBat Roost Logger, which is a small, well-protected device that can be easily deployed for long periods of time. Conveniently, this unit can also collect temperature data.

Characterizing Hibernacula

Once a known hibernaculum is identified, details about the site should be assessed. In the badlands of western North Dakota, this can be particularly difficult, as bats may occupy small, inaccessible crevices. In addition, entering and moving around larger caves can modify the structure, as the brittle bentonite easily crumbles when disturbed. Despite this, the researcher should attempt to estimate the dimensions of the hibernaculum, the direction of the cave/crevice opening and elevation. In addition, temperature and humidity information should be collected using sensors, such as IButtons (Maxim Integrated, USA). Ideally, these temperatures should be deployed as close as possible to the location where bats are known to roost. It may also be appropriate to collect soil samples to determine if the fungus that causes white-nose syndrome is present; details and supplies for *P. destructans* soil sampling can be received from Dr. Winifred Frick at UC Santa Cruz (wfrick@ucsc.edu).

VII. LITERATURE CITED

Acharya, L., & Fenton, M. B. (1999). Bat attacks and moth defensive behaviour around street lights. *Canadian Journal of Zoology, 77*(1), 27-33.

Aldridge, H., & Brigham, R. (1988). Load carrying and maneuverability in an insectivorous bat: a test of the 5%" rule" of radio-telemetry. *Journal of mammalogy*, 379-382.

Amelon, S., Dalton, D. C., Millspaugh, J. J., & Wolf, S. A. (2009). Radiotelemetry; techniques and analysis. In T. H. Kunz & S. Parsons (Eds.), *Ecological and behavioral methods for the study of bats.*

Arnett, E. B., Huso, M. M., Schirmacher, M. R., & Hayes, J. P. (2010). Altering turbine speed reduces bat mortality at wind-energy facilities. *Frontiers in Ecology and the Environment, 9*(4), 209-214.

Arnett, E. B., Brown, W., Erickson, W. P., Fiedler, J. K., Hamilton, B. L., Henry, T. H., Jain, A., Johnson, G. D., Kerns, J., & Koford, R. R. (2008). Patterns of bat fatalities at wind energy facilities in North America. *The Journal of wildlife management, 72*(1), 61-78.

Austad, S. N., & Fischer, K. E. (1991). Mammalian aging, metabolism, and ecology: evidence from the bats and marsupials. *Journal of Gerontology, 46*(2), B47-B53.

AWEA. (2013). North Dakota Fact Sheet Retrieved http://www.awea.org/, 2014

Baerwald, E. F., & Barclay, R. M. (2009). Geographic variation in activity and fatality of migratory bats at wind energy facilities. *Journal of mammalogy, 90*(6), 1341-1349.

Baerwald, E. F., D'Amours, G. H., Klug, B. J., & Barclay, R. M. (2008). Barotrauma is a significant cause of bat fatalities at wind turbines. *Current Biology, 18*(16), R695-R696.

Bailey, V. (1926). *A Biological Survey of North Dakota: I. Physiography and Life Zones; II. The Mammals of North Dakota*: Washington Government Printing Office.

Bales, B. T. (2007). *Regional distribution and monitoring of bats, especially species of conservation concern, along the lower Missouri River in South Dakota.* Paper presented at the Masters Abstracts International.

Barclay, R. M., & Kurta, A. (2007). Ecology and behavior of bats roosting in tree cavities and under bark. *Bats in forests: conservation and management (MJ Lacki, JP Hayes, and A. Kurta, eds.). Johns Hopkins University Press, Baltimore, Maryland*, 17-59.

Barclay, R. M. R., & Harder, L. D. (2003). Life histories of bats: life in the slow lane. In T. H. K. a. M. B. Fenton (Ed.), *Bat Ecology* (pp. 209–253). Chicago, IL: University of Chicago Press,.

Barnhart, P. R., & Gillam, E. H. (2014). The impact of sampling method on maximum entropy species distribution modeling for bats. *Acta Chiropterologica, 16*(1), 241-248.

Bicknell, L. J., & Gillam, E. H. (2013). Survey of bat mortalities at a wind-energy facility in North Dakota. *Journal of Fish and Wildlife Management, 4*(1), 139-143.

Blehert, D. S., Hicks, A. C., Behr, M., Meteyer, C. U., Berlowski-Zier, B. M., Buckles, E. L., Coleman, J. T. H., Darling, S. R., Gargas, A., Niver, R., Okoniewski, J. C.,

Rudd, R. J., & Stone, W. B. (2009). Bat White-Nose Syndrome: An Emerging Fungal Pathogen? *Science, 323*(5911), 227-227. doi: 10.1126/science.1163874
Boyles, J. G., & Willis, C. K. R. (2010). Could localized warm areas inside cold caves reduce mortality of hibernating bats affected by white-nose syndrome? *Frontiers in Ecology and the Environment, 8*(2), 92-98. doi: 10.1890/080187
Brigham, R. M. (1991). Flexibility in foraging and roosting behaviour by the big brown bat (Eptesicus fuscus). *Canadian Journal of Zoology, 69*(1), 117-121.
Brigham, R. M., Lacki, M., Hayes, J., & Kurta, A. (2007). *Bats in forests: conservation and management.* Baltimore: Johns Hopkins University Press.
Britzke, E. R., Gillam, E. H., & Murray, K. L. (2013). Current state of understanding of ultrasonic detectors for the study of bat ecology. *Acta Theriologica, 58*(2), 109-117. doi: 10.1007/s13364-013-0131-3
Britzke, E. R., Slack, B. A., Armstrong, M. P., & Loeb, S. C. (2010). Effects of orientation and weatherproofing on the detection of bat echolocation calls. *Journal of Fish and Wildlife Management, 1*(2), 136-141.
Brussard, P. F. (1984). Geographic Patterns and Environmental Gradients: The Central-Marginal Model in Drosophila Revisited. *Annual Review of Ecology and Systematics, 15*, 25-64. doi: 10.2307/2096942
Caceres, M. C., & Barclay, R. M. (2000). Myotis septentrionalis. *Mammalian species*, 1-4.
Calisher, C. H., Holmes, K. V., Dominguez, S. R., Schountz, T., & Cryan, P. (2008). Bats prove to be rich reservoirs for emerging viruses. *Microbe, 3*, 521-528.
Castle, K. T., & Cryan, P. M. (2010). White-nose syndrome in bats: A primer for resource managers. *Park Science, 27*(1), 20-25.
Chaturvedi, V., Springer, D. J., Behr, M. J., Ramani, R., Li, X. J., Peck, M. K., Ren, P., Bopp, D. J., Wood, B., Samsonoff, W. A., Butchkoski, C. M., Hicks, A. C., Stone, W. B., Rudd, R. J., & Chaturvedi, S. (2010). Morphological and Molecular Characterizations of Psychrophilic Fungus Geomyces destructans from New York Bats with White Nose Syndrome (WNS). *Plos One, 5*(5). doi: e10783
10.1371/journal.pone.0010783
Cleveland, C. J., Betke, M., Federico, P., Frank, J. D., Hallam, T. G., Horn, J., Lopez Jr., J. D., McCracken, G. F., Medellin, R. A., Moreno-Valdez, A., Sansone, C. G., Westbrook, J. K., & Kunz, T. H. (2006). Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas. *Frontiers in Ecology and the Environment, 4*, 238-243.
Cockrum, E. L., & Cross, S. P. (1964). Time of bat activity over water holes. *Journal of mammalogy*, 635-636.
Cosson, J.-F., Pons, J.-M., & Masson, D. (1999). Effects of forest fragmentation on frugivorous and nectarivorous bats in French Guiana. *Journal of Tropical Ecology, 15*(04), 515-534.
Courtin, F., Stone, W. B., Risatti, G., Gilbert, K., & Van Kruiningen, H. J. (2010). Pathologic Findings and Liver Elements in Hibernating Bats With White-Nose Syndrome. *Veterinary Pathology, 47*(2), 214-219. doi: 10.1177/0300985809358614
Cryan, P. M. (2003). Seasonal distribution of migratory tree bats (Lasiurus and Lasionycteris) in North America. *Journal of mammalogy, 84*(2), 579-593.

Cryan, P. M., & Brown, A. C. (2007). Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. *Biological Conservation, 139*(1), 1-11.

Cryan, P. M., & Barclay, R. M. (2009). Causes of bat fatalities at wind turbines: hypotheses and predictions. *Journal of mammalogy, 90*(6), 1330-1340.

Cryan, P. M., Bogan, M. A., & Altenbach, J. S. (2000). Effect of elevation on distribution of female bats in the Black Hills, South Dakota. *Journal of mammalogy, 81*(3), 719-725.

Cryan, P. M., Bogan, M. A., & Yanega, G. M. (2001). Roosting habits of four bat species in the Black Hills of South Dakota. *Acta Chiropterologica, 3*(1), 43-52.

Cryan, P. M., Meteyer, C. U., Boyles, J. G., & Blehert, D. S. (2010). Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. *Bmc Biology, 8*.

Cryan, P. M., Bogan, M. A., Rye, R. O., Landis, G. P., & Kester, C. L. (2004). Stable hydrogen isotope analysis of bat hair as evidnece for seasonal molt and long-distance migration. *Journal of mammalogy, 85*(5), 995-1001.

De Serres, G., Skowronski, D. M., Mimault, P., Ouakki, M., Maranda-Aubut, R., & Duval, B. (2009). Bats in the bedroom, bats in the belfry: reanalysis of the rationale for rabies postexposure prophylaxis. *Clinical infectious diseases, 48*(11), 1493-1499.

Dyke, S., Hagen, S., & Isakson, P. (2004). North Dakota's 100 species of conservation priority. *North Dakota Outdoors, 67,* 2-21.

Elith, J., Kearney, M., & Phillips, S. (2010). The art of modelling range□shifting species. *Methods in ecology and evolution, 1*(4), 330-342.

Esmoil, B., & Anderson, S. (1995). Wildlife mortality associated with oil pits in Wyoming. *Prairie Naturalist, 27*, 81-81.

Fellers, G. M., & Pierson, E. D. (2002). Habitat use and foraging behavior of Townsend's big-eared bat (Corynorhinus townsendii) in coastal California. *Journal of mammalogy, 83*(1), 167-177.

Fenton, M. B., & Barclay, R. M. (1980). Myotis lucifugus. *Mammalian species*, 1-8.

Fiedler, J. K. (2004). *Assessment of bat mortality and activity at Buffalo Mountain Windfarm, eastern Tennessee.* M.Sc., University of Tennessee at Knoxville.

Foresman, K. R. (2001). Wild Mammals of Montana Special publication No. 12.

Frick, W. F., Pollock, J. F., Hicks, A. C., Langwig, K. E., Reynolds, D. S., Turner, G. G., Butchkoski, C. M., & Kunz, T. H. (2010). An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. *Science, 329*(5992), 679-682. doi: 10.1126/science.1188594

Geiser, F. (1996). *Torpor in reproductive endotherms.* Paper presented at the Adaptations to the cold: 10th international hibernation symposium. University of New England Press, Armidale.

Genoways, H. H. (1967). Second report of Myotis volans from North DAkota. *Transactions of the Kansas Academy of Science, 69*, 355.

Genoways, H. H., & Jones, J. K. (1972). *Mammals from southwestern North Dakota*: Museum, Texas Tech University.

Gillam, E. H. (2014). Annual Report for SWG Grant: Hibernating Bats in North Dakota: Species Diversity, Habitat Use, and Potential Impacts of White-Nose Syndrome (pp. 16). Fargo, ND: North Dakota State University.

Gillam, E. H., & Barnhart, P. R. (2012). Distribution and habitat use of the bats of North Dakota: A final report prepared for North Dakota Game and Fish Department.
Gillam, E. H., Ulanovsky, N., & McCracken, G. F. (2007). Rapid jamming avoidance in biosonar. *Proceedings of the Royal Society of London B, Biological Sciences, 274*, 651-660.
Goehring, H. H. (1972). Twenty-year study of Eptesicus fuscus in Minnesota. *Journal of mammalogy*, 201-207.
Griffin, D. R. (1958). *Listening in the dark: the acoustic orientation of bats and men*. Ithaca: Comstock Publishing Associates.
Hall, E. R., & Kelson, K. R. (1981). *The mammals of north america* (Vol. 1): Wiley New York.
Hallam, T. G., & McCracken, G. F. (2011). Management of the Panzootic White-Nose Syndrome through Culling of Bats. *Conservation Biology, 25*(1), 189-194. doi: 10.1111/j.1523-1739.2010.01603.x
Haugen, D. E., & Harsel, R. A. (2013). North Dakota Timber Industry: An Assessment of Timber Product Output and Use: USFS.
Hazard, E. B. (1982). *The mammals of Minnesota*: U of Minnesota Press.
Hibbard, E. A. (1963). Another hoary bat found hanging on a fence. *Journal of mammalogy, 44*(2), 265-265.
Hibbard, E. A. (1973). *Vertebrate ecology and zoogeography of the Missouri River Valley in North Dakota.*
Higgins, K. F. (2000). Wild mammals of South Dakota.
Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International journal of climatology, 25*(15), 1965-1978.
Hoffmann, R. S., Pattie, D. L., & Bell, J. F. (1969). The distribution of some mammals in Montana. II. Bats. *Journal of mammalogy*, 737-741.
Holloway, G. L., & Barclay, R. M. (2001). Myotis ciliolabrum. *Mammalian species*, 1-5.
Horn, J. W., Arnett, E. B., & Kunz, T. H. (2008). Behavioral responses of bats to operating wind turbines. *The Journal of Wildlife Management, 72*(1), 123-132.
Huot, C., De Serres, G., Duval, B., Maranda-Aubut, R., Ouakki, M., & Skowronski, D. M. (2008). The cost of preventing rabies at any cost: Post-exposure prophylaxis for occult bat contact. *Vaccine, 26*(35), 4446-4450.
Izor, R. J. (1979). Winter range of the silver-haired bat. *Journal of mammalogy, 60*, 641-643.
Johnson, G. (2005). A review of bat mortality at wind-energy developments in the United States. *Bat Research News, 46*(2), 45-49.
Johnson, G. D., Erickson, W. P., Dale Strickland, M., Shepherd, M. F., Shepherd, D. A., & Sarappo, S. A. (2003). Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. *The American Midland Naturalist, 150*(2), 332-342.
Jones, G., & Siemers, B. (2011). The communicative potential of bat echolocation pulses. *Journal of Comparative Physiology A, 197*(5), 447-457. doi: 10.1007/s00359-010-0565-x

Jones, G., Jacobs, D. S., Kunz, T. H., Willig, M. R., & Racey, P. A. (2009). Carpe noctem: the importance of bats as bioindicators. *Endangered Species Research, 8*(1-2), 93-115.
Jones, J. K. (1973). *Notes on the distribution and natural history of bats in southeastern Montana*: Museum, Texas Tech University.
Jones, J. K. (1983). *Mammals of the northern Great Plains*: University of Nebraska Press.
Jones, J. K., & Stanley, W. C. (1962). Myotis subulatus in North Dakota. *Journal of mammalogy*, 263-263.
Jones, J. K., & Genoways, H. H. (1966). Records of bats from western North Dakota. *Transactions of the Kansas Academy of Science (1903)*, 88-90.
Jones Jr, J. K., & Genoways, H. H. (1967). A new subspecies of the fringe-tailed bat, Myotis thysanodes, from the Black Hills of South Dakota and Wyoming. *Journal of mammalogy*, 231-235.
Kalcounis, M. C., & Brigham, R. M. (1998). Secondary use of aspen cavities by tree-roosting big brown bats. *The Journal of wildlife management*, 603-611.
Kasso, M., & Balakrishnan, M. (2013). Ecological and Economic Importance of Bats (Order Chiroptera). *ISRN Biodiversity, 2013*, 9. doi: 10.1155/2013/187415
Koehler, C. E., & Barclay, R. M. (2000). Post-natal growth and breeding biology of the hoary bat (Lasiurus cinereus). *Journal of mammalogy, 81*(1), 234-244.
Kramer□Schadt, S., Niedballa, J., Pilgrim, J. D., Schröder, B., Lindenborn, J., Reinfelder, V., Stillfried, M., Heckmann, I., Scharf, A. K., & Augeri, D. M. (2013). The importance of correcting for sampling bias in MaxEnt species distribution models. *Diversity and Distributions, 19*(11), 1366-1379.
Kunz, T. H. (1982). Roosting ecology of bats. In T. H. Kunz (Ed.), *Ecology of Bats* (pp. 1-50). New York: Plenum Press.
Kunz, T. H., & Martin, R. A. (1982). Plecotus townsendii. *Mammalian species*, 1-6.
Kunz, T. H., & Fenton, M. B. (2006). *Bat ecology*: University of Chicago Press.
Kurta, A., & Baker, R. (1982). Eptesicus fuscus. *Mammalian species, 356*, 1-10.
Lacki, M. J., Amelon, S. K., Baker, M. D., Lacki, M., Hayes, J., & Kurta, A. (2007). Foraging ecology of bats in forests. *Bats in forests: conservation and management. Johns Hopkins University Press, Baltimore, Maryland, USA*, 83-127.
Lausen, C. L., & Barclay, R. M. (2006). Benefits of living in a building: big brown bats (Eptesicus fuscus) in rocks versus buildings. *Journal of mammalogy, 87*(2), 362-370.
Lenard, S., & Lausen, C. (2010). A Summary of 2009 bat surveys conducted in North Dakota on U.S. Forest Service Little Missouri National Grasslands and North Unit of Theodore Roosevelt National Park (pp. 24).
Lindner, D. L., Gargas, A., Lorch, J. M., Banik, M. T., Glaeser, J., Kunz, T. H., & Blehert, D. S. (2011). DNA-based detection of the fungal pathogen Geomyces destructans in soils from bat hibernacula. *Mycologia, 103*(2), 241-246. doi: 10.3852/10-262
Maher, S. P., Kramer, A. M., Pulliam, J. T., Zokan, M. A., Bowden, S. E., Barton, H. D., Magori, K., & Drake, J. M. (2012). Spread of white-nose syndrome on a network regulated by geography and climate. *Nature communications, 3*, 1306.

Manning, R. W., & Jones, J. K. (1989). Myotis evotis. *Mammalian species*, 1-5.
Mattson, T. A., Stanton, N. L., & Buskirk, S. W. (1994). The Roosting Ecology of the Silver-Haired Bat Lasionycteris noctivagans in the Black Hills of South Dakota. *University of Wyoming National Park Service Research Center Annual Report, 18*(1), 99-102.
Mattson, T. A., Buskirk, S. W., & Stanton, N. L. (1996). Roost sites of the silver-haired bat (Lasionycyeris noctivagans) in the Black Hills, South Dakota. *Western North American Naturalist, 56*(3), 247-253.
McGuire, L. P., Guglielmo, C. G., Mackenzie, S. A., & Taylor, P. D. (2012). Migratory stopover in the long□distance migrant silver□haired bat, Lasionycteris noctivagans. *Journal of Animal Ecology, 81*(2), 377-385.
Medlin, R. E., Connior, M. B., Gaines, K. F., & Risch, T. S. (2010). Responses of Bats to Forest Fragmentation in the Mississippi River Alluvial Valley, Arkansas, USA. *Diversity, 2*(10), 1146-1157.
Moritz, C. (1994). Defining 'evolutionarily significant units' for conservation. *Trends in Ecology & Evolution, 9*(10), 373-375.
Mullican, T. (1999). Earliest seasonal record of reproduction in the hoary bat on the northern great plains. *Prairie Naturalist, 31*(4), 249-250.
Norberg, U. (1996). Energetics of Flight. In C. Carey (Ed.), *Avian Energetics and Nutritional Ecology* (pp. 199-249): Springer US.
Norberg, U. M. (1990). *Vertebrate flight: mechanics, physiology, morphology, ecology and evolution*: Springer-Verlag.
Norberg, U. M., & Rayner, J. M. V. (1987). Ecological Morphology and Flight in Bats (Mammalia; Chiroptera): Wing Adaptations, Flight Performance, Foraging Strategy and Echolocation. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 316*(1179), 335-427. doi: 10.2307/2396486
Nowak, R. M. (1994). *Walker's mammals of the World. Volume 1*. Baltimore: The Johns Hopkins University Press.
O'Farrell, M. J., & Studier, E. H. (1980). Myotis thysanodes. *Mammalian species*, 1-5.
Obrist, M. K. (1995). Flexible bat echolocation: the influence of individual, habitat and conspecifics on sonar signal design. *Behavioral Ecology and Sociobiology, 36*, 207-219.
Orloff, S., Flannery, A., Commission, C. E., County, A., County, C. C., & County, S. (1992). *Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas, 1989-1991: Final Report*: The Commission.
P Anderson, R., Dudík, M., Ferrier, S., Guisan, A., J Hijmans, R., Huettmann, F., R Leathwick, J., Lehmann, A., Li, J., & G Lohmann, L. (2006). Novel methods improve prediction of species' distributions from occurrence data. *Ecography, 29*(2), 129-151.
Peterman, W. E., Feist, S. M., Semlitsch, R. D., & Eggert, L. S. (2013). Conservation and management of peripheral populations: Spatial and temporal influences on the genetic structure of wood frog (Rana sylvatica) populations. *Biological Conservation, 158*(0), 351-358. doi: http://dx.doi.org/10.1016/j.biocon.2012.07.028

Phillips, S. J., & Dudík, M. (2008). Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography, 31*(2), 161-175.
Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological modelling, 190*(3), 231-259.
Pierson, E. (1998). Tall trees, deep holes, and scarred landscapes: conservation biology of North American bats *Bat biology and conservation.* (pp. 309-325). Washington, DC: Smithsonian Institution Press.
Rajkumar, S. S., Li, X. J., Rudd, R. J., Okoniewski, J. C., Xu, J. P., Chaturvedi, S., & Chaturvedi, V. (2011). Clonal Genotype of Geomyces destructans among Bats with White Nose Syndrome, New York, USA. *Emerging Infectious Diseases, 17*(7), 1273-1276. doi: 10.3201/eid1707.102056
Redell, D., Arnett, E. B., Hayes, J. P., Huso, M. M., Watt, M., Engelman, A., & Kalson, A. (2006). Patterns of pre-construction bat activity determined using acoustic monitoring at a proposed wind facility in south-central Wisconsin *An annual report submitted to the Bats and Wind Energy Cooperative.* Austin, Texas, USA: Bat Conservation International.
Reiskind, M. H., & Wund, M. A. (2009). Experimental assessment of the impacts of northern long-eared bats on ovipositing Culex (Diptera: Culicidae) mosquitoes. *Journal of medical entomology, 46*(5), 1037.
Roberts, L. (1975). Confirmation of the echolocation pulse production mechanism of Rousettus. *Journal of mammalogy*, 218-220.
Russell, A. L., Medellin, R., & McCracken, G. (2005). Genetic variation and migration in the Mexican free□tailed bat (Tadarida brasiliensis mexicana). *Molecular Ecology, 14*(7), 2207-2222.
Rydell, J., Bach, L., Dubourg-Savage, M.-J., Green, M., Rodrigues, L., & Hedenström, A. (2010). Mortality of bats at wind turbines links to nocturnal insect migration? *European Journal of Wildlife Research, 56*(6), 823-827.
Schmidt, C. (2003). Conservation assessment for the Townsend's big-eared bat in the Black Hills National Forest of South Dakota nad Wyoming.
Schountz, T. (2013). Virology and Immunology of Bats *Bat Evolution, Ecology, and Conservation* (pp. 393-412): Springer.
Seabloom, R. W. (2011). *Mammals of North Dakota*. Fargo, ND: North Dakota State University.
Seabloom, R. W., Crawford, R. D., & MacKenna, M. G. (1978). *Vertebrates of Southwestern North Dakota--amphibians, Reptiles, Birds, Mammals*: Institute for Ecological Studies, University of North Dakota.
Service, U. F. a. W. (2014). White-nose syndrome: North America's response to the devastating bat disease., 2014
Sherwin, R. E., Stricklan, D., & Rogers, D. S. (2000). Roosting affinities of Townsend's big-eared bat (Corynorhinus townsendii) in northern Utah. *Journal of mammalogy, 81*(4), 939-947.
Sherwin, R. E., Gannon, W. L., & Altenbach, J. S. (2003). Managing complex systems simply: understanding inherent variation in the use of roosts by Townsend's big-eared bat. *Wildlife Society Bulletin, 31*(1), 62-72.
Shump, K. A., & Shump, A. U. (1982). Lasiurus cinereus. *Mammalian species, 185*, 1-5.

Simmons, N. B., Voss, R. S., Kunz, T., & Parsons, S. (2009). Collection, preparation, and fixation of specimens and tissues. *Ecological and behavioral methods for the study of bats. Baltimore, The Johns Hopkins University Press, 2nd ed., XVII+ 901p*, 849-867.

Svihovec, L. (1967). *A comparison study of the ecological distribution of small mmammals in southwestern North Dakota.* MS, University of North Dakota, Grand Forks.

Swier, V. J. (2003). *Distribution, roost site selection and food habits of bats in eastern South Dakota.* Biology and Microbiology Department, South Dakota State University.

Swier, V. J. (2006). Investigating possible hibernaculas for the bat population of the Missouri River in South Dakota A report for the South Dakota Game, Fish and Parks Small Grants.

Thomas, J. A., Moss, C. F., & Vater, M. (2004). *Echolocation in bats and dolphins*: University of Chicago Press.

TIgner, J. (2006). Bat Surveys - 2006 Little Missouri National Grasslands, North Dakota (pp. 31).

Tigner, J., Stukel, E. D., & Dakota, S. (2003). *Bats of the Black Hills: a description of status and conservation needs*: South Dakota Department of Game, Fish and Parks.

Turmelle, A. S., Kunz, T. H., & Sorenson, M. D. (2011). A tale of two genomes: contrasting patterns of phylogeographic structure in a widely distributed bat. *Molecular Ecology, 20*(2), 357-375.

USFWS. (2014). White Nose Syndrome: A Coordinated Response to the Devastating Bat Disease, 2014, from https://http://www.whitenosesyndrome.org/

USFWS. (2015). Northern Long-Eared Bat, Myotis septentrionalis, from http://www.fws.gov/midwest/endangered/mammals/nlba/

Warnecke, L., Turner, J. M., Bollinger, T. K., Lorch, J. M., Misra, V., Cryan, P. M., Wibbelt, G., Blehert, D. S., & Willis, C. K. R. (2012). Inoculation of bats with European Geomyces destructans supports the novel pathogen hypothesis for the origin of white-nose syndrome. *Proceedings of the National Academy of Sciences, 109*(18), 6999-7003. doi: 10.1073/pnas.1200374109

Warner, R. M., & Czaplewski, N. J. (1984). Myotis volans. *Mammalian species*, 1-4.

Weller, T. J., & Zabel, C. J. (2001). Characteristics of fringed myotis day roosts in northern California. *The Journal of wildlife management*, 489-497.

Wickramasinghe, L. P., Harris, S., Jones, G., & Vaughan Jennings, N. (2004). Abundance and species richness of nocturnal insects on organic and conventional farms: effects of agricultural intensification on bat foraging. *Conservation Biology, 18*(5), 1283-1292.

Wilkinson, G. S., & South, J. M. (2002). Life history, ecology and longevity in bats. *Aging Cell, 1*, 124-131.

Willis, C. K., Brigham, R. M., & Geiser, F. (2006). Deep, prolonged torpor by pregnant, free-ranging bats. *Naturwissenschaften, 93*(2), 80-83.

Willis, C. K. R., Menzies, A. K., Boyles, J. G., & Wojciechowski, M. S. (2011). Evaporative Water Loss Is a Plausible Explanation for Mortality of Bats from

White-Nose Syndrome. *Integrative and Comparative Biology, 51*(3), 364-373. doi: 10.1093/icb/icr076

WYGFD. (2010). Recommendations for Development of Oil and Gas Resources Within Important Wildlife Habitats. Cheyenne, WY: Wyoming Game and Fish Department.

Young, N., Carter, L., & Evangelista, P. (2011). A MaxEnt Model v3. 3.3 e Tutorial (ArcGIS v10). *Natural Resource Ecology Laboratory at Colorado State University and the National Institute of Invasive Species Science, Colorado, USA.*

VIII. APPENDIX A: SPECIES ACCOUNTS, RANGE MAPS, AND HABITAT SUITABILITY MAPS

Prior to 2009, a statewide survey documenting the occurrence and distribution of bats in North Dakota had not been conducted. Bailey (1926) noted anecdotal sightings and scattered museum specimens within the state of *Lasiurus cinereus*, *L. borealis*, *Eptesicus fuscus*, *Myotis ciliolabrum*, *M. evotis* and *M. lucifugus*. The Museum of Natural History includes field collections from southwestern ND for *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. volans* and *E. fuscus* (Jones & Stanley, 1962; Jones & Genoways, 1966; Genoways & Jones, 1972). More recently, separate studies along the Little Missouri River reported captures of *Corynorhinus townsendii*, *E. fuscus*, *Lasionycteris noctivagans*, *L. cinereus*, *M. ciliolabrum*, *M. evotis*, *M. lucifugus*, *M. septentrionalis*, and *M. volans* as well as acoustical detection of *M. thysanodes* (TIgner, 2006; Lenard & Lausen, 2010). Current ongoing work in the state has documented both physical captures and acoustic detection of all eleven aforementioned species (Barnhart & Gillam, 2014).

Ten of the eleven species accounts included here are taken, with permission, directly from "The Mammals of North Dakota" by Robert Seabloom. Italicized sentences are those in which we have added additional information and/or modified the original text to reflect more recent findings. The species account for the Fringed myotis, *Myotis thysanodes*, was written as part of this management plan.

All range distribution maps depict the IUCN distribution of a given species by diagonal hashmarks (some species have no known distribution in the state or it is limited to the extreme SW corner). Yellow triangles indicate sites where a species was only detected acoustically. Green circles indicate sites where a species was physically captured only, or physically captured and detected acoustically.

VIII.A. Townsend's big-eared bat, *Corynorhinus townsendii*

Description

The Townsend's big-eared bat is easily distinguished from other regional bats by its extremely large ears. They are joined across the forehead at the base, and when laid back, extend to the middle of the body. There are also prominent facial glands between the nostril and the eye. The pelage color can range from brown to slate. Average standard body measurements are: Total Length - 102 mm, Tail Length - 46 mm, Hind Foot - 11 mm, Ear - 36 mm.

Distribution

This bat occurs from southern British Columbia south through much of the western United States, into central Mexico. There are isolated southeastern populations of separate subspecies in Missouri, Arkansas, Oklahoma, Kentucky, and the Virginias. Until very recently, there were no known records from North Dakota, but its occurrence was suspected because of records in adjacent counties in extreme northwestern South Dakota and southeastern Montana. In June 2009, seven females, two of which were visibly pregnant, were live-captured in McKenzie County (Cori Lausen, Birchdale Ecological Ltd., Kaslo, BC, Canada).

Habitat

Throughout much of its range, Townsend's big-eared bat is regarded as a habitat generalist, but it is most commonly associated with mesic deciduous and coniferous forests. In semiarid portions of eastern Montana, it occurs in Rocky Mountain juniper-limber pine vegetation, while in South Dakota, most reports are from the forested Black Hills.

Spring and summer roosting habitat includes the warmer portions of caves and mines, and buildings. The North Dakota observations were made in cottonwood/willow habitat near water and close to log buildings. Winter hibernation occurs in relatively cool but thermally stable sites in caves and mines. Because large caves or underground mines are absent in North Dakota, it is unclear whether this species would hibernate in the state. Currently there are no known wintering sites *of this species* in North Dakota, but winter observations of bats in southeastern Alberta lend to the possibility of hibernacula in North Dakota's *Badlands. This species was captured in mid-September in western North Dakota, although it was unclear if this was a late summer resident or a bat overwintering in the region. These bats are notably sensitive to disturbance at roosting sites* (Kunz & Martin, 1982; Fellers & Pierson, 2002; Sherwin et al., 2003).

Ecology and Behavior

This is a relatively sedentary bat, not known to make long-distance migrations. Recorded movements from maternity roosts to hibernacula have ranged from 3 to 70 km. The recent North Dakota observations could imply much greater potential migration distances, the nearest large caves and mine shafts being in South Dakota's Black Hills, a distance of over 370 km. Alternatively, North Dakota's Badlands contain numerous small caves in eroded mudstone, which might provide suitable hibernacula for this and other bat species.

During spring and summer, males are solitary while females assemble in maternity colonies of usually under 100 bats. Throughout hibernation, these bats roost singly or in small clusters of up to 58 individuals.

Townsend's big-eared bat forages later than many other bats, reaching its peak of activity nearly two hours after sunset. The species seems to prefer forest edges and riparian zones within 3 km of the roost. Foraging is principally on small moths, but other insects, e.g., beetles, lacewings, flies, wasps, etc., are taken as well.

Mortality of young-of-the-year bats runs about 5% prior to hibernation, and 50% over the first year. Annual survival of adults is approximately 80%, with a maximum known longevity of 16 years.

Reproduction

The breeding season extends from October through late February. Young females are believed to be capable of reproduction during their first year, but young males are not. As with other regional bats, delayed fertilization occurs, with parturition beginning in late May following a gestation of 56 to 100 days. Young are fledged at 2.5 to 3 weeks, and weaned by 6 weeks of age.

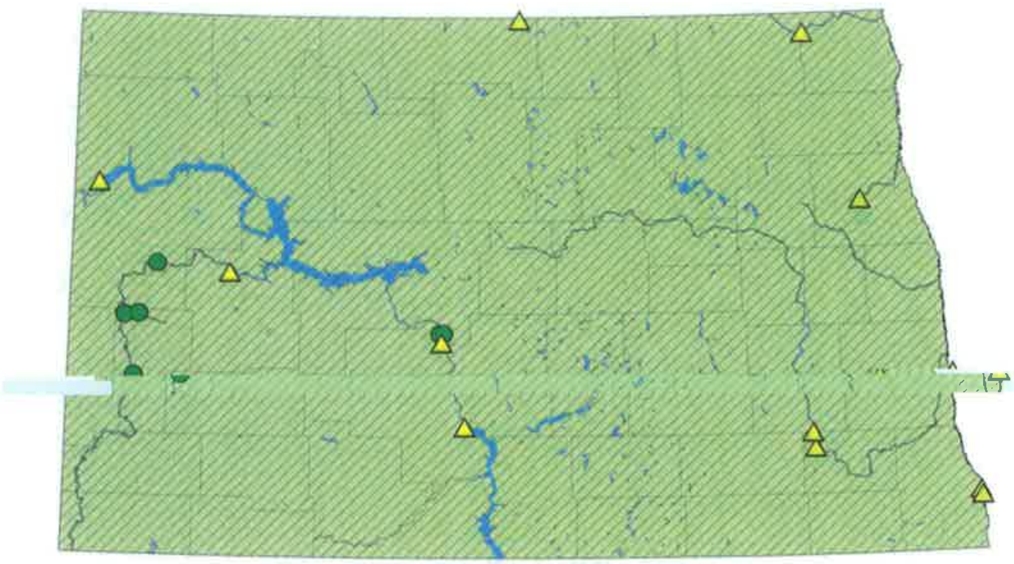
Status and Conservation

The U. S. Forest Service lists the Townsend's big-eared bat as a Sensitive Species, and the states of South Dakota and Wyoming list it as a species of concern. *In 2014, North Dakota Game and Fish Department listed this species as Level I Conservation Priority.* Two eastern subspecies are listed by the U.S. Fish and Wildlife Service as Endangered.

Until 2009, the species was not known to occur in North Dakota, thus it has not received conservation attention. The recent southwestern North Dakota observation warrants continued monitoring to determine if this bat is a regular resident of the state.

Selected References
(Cockrum & Cross, 1964; Kunz & Martin, 1982; Jones, 1983; Higgins, 2000; Sherwin et al., 2000; Foresman, 2001; Schmidt, 2003; Sherwin et al., 2003; Lausen & Barclay, 2006)

VIII.B. Big brown bat, *Eptesicus fuscus*



Description
Except for its much larger size, the big brown bat superficially resembles the genus *Myotis* in North Dakota. It is the second largest bat in the region, averaging over 20 grams; only the hoary bat is larger. The dorsal fur is uniformly brown, becoming lighter on the underside. The wing and tail membranes are nearly naked. The ears are short and rounded, with a broad tragus. Average standard body measurements are: Total Length - 121 mm, Tail Length - 46 mm, Hind Foot - 11 mm, Ear -18 mm.

Distribution
This widely distributed species occurs over much of North America, from southern Canada, through all of the United States and much of Mexico, into Central America and northern South America. In North Dakota, it has been recorded throughout the state.

Habitat
The big brown bat is a habitat generalist, foraging over both land and water, in both rural and urban environments. Its use of a particular habitat seems more associated with insect abundance than a specific habitat setting. In some areas, it appears to be more abundant in open deciduous forest having a closed canopy.

Following hibernation, females form maternity colonies, usually of 25 to 75 individuals, while males are generally solitary. Some males may roost in small groups or with females. Maternity colonies occur mainly in buildings, but also in hollow trees and rock crevices. When they occur in buildings, relatively tall, older structures having temperatures 8 to 10° above ambient are preferred. When roosting in rock crevices, preferred sites have small openings and vertical orientation, and are inaccessible from above. Large trees and snags also provide sites for maternity roosts. Winter hibernation habitat is also diverse, including caves, storm sewers and buildings.

Ecology and Behavior

The big brown bat forages over a wide variety of habitats, ranging out 1 to 2 km from the roost. Foraging begins shortly after sunset and continues throughout the night. Small beetles dominate the diet, and include a number of significant agricultural pests. Flies, moths, bugs, wasps, and other insects are also taken, but these are considered to be minor foods. *These bats are frequently abundant in suburban areas with mixed agricultural use and are commonly found roosting in man-made structures (Kurta & Baker, 1982; Brigham, 1991).*

Dispersal from summer roosts may begin as early as August, but bats do not arrive at their hibernacula before November. While many individuals likely migrate during the winter months to Minnesota and *South Dakota, some proportion of the summer population remains in the state, inhabiting hibernacula in the badlands of western North Dakota. It is also likely that some populations within the state overwinter in buildings, although further research is necessary to confirm this pattern.*

These bats are capable of hibernating under cooler, drier conditions than other temperate species, such as the little brown bat. They tend to hibernate singly, or in small clusters, wedging themselves into small crevices or under rocks in the hibernaculum.

Significant factors causing mortality in big brown bats include in- sufficient fat storage prior to hibernation, weather, accidents, and predation. Important predators include grackles, kestrels, owls, weasels, cats and rats. They may also be vulnerable to accumulation of insecticides in their tissues sufficient to cause death. Big brown bats can carry rabies, St. Louis encephalitis, and Histoplasma. As with other members of the family, big brown bats are relatively long-lived, the record being 19 years.

Reproduction

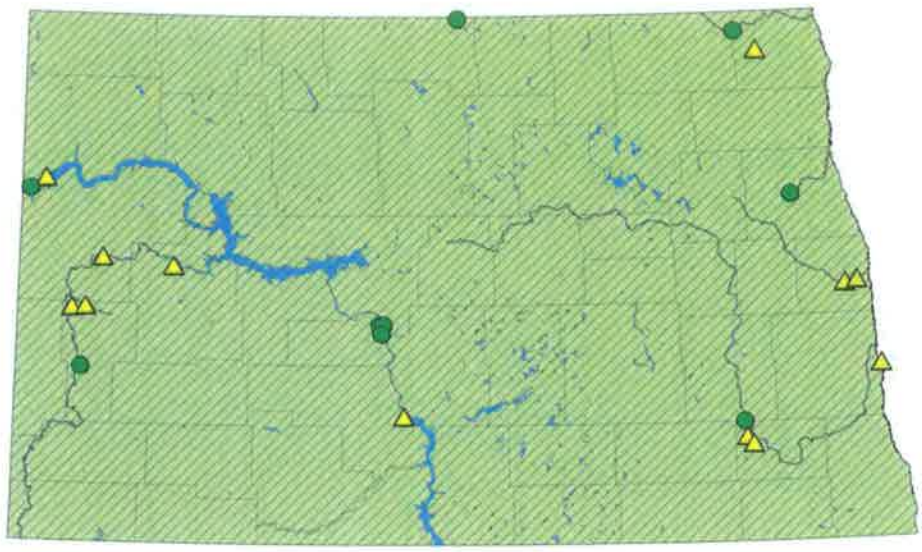
Copulation occurs any time from September to March, followed by delayed fertilization upon arousal from hibernation. Following a 60-day gestation, a single young is born between May and July. As with a number of other bat species, the young fledge at 18 to 35 days, usually prior to weaning. Adult females cease lactating between 32 and 40 days post-partum. Young males tend to become sexually mature by Fall; however, not all young females breed during their first year.

Status and Conservation

The big brown bat is common throughout North Dakota. This species is not limited by habitat type, provided adequate roost sites and insect prey are available. It has been cited as somewhat unique among bats for its hard-bodied insect diet, which includes many important agricultural pests. Protection and enhancement of roost sites, including man-made structures, along with limitation of pesticide use are important practices in maintaining the species. *In 2014, North Dakota Game and Fish Department listed this species as Level I Conservation Priority.*

Selected References
(Bailey, 1926; Jones & Genoways, 1966; Svihovec, 1967; Genoways & Jones, 1972; Goehring, 1972; Hibbard, 1973; Kurta & Baker, 1982; Cryan et al., 2001; Lausen & Barclay, 2006)

VIII.C. Silver-haired bat, *Lasionycteris noctivagans*



Description
The silver-haired bat is relatively easily distinguished from other North Dakota bat species. It is a medium-sized bat, covered with dark brown to black fur with many hairs having silvery white tips, giving it a frosted appearance. Another distinguishing feature is fur covering the basal half of the interfemoral membrane. Average standard body measurements are: Total Length - 101 mm, Tail Length - 41 mm, Hind Foot - 9 mm, Ear - 15 mm.

Distribution
This bat is widely distributed over much of North America from southeastern Alaska and southern Canada throughout most of the United States, and as far south as northern Mexico. There are scattered records from most of North Dakota.

Habitat
The silver-haired bat, along with the red bat and hoary bat, has been referred to as a "tree bat." It prefers deciduous forested areas with nearby water bodies for foraging. *Over most of their distribution, silver-haired bats are considered migratory and are typically not found over-wintering in caves. However, migration in this species is poorly understood and may differ between populations (Cryan, 2003; McGuire et al., 2012). Availability of suitable hibernacula may be a key factor influencing migration in these bats and the boundaries of their winter distribution are poorly known (Izor, 1979). In North Dakota, multiple acoustic detections of these bats in the badlands during the winter months suggest that the species may be a winter resident. Given North Dakota's harsh winters, the most likely hibernacula for these bats would be the caves and crevices that are typical to the badlands geology.*

Ecology and Behavior

This is a solitary species, typically roosting in the tree canopy or under loose bark. It has also been known to roost in buildings, woodpiles, rock crevices, and occasionally in caves. In South Dakota's Black Hills, silver-haired bats prefer hollow dead snags of ponderosa pine for maternity colonies, where they roost in groups of 6-55. Winter hibernation roosts include hollow trees, loose tree bark, rock crevices, and caves. There is only one record of cave roosting for hibernation in Minnesota, and reports indicate that most silver-haired bats migrate out of that state for the winter.

Foraging occurs over water bodies and along forest edges. Feeding appears to be opportunistic, with a wide variety of insect prey taken. This bat becomes active later than other species and follows a bimodal pattern of activity, with peaks about *two to* three hours and seven hours after sunset.

Although this is a very common bat, its numbers tend to fluctuate greatly, both annually and geographically. It is relatively short-lived for a bat species, with an average longevity of about two years and a maximum longevity of 12 years. This relatively short longevity could be attributed to its solitary nature, the vulnerability of its summer and hibernation roosts to disturbance, predation, and the vagaries of climate. Recent research indicates that this species, along with other "tree bats," is especially vulnerable to mortality associated with wind energy facilities.

Reproduction

The reproductive pattern follows other temperate members of the family. Mating is thought to occur in the Fall, with storage of sperm in the female during the hibernation period. Ovulation occurs during April and May, followed by fertilization (delayed fertilization). Gestation is 50 to 60 days, followed by parturition in June and July. Females usually give birth to two young, each weighing about 2 grams. At North Dakota's latitude, young bats have been observed to begin flying by late July.

Status and Conservation

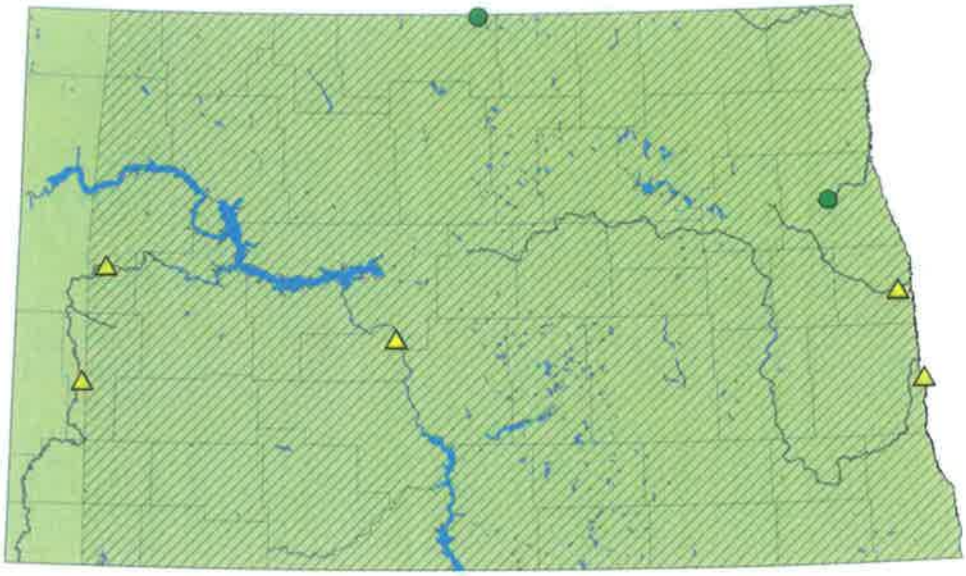
Although its numbers can fluctuate greatly from year to year, the silver-haired bat is one of the more common species in North Dakota. Reports of the species seem to be most frequent during spring and fall migration.

Deforestation, resulting in loss of roosting habitat, and insecticide use are probably the most significant factors limiting this bat in North Dakota. Practices protecting older forests, including dead and dying trees, would enhance roosting habitat for the species. Research indicates the likely need for mitigation efforts to minimize mortality from barotrauma in the vicinity of wind energy facilities.

Selected References

(Bailey, 1926; Jones, 1973; Izor, 1979; Hazard, 1982; Kunz, 1982; Jones, 1983; Mattson et al., 1996; Cryan, 2003; Arnett et al., 2008; Baerwald et al., 2008; McGuire et al., 2012)

VIII.D. Red bat, *Lasiurus borealis*



Description

This medium-size bat (8 to 14 g) is one of the most easily identified of North Dakota's bats. It has a distinctive reddish coloration washed with white hairs, and a buff-colored patch on the shoulder. The inter-femoral membrane is entirely covered with fm; along with the basal portions of the wings. The ears are short and rounded, and have a tri-angular tragus. Average standard body measurements are: Total Length - 113 mm, Tail Length - 48 mm, Hind Foot - 9 mm, Ear - 12 mm.

Distribution

The red bat is widely distributed from southern Canada south throughout much of the United States (except the mountainous West), Mexico, Central America, and South America as far south as Argentina and Chile. In North Dakota, there are records from throughout the state, and there are numerous records from neighboring Minnesota. It is more sparsely distributed in South Dakota, and is believed to be the least common bat species in the Black Hills. There are only two reports of specimens collected in Montana, where it is considered rare.

Habitat

This bat roosts mainly in forest edges near water. These bats will roost at varying heights from low shrubs to the upper canopy. American elm seems to be a preferred roosting tree, but a wide variety of other deciduous trees and shrubs are used as well. Red bats seem to prefer heavy shade and cover from above and to all sides, but not below. Such sites are thought to not only provide concealment from predators, but also a more stable thermal environment.

Little is known about winter habitat requirements of the red bat. They have been known to swarm around cave entrances with other species, but do not usually undergo hibernation in these sites. Winter habitat seems to consist of forested areas in southern states having daytime temperatures warm enough to allow occasional foraging.

Ecology and Behavior
The red bat is a solitary species, roosting singly or in family groups. Although these bats are not colonial, there seems to be some vocal communication around favored roosting sites. Rather than utilizing loose bark and cavities, as in other tree-roosting bats, this bat hangs from twigs and leaf petioles and blends in well with the foliage.

As with other solitary bats, little is known of the red bat's migratory patterns. The earliest known arrival in the northern Great Plains is mid-April. This probably coincides with emergence of primary insect prey. Departure dates are unknown, but are likely in September or October. Museum records indicate that the species winters in the south-eastern United States.

Nightly foraging begins shortly after sunset, with a secondary peak occurring just before sunrise. They do not range over long distances, but rather forage over a favored area within about 1,000 meters from the roost. These bats feed on a wide variety of larger insects, but seem to prefer moths.

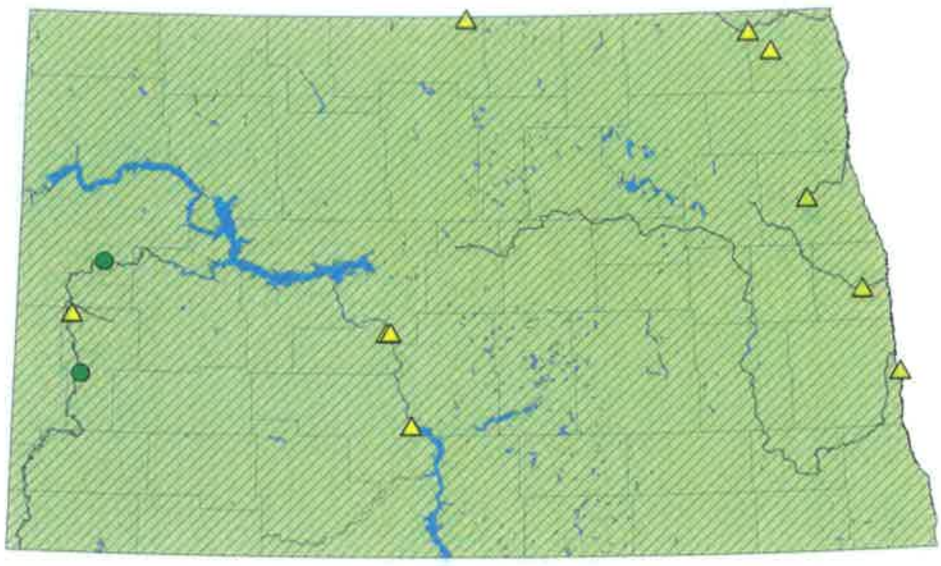
The red bat, along with other tree bats, is subject to different patterns of mortality than the colonial species. A variety of avian predators and some mammals are known to take red bats. The blue jay is probably the most important predator on these bats, especially their young. This species has one of the higher incidences of rabies among North American bats. As with the other "tree bats," red bats appear to be susceptible to mortality from barotrauma associated with wind turbines.

Reproduction
As with other temperate zone members of the family, this bat breeds in late summer and fall and stores sperm over winter (delayed fertilization). Following an 80- to 90-day gestation, parturition occurs during mid- to late June. The litter size ranges from one to five, averaging about three. This is the highest known litter size for North American bats. Young are weaned at 4 to 6 weeks, and achieve flight status between 3 and 6 weeks.

Status and Conservation
The red bat is considered a common summer resident throughout North Dakota, especially in wooded areas. As with other tree bats, this species requires woodland for roosting, and generally prefers water areas having large numbers of flying insects. As an insect-eating species, it is believed to be vulnerable to insecticide use. As a potential rabies carrier, human contact with the species should be avoided.

Selected References
(Bailey, 1926; Hazard, 1982; Shump & Shump, 1982; Jones, 1983; Higgins, 2000; Foresman, 2001; Cryan, 2003; Arnett et al., 2008; Baerwald et al., 2008)

VIII.E. Hoary bat, *Lasiurus cinereus*



Description
The hoary bat is easily identified by its large size, coloration, and pelage. Weighing over 20 grams, its fur is a mixture of dark brown and grayish with hairs tipped with white, giving it a frosted appearance. There is a white patch on the shoulder and a yellowish patch on the throat. Like the smaller red bat, and unlike the smaller silver-haired bat, the interfemoral membrane is completely furred. The ears are short and rounded, and have a short, blunt tragus. Average standard body measurements are: Total Length - 139 mm, Tail Length - 55 mm, Hind Foot - 13 mm, Ear - 19 mm.

Distribution
This is our most widely distributed bat, ranging from the tree line in Canada south to Argentina and Chile. It occurs in all of the lower 48 states, and some of the Caribbean and north Atlantic islands. In North Dakota, there have been widely scattered records over the state.

Habitat
Tree foliage provides the primary roosting sites for the hoary bat, but they have also been observed in tree cavities, squirrel nests, and on the sides of buildings. They tend to prefer to roost at woodland edges, at least 3 meters above the ground, and well covered from above by foliage.

Ecology and Behavior
Like the red bat, the hoary bat is solitary, mainly roosting along the edges of open woodlands. Their roosting sites among tree foliage are well concealed from above, presumably protection from avian predation.

The species appears to exhibit sexual differentiation in migration patterns and summer range. Museum records indicate that hoary bats mainly winter in California, Mexico, and the southeastern states. However, during the warm months males are predominant in the western states, females in the east. Both sexes occur in the Plains states, including North Dakota. Some bats may winter in relatively northern states, going into hibernation, while those that migrate further south remain relatively active during the colder months.

Nightly foraging of these bats peaks around 3 to 4 hours after sunset. In wintering areas with a relatively warm climate, they may be active during the day, feeding on insects. Though solitary while roosting, they are known to forage in groups for insects, and also may associate with other bat species while foraging. They seem to prefer moths, but a variety of other larger insects are also taken.

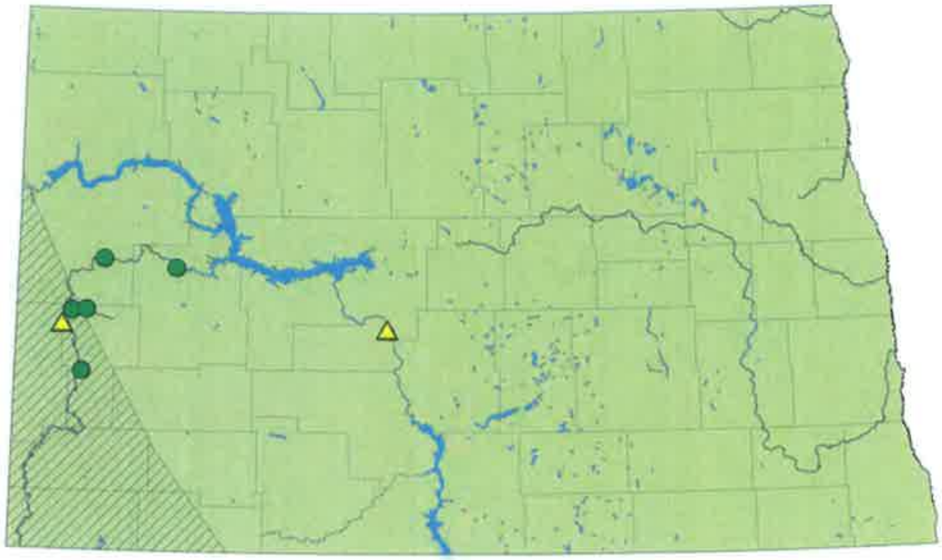
Little is known about mortality in hoary bats, but predation by hawks and owls has been suspected. High winds have been known to dislodge females with attached young, subjecting them to potential predation on the ground. Impalement on barbed wire has also been noted. Like the other "tree bats," hoary bats appear to be especially vulnerable to wind turbine fatalities. Hoary bats have had a relatively high incidence of rabies, up to 17 to 25%.

Reproduction
Copulation may occur during fall migration, followed by delayed fertilization characteristic of other bat species in the family. Most reported parturition dates range from mid-June to early July, following a 90-day gestation. However, one South Dakota report estimated a parturition date of May 15. Typical litter size is two but can run from one to four. Lactating females have been observed in the northern Plains states from mid-July through the first week of August. The young fledge at about 3 weeks of age, but are not weaned until 7 weeks. They have a relatively slow rate of growth, which may be compensated for by migration to warmer climates, which facilitate winter foraging.

Status and Conservation
Although not often observed, this bat is regarded as relatively common in North Dakota. Wooded areas having an abundance of flying insects comprise essential habitat for this tree bat. As with other North Dakota bats, it is vulnerable to indiscriminate insecticide use. As a carrier of rabies, human contact should be avoided.

Selected References
(Bailey, 1926; Hibbard, 1963; Hibbard, 1973; Shump & Shump, 1982; Jones, 1983; Mullican, 1999; Foresman, 2001; Cryan, 2003; Arnett et al., 2008; Baerwald et al., 2008)

VIII.F. Western small-footed myotis, *Myotis ciliolabrum*



Description
This bat has undergone a series of taxonomic changes in recent years. It was originally known as *M. subulatus*, then *M leibii,* and finally separated into two distinct species, the eastern small-footed myotis (*M. leibii*) and the western small-footed myotis (*M. ciliolabrum*). Weighing less than 8 grams, it is North Dakota's smallest bat. The species can be distinguished from other related bats by its coppery coat coloration blackish mask, ears and membranes, and small feet (<9 mm) and forearm (<34 mm). Standard body measurements are: Total Length - 87 mm, Tail Length - 38 mm, Hind Foot - 8 mm, Ear - 14 mm.

Distribution
The western small-footed myotis occurs throughout much of western North America from central British Columbia, Alberta, and Saskatchewan, south well into Mexico, and east to the southwestern corner of North Dakota, the southwestern half of South Dakota, and western Nebraska and Kansas. In North Dakota, all records have been from Badlands areas of Golden Valley, Slope, and Bowman counties.

Habitat
Preferred habitats appear to be semiarid and arid badlands and desert regions, but bats have also been taken near water bodies and deciduous and coniferous forests. North Dakota records have been from the rugged Badlands adjacent to the Little Missouri River, and also from trees and buildings. Summer roosts are typically in rocky crevices, holes in the sides of buttes, under tree bark, or in buildings. Winter hibernation is in caves and mine shafts.

Ecology and Behavior
These bats probably arrive in North Dakota during April and May, establishing roosts and small maternal colonies. Unlike the little brown bat, this bat is relatively solitary, roosting singly or in very small groups. Nightly foraging begins around dusk, and peaks from 10 p.m. to 2 a.m. The western small-footed myotis feeds on a variety of night-flying insects, especially moths.

During the Fall, these and other North Dakota bats may migrate to caves and mine shafts in the Black Hills of South Dakota for hibernation. Recent records of hibernation in southeastern Alberta habitats similar to the North Dakota Badlands raise the possibility of overwintering in the state, *and recent work has documented this species as a winter resident of North Dakota*. This species does not aggregate in large groups. They usually hibernate singly or in clusters of two; less than 12 bats are normally found in a cave. *The single bat tracked during winter months in North Dakota inhabited two small rock crevices.*

Because of its solitary nature, little is known of the population ecology of this bat. Causes of mortality are probably similar to those of the little brown bat, i.e. limited predation, accidents, and human disturbance including pesticide use. As with other bats, it appears to be quite long-lived, the record for a known-age individual being 12 years.

Reproduction
Like the little brown bat, breeding takes place in the Fall, just prior to hibernation, with ovulation and fertilization occurring upon arousal in the spring (delayed fertilization). A single young is born during June - July. North Dakota collection records document pregnant females between June 17 and 29.
Status and Conservation
Because of the solitary nature of the species and few collection records, this bat might appear to be relatively uncommon in southwestern North Dakota. However, surveys indicate that it may be the commonest member of the genus in the Badlands along the Little Missouri River. *North Dakota Game and Fish Department lists this species as Level III Conservation Priority.*

These bats do not aggregate in large enough numbers to be considered to be pests. Neither have they been documented as carriers of rabies or other diseases. Because of its occurrence in a very limited potion of North Dakota, the species merits careful scrutiny and has been designated a species of conservation priority in the state.

Selected References
(Jones & Stanley, 1962; Jones & Genoways, 1966; Svihovec, 1967; Genoways & Jones, 1972; Seabloom et al., 1978; Jones, 1983; Holloway & Barclay, 2001; Lausen & Barclay, 2006)

VIII.G. Long-eared myotis, *Myotis evotis*

Description
As the common name implies, the ears of this bat distinguishes it from other myotis bats in North Dakota. When laid forward, they extend >5 mm beyond the tip of the nose. A minute fringe of hairs along the edge of the tail membrane (uropatagium) also aids in identification of the species. Its brownish coat color, and black ears and wing membranes are similar to most other members of the genus. Average standard body measurements are: Total Length - 86 mm, Tail Length - 44 mm, Hind Foot - 9 mm, Ear - 18 mm.

Distribution
The long-eared myotis occurs from central British Columbia, Alberta, and southwestern Saskatchewan through much of the western United States, south into Baja California, and as far East as extreme western North Dakota and South Dakota. In North Dakota, there are records from Grinnell in southeastern Williams County, the Killdeer Mountains of Dunn County, Billings County along the Little Missouri River, and Slope County.

Habitat
This bat appears to be primarily a forest dweller. It has been reported in ponderosa pine woodlands of the Badlands areas of the Dakotas and southeastern Montana, although it has also been reported in agricultural areas, sagebrush and shrublands. Summer roosts include buildings, hollow trees, rock crevices, or other protected sites. Foraging frequently occurs near water areas where there are abundant insects. As with other myotis bats, winter hibernation probably occurs in caves and mine shafts.

Ecology and Behavior

The spring arrival of this relatively solitary bat in North Dakota is unknown, but probably coincides with the emergence of flying insects. Females establish small maternity colonies in buildings or other protected places, while males and non-reproductive females roost singly or in small groups.

Long-eared myotis forage later than do other myotis bats, frequently after dark, and they continue well past midnight. A variety of nocturnal insects are taken, primarily moths.

Practically nothing is known of hibernation sites or behavior of this species, but these western North Dakota bats may migrate to hibernacula in caves and mine shafts in the South Dakota Black Hills. Recent observations of hibernation in southeastern Alberta raise the possibility of the species overwintering in the North Dakota Badlands. *This species was captured in mid-September in western North Dakota, although it was unclear if this was a late summer resident or a bat overwintering in the region.*

Reproduction

There are practically no data on reproduction in the long-eared myotis, but it probably follows a similar pattern to that exhibited by the little brown bat. In southeastern Montana, pregnant females were observed during early July.

Status and Conservation

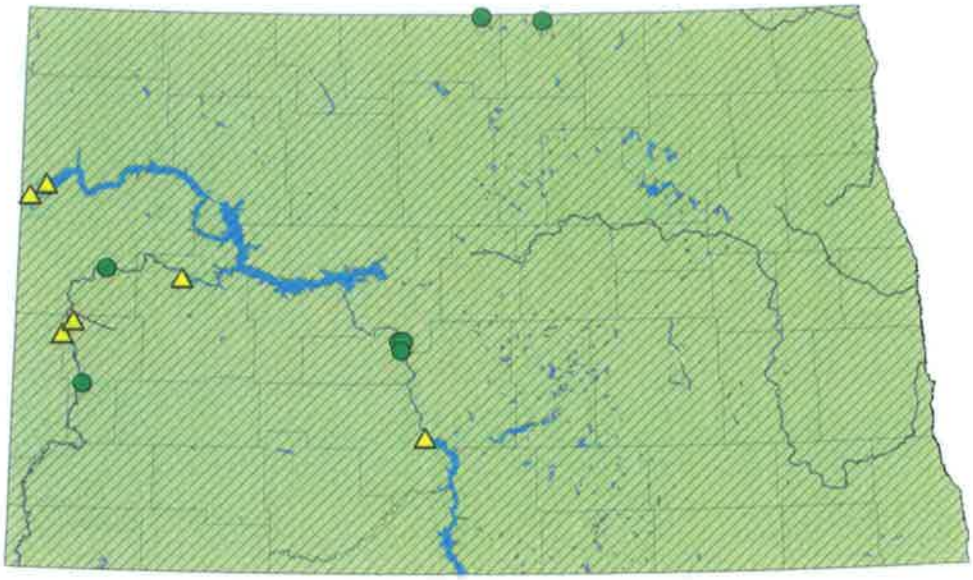
Based on reports and collections, the long-eared myotis is believed to be uncommon to rare in western North Dakota. It has been designated a Level III Species of Conservation Priority in the state.

Management efforts for this species at its eastern range limit should entail protection of forest land in southwestern North Dakota, especially ponderosa pine and juniper woodland. As with other bats, use of insecticides around these areas and nearby water bodies may prove harmful to the species.

Selected References

(Bailey, 1926; Jones & Genoways, 1966; Genoways & Jones, 1972; Jones, 1973; Manning & Jones, 1989; Higgins, 2000; Foresman, 2001; Dyke et al., 2004; Lausen & Barclay, 2006)

VIII.H. Little brown bat, *Myotis lucifugus*



Description
The little brown bat is one of the most common and well-known bats in North America. It is a small bat, coppery brown above, lighter below, and has a dark spot on the shoulder. The wings and interfemoral membrane (uropatagium) on the tail are naked. Average standard body measurements are: Total Length - 91 mm, Tail Length - 38 mm, Hind Foot - 10 mm, Ear - 15 mm. The tragus (a fleshy flap projecting up from the base of the ear) is short and blunt. This bat is quite similar to two other myotis occurring in North Dakota: the northern myotis and the long-legged myotis. Refer to those species' accounts and Appendix B for distinguishing characteristics.

Two subspecies of *M. lucifugus* occur in North Dakota: *M. l. lucifugus* in the eastern half of the state and *M. l. carissima* in the west. The eastern subspecies is darker and slightly smaller than that occurring in the west.

Distribution
This species is widely distributed throughout much of North America, occurring from the tree line in Alaska and Canada south well into Mexico. Little brown bats occur throughout North Dakota, wherever there are suitable roosts (usually buildings) and water. *While this species has not been physically captured during the winter months, it has been detected acoustically, indicating that it may hibernate in the caves and rock crevices of western North Dakota.*

Habitat
During the warm months, female little brown bats establish traditional roosts, which may be used for many years. These roosts are usually in buildings (attics, barns, sheds, etc.), but they may also be found in other protected sites such as under bridges or in

hollow trees. These concentrations of bats may number more than 1,000. Males and non-breeding females may assemble in small groups, or singly, in other protected sites such as under eaves of buildings or rock outcrops. Roosts are typically near water, such as lakes, streams or stock ponds, where there are large concentrations of flying insects.

The cold months of the year are spent in a hibernation site (hibernaculum), usually a cave or mine shaft. Requisite conditions in the hibernaculum are temperatures above freezing and high humidity (≥90%). The nearest known sites for North Dakota Myotis *lucifugus* are caves in central/southern Minnesota for eastern populations, and the Black Hills of South Dakota for bats living in the west.

Ecology and Behavior

Little brown bats probably arrive in North Dakota during April and May, coincident with the appearance of flying insects. They emerge from the roost, and commence their nightly foraging about dusk. Foraging continues for at least five hours, with bats flying at heights of 3 to 10 m in the vicinity of water bodies, woodland edges, streetlights, or wherever flying insects are likely to congregate. During foraging, these bats may consume prodigious numbers of flying insects, up to the equivalent of 1,200 mosquitoes per hour. Following the nightly foraging bout, they return to the roost, where they enter into a light torpor.

During September-October, little brown bats depart North Dakota, migrating to their winter hibernacula (*although see above for information about possible winter residency in the state)*. Banding returns indicate that they are capable of migrating several hundred miles. Upon arrival at the hibernaculum, they aggregate in large numbers, mate, and enter into hibernation. Hibernation is not continuous; bats arouse periodically during the winter months and engage in some movement in the hibernaculum.

The mating system of the little brown bat is random and promiscuous. There is no evidence of an organized social structure or territorial behavior. They are quite vocal and emit loud calls, especially when arousing from torpor. Bats of this family (Vespertilionidae) are known for their ability to echolocate using ultrasonic pulses. This echolocation is used in location of prey and in avoiding obstacles.

Little brown bats are very long-lived for their size. Average longevity is 2 to 3 years; 10 years is common, and the known record for an individual in the wild is over 31 years. Such longevities have been attributed to roosting in relatively secure places, seasonal exploitation of abundant food resources, and hibernation during the severe months. A wide variety of predators will take bats, but none seem significant in controlling populations. Accidents and human disturbance, including use of pesticides, appear to be important limiting factors. Drastic population declines in some areas have been attributed to pesticide use and human disturbance of hibernacula. Little brown bats can carry rabies, but the incidence is low (<1%), and there is no clear relationship to rabies in other species of wildlife.

Reproduction

Most little brown bats mate just prior to entering hibernation. In a process known as "delayed fertilization," sperm are stored as a semi-solid mass in the female during hibernation. Upon arousal in the spring, the female ovulates and fertilization occurs, followed by a 50- to 60-day gestation. A single young is born following arrival at the nursery roost. The young is able to cling to its mother even during flight. Growth is rapid, with weaning and capability of flight occurring at about 3 weeks.

Status and Conservation

The little brown bat is one of the most common bats in North Dakota, and may be found wherever there are suitable roosts and nearby water bodies. *In 2014, North Dakota Game and Fish Department listed this species as Level I Conservation Priority.*

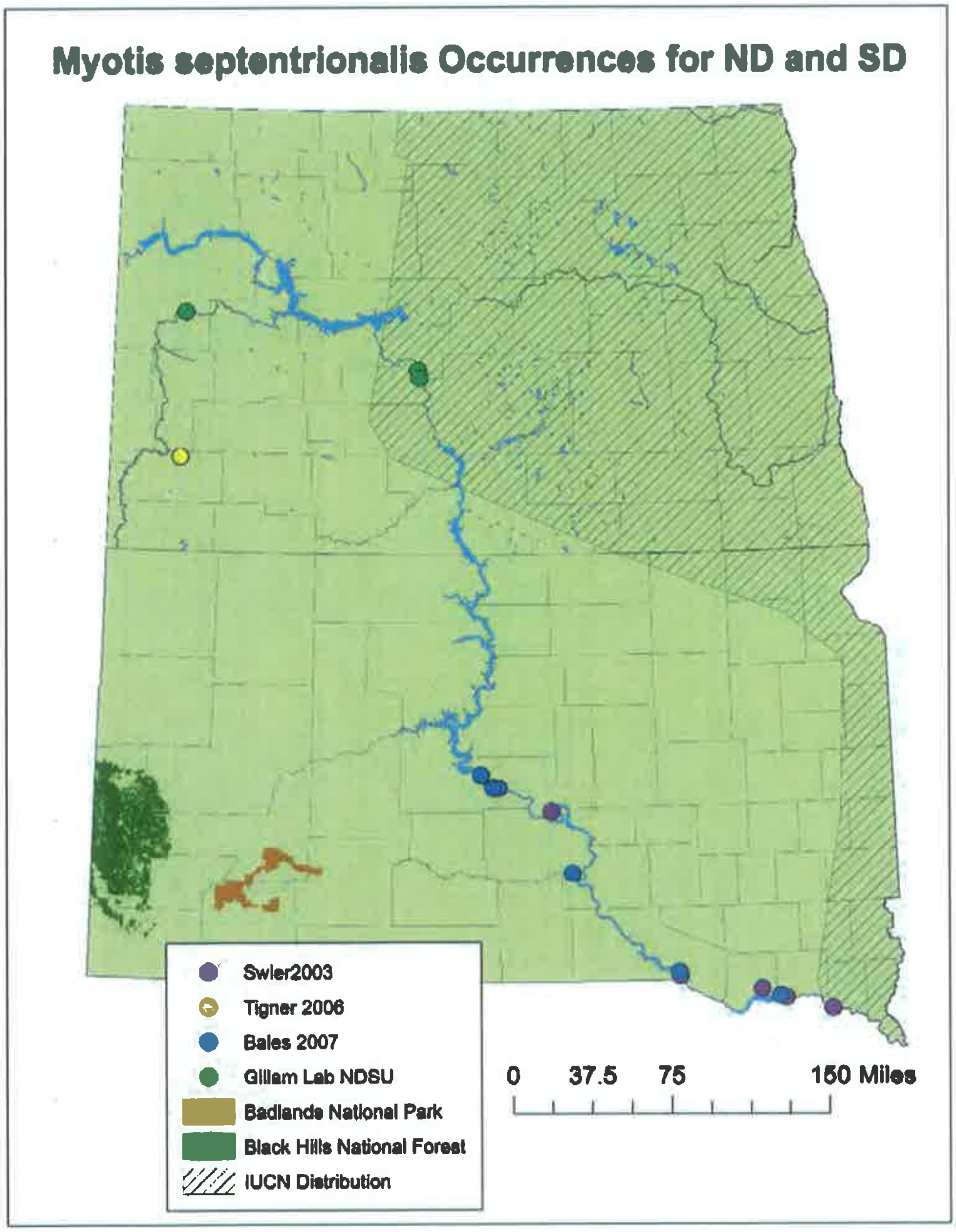
Occasionally, little brown bats establish roosts in occupied buildings, where they are regarded as pests because of their vocalizations, accumulation of excrement, and potential for disease transmission. Recommendations for mitigation or control in such situations are available through Bat Conservation International (http://www.batcon.org/).

Because of its potential for control of flying insect pests, this species is generally regarded as beneficial, and efforts have increased to encourage populations. In some areas, erection of bat houses has been successful in establishment of new roosts. Plans are available from Bat Conservation International and the North Dakota Game and Fish Department. The use of insecticides in the vicinity of known bat roosts should be discouraged.

Selected References

(Bailey, 1926; Jones & Genoways, 1966; Svihovec, 1967; Genoways & Jones, 1972; Seabloom et al., 1978; Fenton & Barclay, 1980; Hazard, 1982; Jones, 1983)

VIII.I. Northern myotis, *Myotis septentrionalis*



Description
Once known as a subspecies of Keen's little brown bat (*M. keenii*), this bat is now recognized as a separate species. A significant character of this small bat is its relatively long ears, tragus, and tail. The ears, when laid forward, extend just beyond the tip of the nose. They are not as long as those of the long-eared myotis, however, which extend up to 5 mm. Another character is its long, pointed tragus (10 to 12 mm), in

contrast to a shorter (7 to 8 mm), blunt tragus in the little brown bat. The tail is also longer than that of the little brown bat. Average standard body measurements are: Total Length - 94 mm, Tail Length - 40 mm, Hind Foot - 9 mm, Ear - 17 mm. Many of the distinguishing features of the myotis bats are relatively subtle, and care should be used in identification.

Distribution

This bat occurs over much of Canada east of British Columbia, and throughout most of the eastern half of the United States. There is a single record from northeastern Montana, and scattered records from South Dakota, primarily from the Badlands and Black Hills. *Swier (2003) and Bales (2007) found them to be common along the Missouri River in SD.* Minnesota records are from the eastern half of the state. Its North Dakota distribution is problematic. There is a marginal record from Fort Buford (McKenzie County), but it has not been known to be collected in the state in recent years. This bat is uncommon near its western range limits. *Tigner (2006) documented M. septentrionalis in the Little Missouri National Grasslands. A survey of bats in ND from 2009-2014 reports that captures of this species occurred almost exclusively in the Missouri River Valley, with some additional documentation in the Badlands of western North Dakota. Future research investigating how closely the distribution of this species is linked to the Missouri River and associated riparian areas would be valuable.*

Habitat

Summer habitat for the northern myotis appears to be wooded areas, where it frequently roosts singly or in small clusters behind the loose bark of over mature and decaying trees. It has also been known to roost behind shingles, in caves, and other protected sites. Small maternity colonies of less than 60 bats occur in similar sites, and also in buildings. As with other myotis bats, hibernation is in caves and mine shafts.

Ecology and Behavior

This relatively solitary bat forages intermittently through the night, but has two peaks, just after dusk and again before sunrise. It not only feeds on flying insects, but also gleans them off of surfaces such as tree bark and leaves. This opportunistic feeding allows a more varied diet, and utilization of prey that may be able to detect ultrasound in echolocation. A wide variety of insect prey is taken depending on location, season, and individual preferences.

As with other myotis bats, the nearest hibernacula for North Dakota summer residents are probably in central Minnesota and the Black Hills of South Dakota. These bats have been known to hibernate in Minnesota as far north as St. Cloud. Little is known of mortality or its causes in the northern myotis, but an extreme longevity of 18.5 years has been recorded.

Reproduction

Reproductive patterns appear to be similar to those of other myotis bats (see account of *M. lucifugus*). Copulations have been observed around the time of arrival at the hibernaculum in late summer or early fall. Delayed fertilization is believed to occur with parturition occurring from mid-May to July. Flying subadults have been captured as early as July.

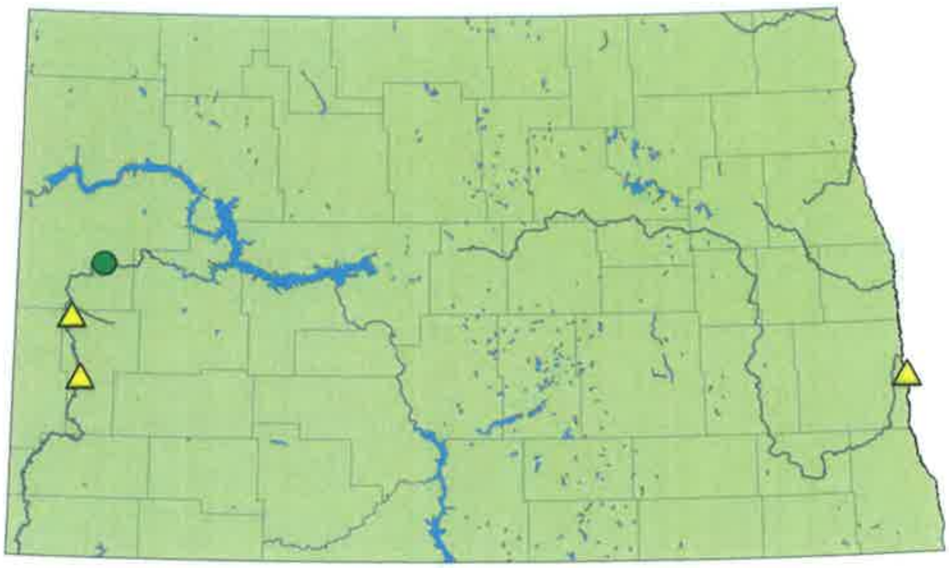
Status and Conservation

This species, also known as the northern long-eared bat, is currently being considered by the US Fish and Wildlife Service for addition to the Endangered Species List, primarily due to extensive losses in the eastern United States from white-nose syndrome. In 2014, North Dakota Game and Fish Department listed this species as Level I Conservation Priority. In Minnesota, this bat has been listed as a species of special concern. It is also on the "blue list" in Alberta as an at risk species. The paucity of records near its western range limits, together with the lack of any recent records from North Dakota suggests that it is a very rare bat in the state. As with other forest bats protection of woodlands and limitation on use of insecticides are recommended.

Selected References

(Hall & Kelson, 1981; Hazard, 1982; Jones, 1983; Caceres & Barclay, 2000; Cryan et al., 2000; Higgins, 2000; Foresman, 2001; Swier, 2003; Tigner et al., 2003; Swier, 2006; TIgner, 2006; Bales, 2007; Gillam & Barnhart, 2012; USFWS, 2015)

VIII.J. Fringed myotis, *Myotis thysanodes*



Description

The fringed myotis is very similar in appearance to Myotis evotis so care should be taken to properly distinguish between the species in the hand. M. thysanodes is slightly larger than M. evotis, except for the ears. The key distinguishing feature of the fringed myotis is well developed fringe hairs on the posterior edge of the uropatagium. Fur color ranges from yellow or straw colored to darker tones. The few individuals captured in North Dakota have been straw colored and slightly lighter colored ventrally. The calcar is not distinctly keeled. Body measurements are: weight approximately 9 grams; total length 43-59 mm; tail 34-45 mm; ears 16-20 mm; forearms 39-47 mm (O'Farrell & Studier, 1980).

Distribution

Myotis thysanodes is found in western North America, from British Columbia south through Mexico and east from the Pacific coast to western Colorado with a possibly isolated population in the Black Hills of South Dakota and Wyoming (Jones Jr & Genoways, 1967; O'Farrell & Studier, 1980). However individuals have also been documented in Montana (Hoffmann et al., 1969) and southwestern North Dakota (Unpublished data from Barnhart, Nelson and Gillam).

Habitat

These bats are most commonly associated with oak and pinyon woodlands but are also found in desert scrub, sagebrush grasslands habitats and riparian areas (O'Farrell & Studier, 1980; Weller & Zabel, 2001). Roosts have been found in caves and mines. In North Dakota, M. thysanodes likely roosts in rock outcroppings, crevices, or caves during the summer. In other areas, fringed myotis are known to migrate at least short distances to hibernacula in September, with spring migration in late April. As with many other North Dakota bats, hibernation within or migration out of the state is speculative.

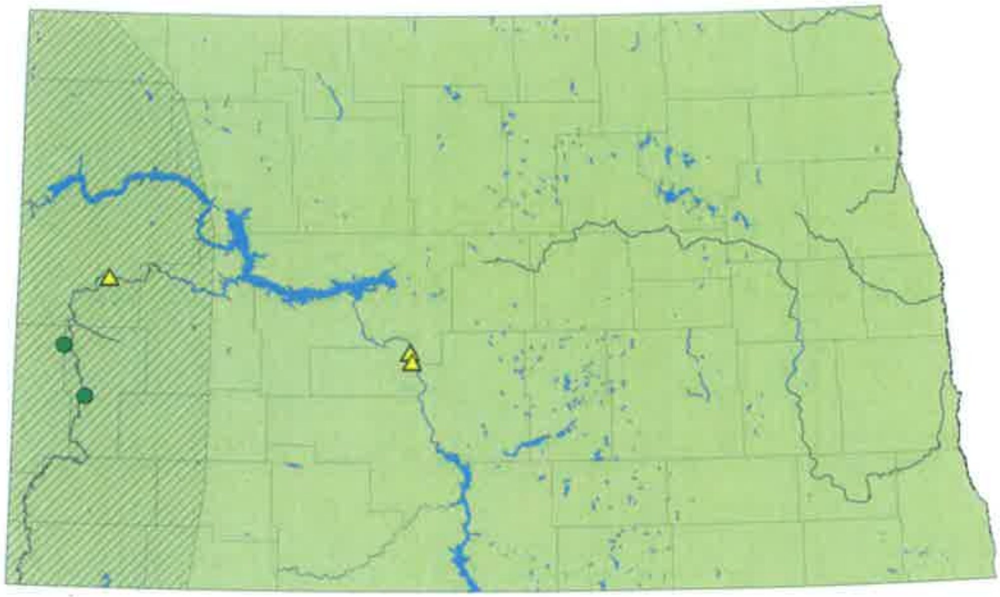
Ecology and Behavior
Although foraging data is lacking, M. thysanodes has been noted to forage primarily on beetles in the proximity of the vegetative canopy (O'Farrell & Studier, 1980). In North Dakota, these bats have typically been captured low over small streams in sagebrush grasslands adjacent to riparian habitat. *M. thysanodes* is typically active within the first few hours after sunset.

Reproduction
The reproductive cycle for fringed myotis is poorly known through much of the species distribution although there seems to be little variation in the timing of reproduction. In northeastern New Mexico, ovulation, fertilization and implantation occurred from late April to mid-May, with a gestation period of 50 to 60 days and parturition starting in late June (O'Farrell & Studier, 1980).

Status and Conservation
The paucity of occurrences of M. thysanodes suggest that these bats are rare in North Dakota with a distribution likely limited to the badlands region. This species seems easily disturbed by human presence (O'Farrell & Studier, 1980). Management practices should include further ecological studies and conservation of habitat.

Selected References
(Jones & Genoways, 1966; Jones Jr & Genoways, 1967; Hoffmann et al., 1969; O'Farrell & Studier, 1980; Weller & Zabel, 2001)

VIII.K. Long-legged myotis, *Myotis volans*



Description
The long-legged myotis is of medium size when compared to its close relatives. Overall, it is very similar in appearance to the little brown bat. As the common name implies, it has a longer tibia than other myotis bats, but reliable identification requires careful examination of other characters as well. Other identifying features include its short, rounded ears, which do not reach the tip of the nose when laid forward, a keeled calcar extending about to a line connecting the knee and elbow. Average standard body measurements are: Total Length - 97 mm, Tail Length - 44 mm, Hind Foot - 9 mm, Ear - 14 mm.

Distribution
This is a western North American bat, occurring from southeastern Alaska to central Mexico. Its eastern distributional limits include the western Dakotas and Nebraska. There are only two North Dakota records. The first North Dakota record was a bat collected in 1965 along the Little Missouri River in Billings County, near Medora. The other records are from the vicinity of Granville in McHenry County. These two reports constitute the most northeasterly records of the species.

Habitat
Coniferous forests appear to comprise the primary habitat of the long-legged myotis, but they have also been reported along riparian woodland, grasslands, and badlands. The two North Dakota records are from cottonwood river bottoms and from a house in agricultural land. Roosts include loose tree bark, rock crevices, and buildings. Typically, roosts comprise only a few bats, but maternity roosts can be quite large, up to 180. One of the North Dakota records is from a maternity colony in an attic comprising about 60 individuals. Hibernation is in caves and mine shafts; hence, as with other myotis bats,

this species undergoes fall migration from North Dakota, presumably to the Black Hills of South Dakota.

Ecology and Behavior
This bat is active throughout the night, but appears to have an activity peak several hours after sunset. A large variety of soft-bodied flying insects are taken during foraging. As with other myotis bats, the long-legged myotis is quite long-lived, the record being 21 years.

Reproduction
The reproductive strategy of this bat is similar to its close relatives, i.e., fall breeding, delayed fertilization, and parturition during spring and summer. Pregnant females have been captured from mid-April to mid-August. Females are thought to reach sexual maturity during their first year, but males may be more variable.

Status and Conservation
With only two known observations in North Dakota, the long-legged myotis must be considered to be rare to uncommon. The North Dakota Game and Fish Department has designated the long-legged myotis as a Level III Species of Conservation Priority. Additional surveys in the state together with careful re-examination of existing collections may result in reassessment of its status.

Management strategies for this species, as well as its relatives, entails protection of conifer forests and riparian woodland in the western part of the state. Insecticide use in such areas should be limited.

Selected References
(Jones & Genoways, 1966; Genoways, 1967; Genoways & Jones, 1972; Jones, 1983; Warner & Czaplewski, 1984; Higgins, 2000; Foresman, 2001)

IX. APPENDIX B. FIELD KEY FOR IDENTIFICATION OF BATS IN HAND IN ND

The following key and associated text is reproduced, with permission, from the South Dakota Game, Fish and Parks Department. Originally, the Order Chiroptera key was included in “Wild Mammals of South Dakota” by Kenneth Higgins, Eileen Dowd Stukel, Judyann Goulet, and Douglas Backlund copyrighted in 2000.

A key can be used to help identify species. Some mammal species are easily identified without the use of a key, while others are difficult to identify even with the use of a key. Chiroptera is among the more difficult species to identify. Keys help to identify a mammal, in particular bats, to genus and often species. If identification is questionable, do not hesitate to seek assistance from professional mammalogists in the various wildlife agencies and universities.

To use the keys, read the choices in descriptions of the same number and choose the best result. Go to the number that is indicated at the end of the chosen alternative and continue moving through the key until a final choice is indicated. However, a key seldom works for every specimen because each species varies in size, color, and other characteristics. It is best to have several specimens on hand for comparison. Characteristics in these keys apply to only adult animals.

ORDER CHIROPTERA

1. Large bat, forearm length usually greater than 50 mm (1.97 in.). Fur is yellowish brown to mahogany and “frosted” with silver; rounded ears edged in black------------------------*Hoary Bat*

1. Forearm length usually less than 50 mm (1.97 in.). Fur not as described above---------*Go to 2*

2. Forearm length usually 41-48 mm (1.61-1.89 in.). Ears large, length greater than 25 mm (0.98 in.)--*Townsend's Big-eared Bat*

2. Ears less than 25 mm (0.98 in.) length--*Go to 3*

3. Large bat, forearm length usually less then 50 mm (1.97 in.) but greater than 41 mm (1.61 in.). Fur is brown, ears less than 20 mm length (0.79 in.), total length greater than 110 mm (4.33 in.); blunt tragus; broad head and snout--*Big Brown Bat*

3. Forearm length usually less than 45 mm (1.77 in.), total length less than 110 mm (4.33 in) --*Go to 4*

4. Fur black to dark black-brown, “frosted” with silver or white----------------------*Silver-haired Bat*

4. Fur not as described above---*Go to 5*

5. Fur bright reddish orange to chestnut, no “frosted” fur---*Red Bat*
5. Fur not as described above---*Go to 6*

6. Forearm usually less than 34 mm (1.34 in.), black facial mask, ears, and flight membranes contrasting with yellowish-brown to golden-brown fur------------------*Western Small-footed Myotis*

6. Forearm usually greater then 34 mm (1.34 in.)---*Go to 7*

7. Ears usually 18 mm (0.71 in.) or more in length---*Go to 8*

7. Ears usually less than 18 mm (0.71 in.) in length--*Go to 9*

8. Ears usually 22-25 mm (0.87-0.98 in.) in length, ears extend 5 mm (0.2 in.) or more beyond nose tip when laid forward, forearm usually less than 39.5 mm (1.56 in.) but may range from 36 41 mm (1.42-1.61 in.); indistinct fringe of minute hairs along edge of uropatagium--*Long-eared Myotis*

8. Ears usually 18-20 mm (0.71-0.79 in.) in length but may range from 16-20 mm (0.63-0.79 in.), forearm usually more than 39.5 mm (1.56 in.); distinct fringe of small, stiff hairs along the edge of the uropatagium--*Fringe-tailed Myotis*

9. Ear length usually 17-18 mm (0.67-0.71 in.) but may range up to 19 mm (0.75 in.); when ear laid forward extending beyond tip of nose (forearm length ranges from 32-39 mm or 1.26-1.54 in.)---*Northern Myotis*

9. Ear length usually less than 16 mm (0.63 in.); when ear laid forward, extending to end of nose but not much past end of nose---*Go to 10*

10 Ears usually 13-15 mm (0.51-0.59 in.), calcar keeled--------------------------*Long-legged Myotis*

10. Ears usually 14-15 mm (0.55-0.59 in.), calcar not keeled--------------------------*Little Brown Bat*

X. APPENDIX C. ACOUSTIC PARAMETERS OF BAT SPECIES IN ND

The following information is based on five years of acoustic data collected in North Dakota by the authors. Table 1 includes acoustic parameters of calls recorded from bats that were captured via mistnets and released with a light tag, which facilitates tracking of the animal as they fly in the release area. In other words, these calls were collected from bats in which the species identity was confirmed with a taxonomic key.

Table 2 includes the known calls from Table 1, plus those collected from acoustic monitoring in which the species was not captured; rather, species identification was conducted using Sonobat 3. Only calls given a 95% classification quality value or higher, which indicates high confidence in the accuracy of the assigned species, were included. Calls for both tables are collected from throughout the state of North Dakota.

Table 1. Parameters of calls collected from individuals that were identified in hand (2009-2011). Species are only included if we had high quality light-tagged recordings. N refers to the number of individuals of each species.

Species	N	Dur (ms)	Fc (kHz)	MaxF (kHz)	MinF (kHz)	BW (kHz)	PeakF (kHz)
Epfu	13	4.7	27.9	48.8	26.4	22.4	31.8
Lano	22	7.1	26.5	43.8	25.5	18.3	28.3
Myci	4	3.0	42.2	99.3	38.7	60.6	47.5
Myev	6	2.6	34.2	70.4	28.1	42.3	40.5
Mylu	55	3.9	38.6	78.2	34.4	43.7	44.3
Myse	8	4.8	34.6	77.1	30.7	46.5	40.3

Table 2. Parameters of calls from from free-flying unknown individuals that were assigned a 95% classification quality value or higher by Sonobat 3 (2009-2014). N refers to the number of call sequences of each species. Data includes average ± SD.

Species	N	Dur (ms)	Fc (kHz)
Coto	39	4.52 ± 2.20	26.83 ± 4.58
Epfu	3,536	7.47 ± 2.81	28.51 ± 1.66
Labo	68	7.98 ± 0.93	38.56 ± 1.51
Laci	1,866	12.07 ± 4.55	21.34 ± 2.25
Lano	7,562	10.62 ± 3.30	26.83 ± 1.05
Myci	978	3.34 ± 0.60	42.23 ± 1.2
Myev	345	3.01 ± 0.61	34.48 ± 1.94
Mylu	3,082	5.30 ± 1.05	38.87 ± 1.37
Myse	2	3.29	40.93
Myth	5	3.44 ± 0.93	23.68 ± 3.15
Myvo	8	4.45 ± 1.85	39.29 ± 6.36

XI. APPENDIX D: USFWS DISINFECTION PROTOCOL FOR BAT FIELD STUDIES

National White-Nose Syndrome Decontamination Protocol - Version 06.25.2012

The fungus *Geomyces destructans* (*G.d.*) is the cause of white-nose syndrome (WNS), a disease that has devastated populations of hibernating bats in eastern North America. Since its discovery in New York in 2007, WNS has spread rapidly through northeastern, mid-Atlantic, and Midwest states and eastern Canada. It continues to threaten bat populations across the continent. For the protection of bats and their habitats, comply with all current cave and mine closures, advisories, and regulations on the federal, state, tribal, and private lands you plan to visit. In the absence of cave and mine closure policy, or when planned activities involve close/direct contact with bats, their environments, and/or associated materials, the following decontamination procedures should be implemented to **reduce the risk of transmission** of the fungus to other bats and/or habitats. For the purposes of clarification, the use of the word "decontamination," or any similar root, in this document entails both the 1) cleaning and 2) treatment to disinfect exposed materials.

Under no circumstances should clothing, footwear, or equipment that was used in a confirmed or suspect WNS-affected state or region be used in a WNS-unaffected state or region. Some state/federal regulatory or land management agencies have supplemental documents[1] that provide additional requirements or exemptions on lands under their jurisdiction.

I. TREATMENTS TO REDUCE RISK OF TRANSFERRING *GEOMYCES DESTRUCTANS*[2]:

Applications/Products:

The most universally available option for treatment of submersible gear is:

Submersion in Hot Water: Effective at sustained temperatures ≥50°C (122°F) for 20 minutes

Secondary or non-submersible treatment options (for a minimum of 10 min.) include:

	PRODUCT	Clorox® (6% HOCl) Bleach	Lysol® IC Quaternary Disinfectant Cleaner	Professional Lysol® Antibacterial All-purpose Cleaner	Formula 409® Antibacterial All-Purpose Cleaner	Lysol® Disinfecting Wipes
APPROVED USES	**Hard, non-porous surfaces**	Yes	Yes	Yes	Yes	Yes
APPROVED USES	**Non-porous personal protective safety equipment**	No	Yes (headgear, goggles, rubber boots, etc.)	No	No	No
APPROVED USES	**All surfaces, including: porous clothing, fabric, cloth footwear, rubber boots**	Yes (Do not use on ropes, harnesses or fabric safety gear.)	No	No	No	No
DILUTION / TREATMENT (as per label)		Effective at 1:10 dilution (bleach : water)[3,4]	Effective at 1:128 dilution (1 ounce: 1 gallon of water)[3,4]	Effective at 1:128 dilution (1 ounce: 1 gallon of water)[3,4]	Effective at concentrations specified by label[3,4]	Effective at 0.28 % di-methyl benzyl ammonium chloride[3,4]

---

[1] To find applicable addenda and/or supplemental information, visit http://www.whitenosesyndrome.org/topics/decontamination

[2] The use of trade, firm, or corporation names in this protocol is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by state and/or federal agencies of any product or service to the exclusion of others identified in the protocol that may also be suitable for the specified use.

[3] Product guidelines should be consulted for compatibility of use with one another before using any decontamination product. Also, detergents and quaternary ammonium compounds (i.e. Lysol® IC Quaternary Disinfectant Cleaner) should not be mixed directly with bleach as this will inactivate the bleach and in some cases produce a toxic chlorine gas. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

[4] Final determination of suitability for any decontaminant is the sole responsibility of the user. Use of some treatments which utilize such method need to be applied carefully, especially in confined spaces, due to inhalation or contact risks of the product. All users should be aware of these risks

Other effective disinfectant(s) with similar chemical formulas (e.g., a minimum of 0.3% quaternary ammonium compound) or water based applications may exist but are unknown and not recommended at this time.

REMEMBER, the product label is the law!

It is the responsibility of the users of this protocol to read and follow the product label and MSDS.

<u>Products must be used in accordance with the label:</u>

Ensuring the safety of those who use any of the above products for treatment is of utmost importance. Material safety data sheets (MSDS) developed by product manufacturers provide critical information on the physical properties, reactivity, potential health hazards, storage, disposal, and appropriate first aid procedures for handling or working with substances in a safe manner. Familiarization with MSDS for chemical products prior to use will help to ensure appropriate use of these materials and assist in emergency response.

It is a violation of federal law to use, store, or dispose of a regulated product in any manner not prescribed on the approved product label and associated MSDS.

- Disinfectant products, or their contaminated rinse water, should be managed and disposed of as per product label directions to avoid contamination of groundwater, drinking water, or non-municipal water feature such as streams, rivers, lakes, or other bodies of water. Follow all local, state and federal laws. State-by-state requirements for product disposal may vary. Note: Quaternary ammonium wastewaters should not be drained through septic systems because of the potential for system upset and subsequent leakage into groundwater.

II. PLAN AHEAD AND CAVE CLEAN:

Dedicate your Gear: Many types of rope and webbing have not been thoroughly tested for integrity after decontamination. Dedicate your gear to a single cave/mine or don't enter caves/mines that require this gear. **Bag it Up:** Bring bags on all of your trips. All gear not decontaminated on site should be isolated (quarantined) in a sealed plastic bag/s or container/s to be cleaned and disinfected off-site.

Before Each Cave/Mine or Site Visit:

1.) Determine *G.d.*/WNS status[5] of the state/county(s) where your gear was previously used. 2.) Determine *G.d.*/WNS status[5] of state/county(s) to be visited.

3.) Determine whether your gear is permitted for your cave/mine visit or bat related activity, as defined by the current WNS case definitions[6] and the flowchart below.

4.) Choose gear that can be most effectively decontaminated [i.e., rubber wellington type (which can be treated with hot water and/or secondary treatment options in section I.) vs. leather boots] or dedicated to a specific location. **Remember, under no circumstances should any gear that was used in a WNS-affected state or region be used in a WNS-unaffected state or region.** Brand new gear can be used at any location where access is otherwise permitted.

5.) Determine if any state/federal regulatory or land management agency addendum or supplemental document[1] provides additional requirements or exemptions on lands under its jurisdiction that supplement the final instruction identified in the flowchart below.

6.) Prepare a "Clean Caving" strategy (i.e., how and where all gear and waste materials will be stored, treated and/or disposed after returning to your vehicle and base area) for your particular circumstances that provides for cleaning and treatment of gear on a daily basis **unless** instructed above to do so more frequently throughout the day.

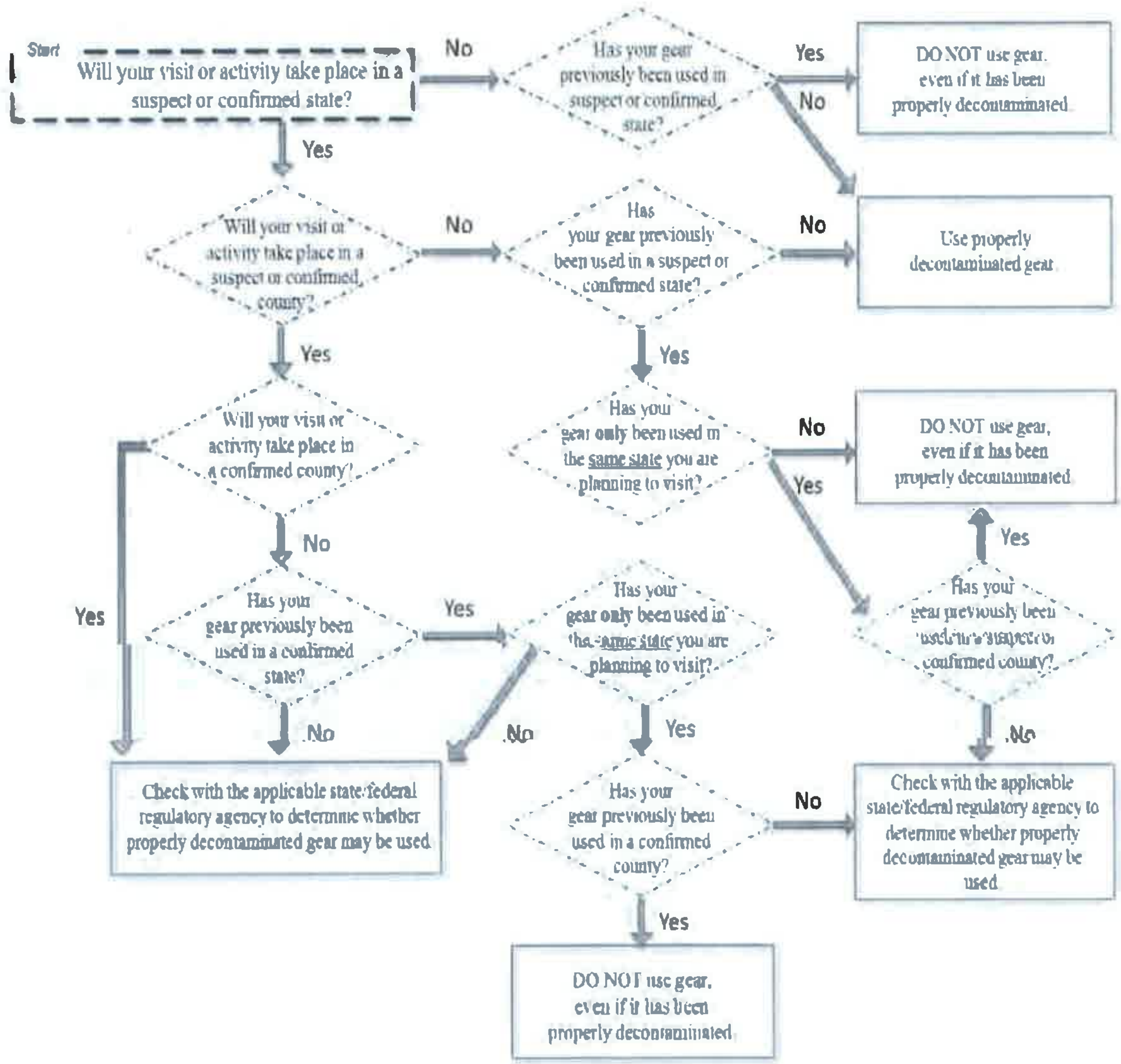
---

prior to entering cave environments and understand that products and corresponding procedures may cause irreversible harm. Always use personal protective equipment to reduce contact with these products, particularly when recommended by the manufacturer.

[5] Visit http://www.whitenosesyndrome.org/resources/map to determine the WNS status of a county or state.
[6] Visit http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/wns_definitions.jsp for current WNS case definitions.

7.) When visiting multiple caves/mines or bat research sites on the same day, clean and treat all gear between **each** cave/mine/site, **unless** otherwise directed in an agency/landowner addendum. It is recommended that known confirmed or suspect caves/mines be visited only after those sites of unknown *G.d.* status have been visited, to further reduce the risk of inadvertent transmission.

Flowchart to Determine Gear Use or Decontamination



After Each Cave/Mine or Site Visit:

1.) Thoroughly scrub and remove sediment/dirt from clothing, footwear, and other gear immediately upon emerging from the cave/mine or bat research site. Avoid contamination of vehicles; store exposed gear separately from unexposed gear.

2.) Once fully scrubbed and rinsed of all soil and organic material, clothing, footwear, and any appropriate gear should be sealed, bagged in a plastic container and once at home, machine or hand-washed/cleaned using a conventional cleanser like Woolite® detergent or Dawn® antibacterial dish soap in water (the use of Dawn® antibacterial dish soap is **not intended** for use in conventional washing machines.) Once cleaned, rinse gear thoroughly in water. Clean/treat gear used in a suspect or confirmed state prior to transport when traveling back to or through a state **without** known cases of *G.d.*/WNS. Use the treatments listed under Applications/Products on page 1 for a minimum of 10 (products) or 20 (hot water) minutes.

Remember: Many types of rope and webbing have not been thoroughly tested for integrity after decontamination. Dedicate your gear to a single cave/mine or don't enter caves/mines that require this gear.

A.) Submersible Gear (i.e. clothing, footwear, and/or equipment that can be submerged in liquid): Clothing, footwear, and other submersible gear:

Following steps 1 and 2 above, the primary treatment for all submersible gear should always be submersion in **water of at least 50°C (122°F) for a minimum of 20 minutes, where possible**. Some submersible gear (depending on material) could be soaked for a minimum of 10 minutes in the appropriate products listed in the Applications/Products chart on page 1, rinsed thoroughly in water again, and air dried. Note: Although commercially available washing machines with sanitation cycles often sustain desirable water temperatures, their efficacy for killing the conidia of *G.d.* is unknown.

B.) Non-submersible Gear:

Gear that may be damaged by liquid submersion should be cleaned according to the manufacturer's recommendation between cave/mine visits and when appropriate, follow steps 1 and 2 above in addition to following:

Cameras and Electronic Equipment:

Until effective techniques are developed to comprehensively disinfect cameras and electronics, it is recommended that these items only be used in caves when absolutely necessary. Regardless of the cave/mine visited, clean/treat cameras and electronics after each visit using an appropriate product listed in the Applications/Products chart on page 1. Equipment that must be used in the cave/mine may be placed in a sealed plastic casing (i.e., underwater camera housing), plastic freezer bag, or plastic wrap that permits operation of the equipment (i.e., glass lens is exposed) and reduces the risk of exposure to the cave environment. Prior to opening or removing any plastic protections, wipe the outside surfaces with an appropriate product described in the Applications/Products chart on page 1. Plastic freezer bag or wrap should be removed and discarded after each visit. A sealed plastic casing may be reusable if properly submersed in appropriate product as described in the Applications/Products chart and the functionality and protective features of the casing are not sacrificed (check with manufacturer). After removal of any outside plastic protection, all non-submersible equipment surfaces (i.e., camera body, lens, etc.) should be wiped using an appropriate product described in the Applications/Products chart.

3.) Reduce the risk of vehicle contamination and transport of *G.d.* to new areas by making sure to

A) transport gear in clean containers,

B) remove outer clothing/footwear and isolate in a sealed plastic bag or container prior to entering a vehicle. Storage container options vary considerably depending on the type of vehicle; but **always clean and disinfect the outside surfaces of storage containers prior to putting them in the vehicle.**

C) remain outside of the vehicle after exiting a cave/mine or completing field work,

D) change into clean clothing and footwear prior to entering the vehicle, and

E) clean dirt and debris from the outside of vehicles (especially wheels/undercarriage).

OBSERVATION OF LIVE OR DEAD BATS

If you observe live or dead bats (multiple individuals in a single location) that appear to exhibit signs of WNS, contact a wildlife professional in your nearest state (http://www.fws.gov/offices/statelinks.html) or federal wildlife agency (http://www.fws.gov/offices/, http://www.fs.fed.us/, http://www.blm.gov/wo/st/en.html, or http://www.nps.gov/ index.htm). **Do not handle bats unless authorized in writing to do so by the appropriate government agency.**

Note on the use of Pesticides/Products listed above:

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. §136 et seq. (1996)) http://www.epa.gov/oecaagct/lfra.html

defines a pesticide as follows:

(u) Pesticide

The term "pesticide" means (in part)

(1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.

FIFRA defines a pest at §136:

(t) Pest

The term "pest" means (in part)

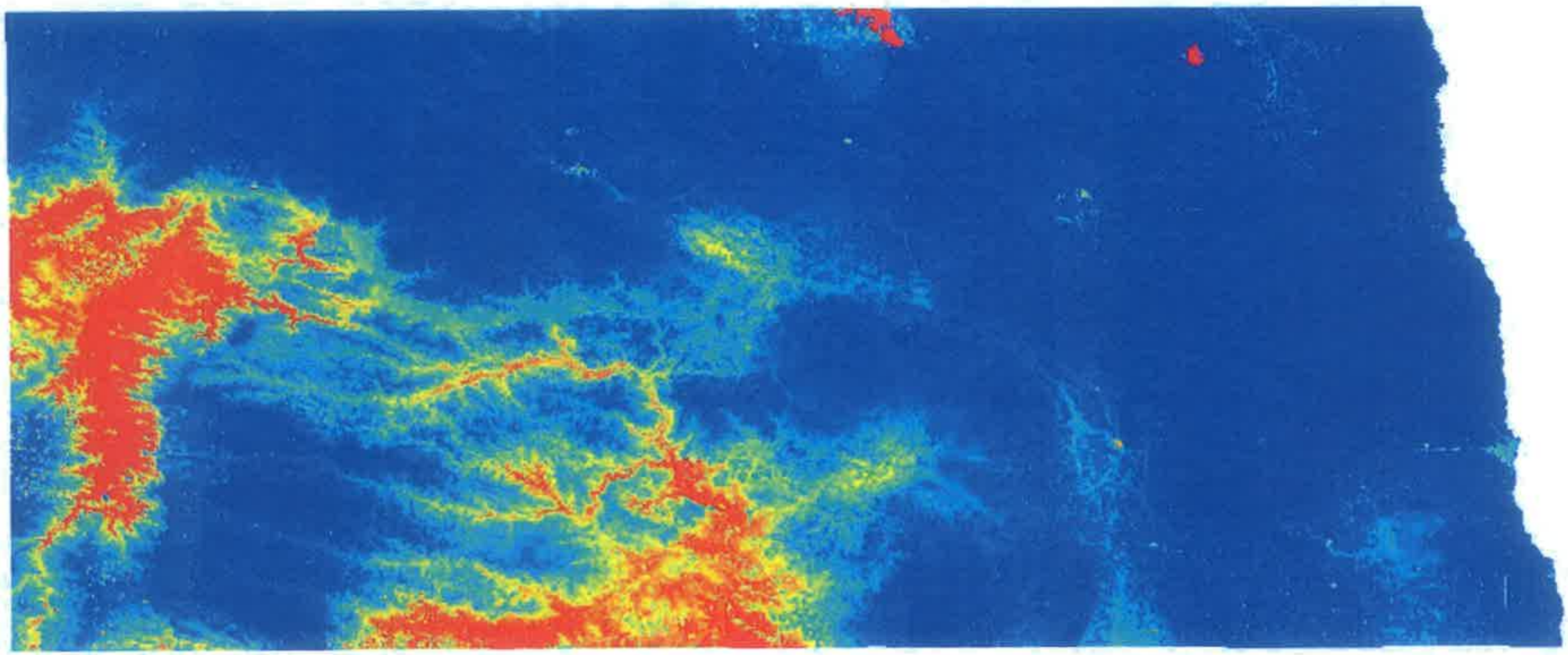
(1) any insect, rodent, nematode, fungus, weed, or (2) any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other micro-organism (except viruses, bacteria, or other micro-organisms on or in living man or other living animals) which the Administrator declares to be a pest under section 25(c)(1).

This document is the product of the multi-agency WNS Decontamination Team, a sub-group of the Disease Management Working Group established by the National WNS Plan (A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats, finalized May 2011). On 15 March 2012 a national decontamination protocol was adopted by the WNS Executive Committee, a body consisting of representatives from Federal, State, and Tribal agencies which oversees the implementation of the National WNS Plan. This version of the protocol contains some modifications to the 15 March version, intended to clarify the recommendations for the appropriate use of treatment options. This decontamination protocol will continue to be updated as necessary to include the most current information and guidance available.

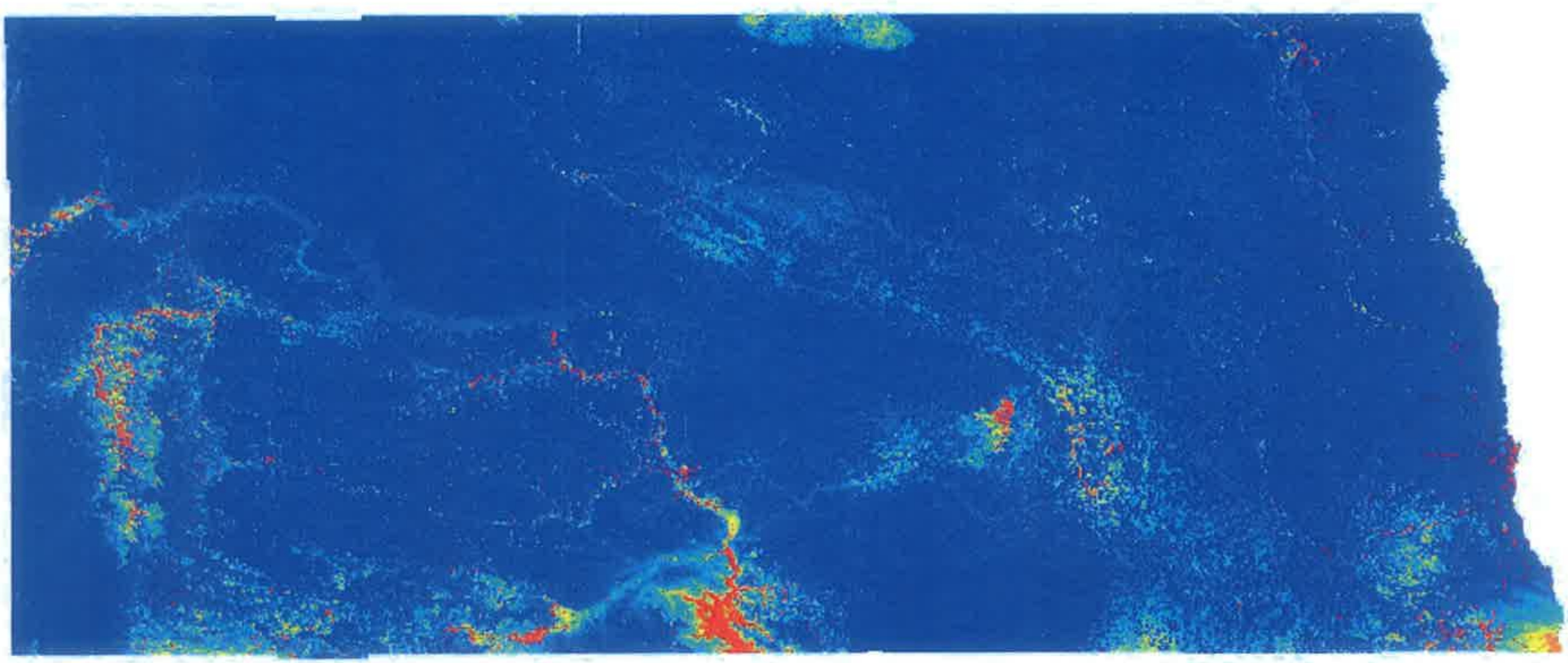
XII. APPENDIX E: HABITAT SUITABILITY MAPS FOR EIGHT ND BAT SPECIES

Note that areas in blue represent regions of low suitability, while areas in red represent regions of high suitability.

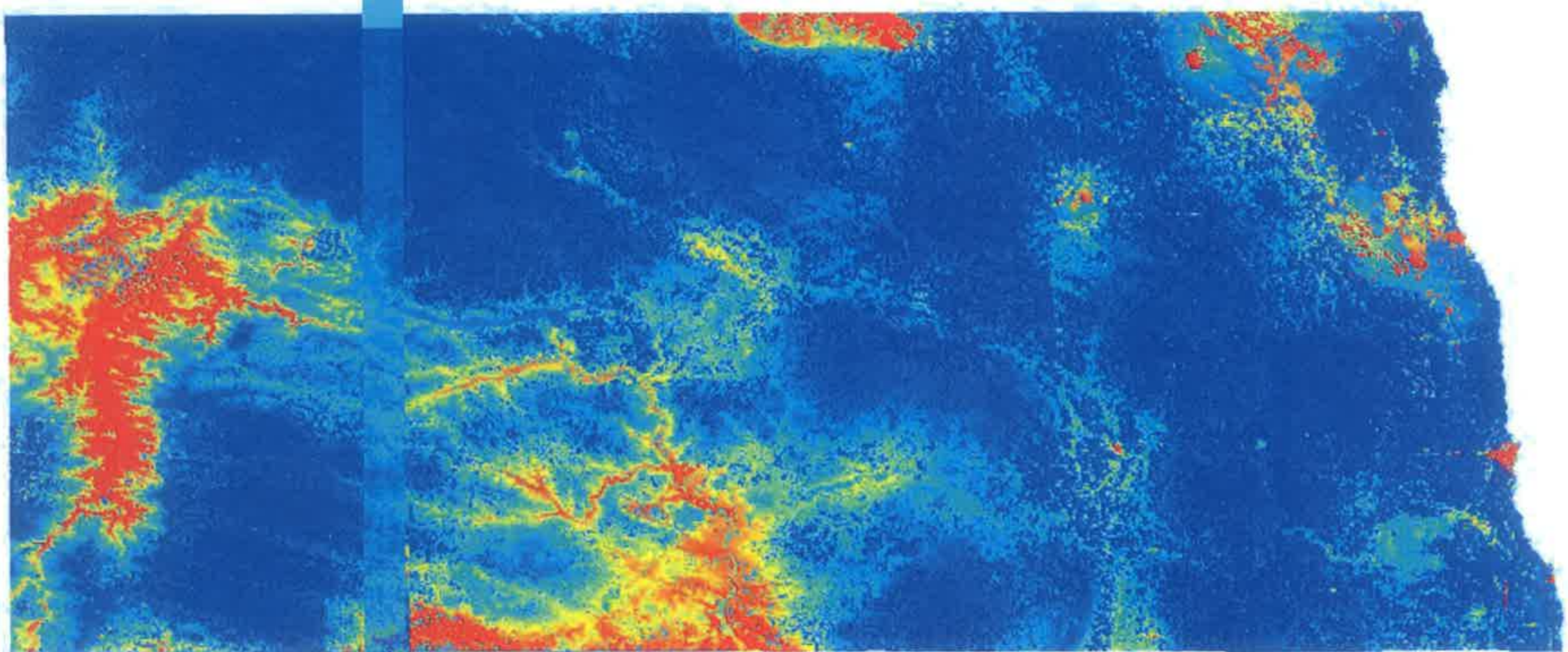
XII.A. Northern long-eared bat, *Corynorhinus townsendii*



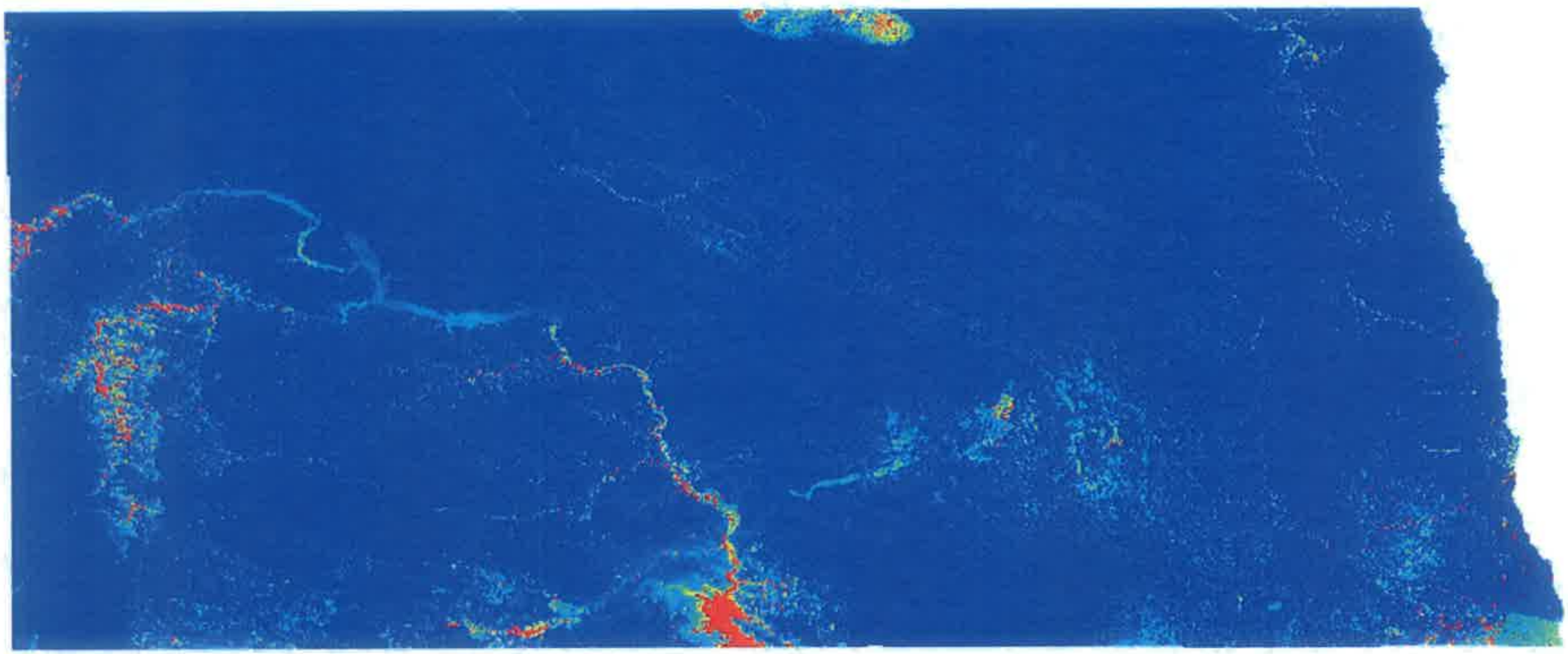
XII.B. Big brown bat, *Eptesicus fuscus*



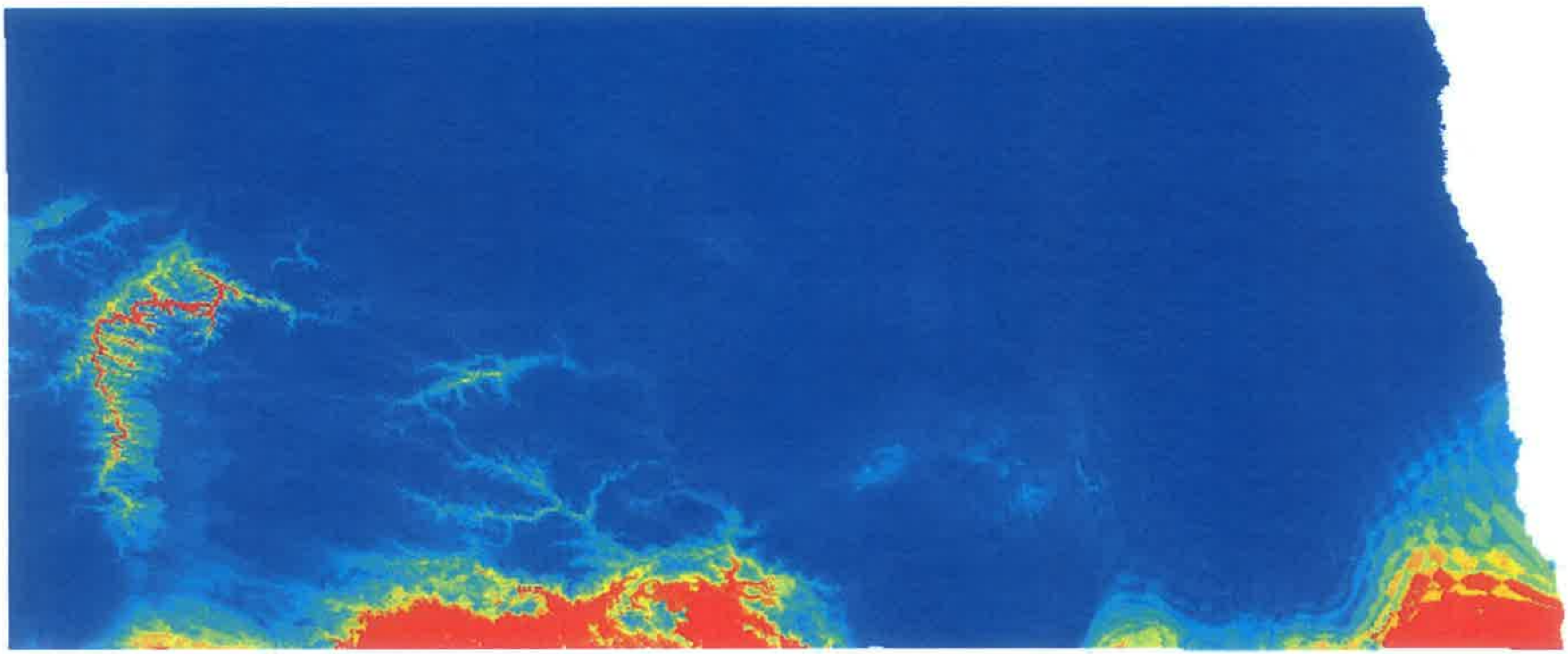
XII.C. Red bat, *Lasiurus borealis*



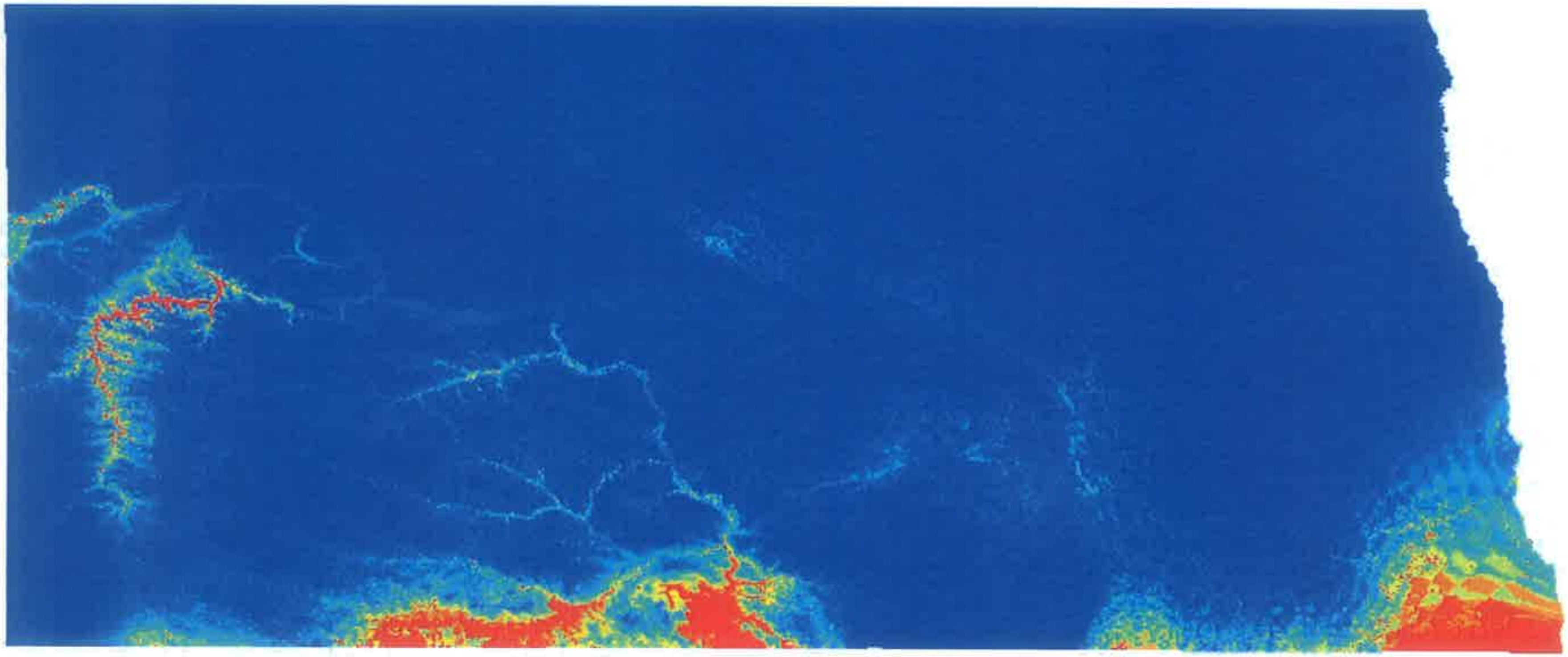
XII.D. Hoary bat, *Lasiurus borealis*



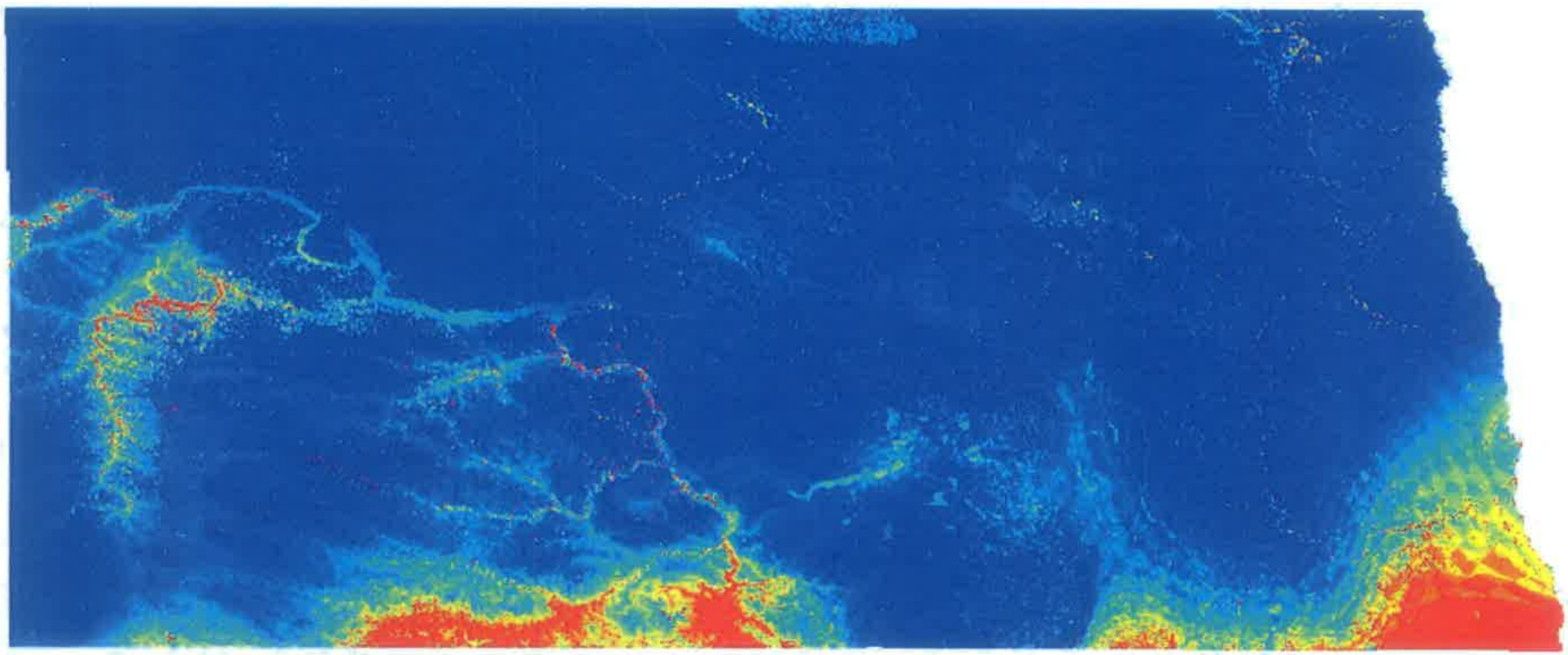
XII.E. Western small-footed Myotis, *Myotis ciliolabrum*



XII.F. Long-eared Myotis, *Myotis evotis*



XII.G. Little brown bat, *Myotis lucifugus*



XII.E. Northern long-eared Myotis, *Myotis septentrionalis*