NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Distribution and Habitat Use of the Bats of North Dakota Project

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Distribution and Habitat Use of the Bats of North Dakota

Final Report

Prepared for the North Dakota Game and Fish Department

By

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Species of Conservation Priority: Western small-footed myotis (*Myotis ciliolabrum)*, Long-eared myotis (*Myotis evotis*), Long-legged myotis (*Myotis volans*)

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I. EXECUTIVE SUMMARY

Although bats play key ecological roles, conservation efforts can be challenging due to a lack of information on habitat requirements for some species. A basic component of an organism's natural history is an understanding of the resources used for obtaining food and gaining protection from predators and weather. For bats, such information can be obtained through direct capture with mist nets, acoustic monitoring, and radio telemetry studies. In North Dakota little is known about the distribution and habitat use of bat species. As bat populations decline due to anthropogenic modifications to the landscape, wind energy development, and the impending spread of White Nose Syndrome, it is imperative to document key habitat requirements for these species. The primary objectives of this research were to obtain baseline information about the bat populations present throughout North Dakota. Specific objectives include to: 1) confirm the presence/absence of bat species that have previously been recorded in North Dakota, 2) document the current distribution of each bat species in the state. 3) determine the locations and types of key foraging and roosting habitats used by bats in North Dakota, with a focus on primarily surveying state wildlife management areas, 4) establish a library of known bat calls that can be used to identify species recorded from passive acoustic monitoring, which will be useful for the current study, as well as future research, and 5) develop a monitoring protocol for the North Dakota Game and Fish department to follow when conducting future bat surveys. After extensive sampling, including 69 nights of mist netting at 38 sites over two field seasons, we captured 255 bats and recorded thousands of echolocation calls. We documented an increase in bat species diversity from eastern to western regions of the state, with the lowest diversity in the Red River Valley (3 species) and the highest diversity in the Badlands of western ND (11 species). We also documented two species in areas of the state where they had not been previously reported, effectively altering the known range of these bats. While efforts at assessing the roosting ecology of ND bats were limited, we did find a strong preference of 2 species for roosting in cottonwood trees. Future research in Summer 2013 will expand our roosting ecology study, hopefully providing more detailed information about the habitats that bat species rely on for roosting in the state. In addition, we are also examining winter activity patterns in western North Dakota to determine if bats are occupying hibernacula in the badlands habitat. Such work is especially critical, as we cannot effectively protect bat populations from White Nose Syndrome if we are not aware of their presence in ND during the winter months. Finally, we will work with NDGF to turn our current and future findings into an effective conservation plan for the bats of North Dakota.

II. INTRODUCTION

Insectivorous bats form a diverse group of mammals with complex ecological niches and habitat requirements. As would be expected, many bat species have become threatened or endangered due to destruction of roosting and foraging habitat (Carmel and Safriel 1998). Although bats play key ecological roles in many ecosystems, conservation efforts can be challenging due to a lack of information on habitat requirements for some species. Characterizing the natural history of a species is critical for asking more advanced questions about ecology and behavior, as well as developing effective conservation plans (Stebbings 1988).

A basic component of an organism's natural history is an understanding of the resources used for obtaining food and gaining protection from predators and weather (Brigham 1991). For bats, such information can be obtained through direct capture, acoustic monitoring and radio telemetry surveys. Although technological advances have produced superior bat detectors and telemetry equipment, the majority of habitat use studies focus on a single species (Dodd et. al 2008, Russo et. al 2002, Mackie and Racey 2007, Farrow and Broders 2011, Elmore et. al. 2004) with few papers (i.e. Rydell et. al 1996) collecting data on several bat species. Research oriented at the ecological requirements of a bat community can provide quicker and more appropriate conservation actions as they relate to habitat use.

Bats are an integral component of a variety of ecosystems found in North Dakota. As nocturnal insectivores, bats can have significant impacts on the size of insect prey populations, including some pest species that cause major damage to agricultural and forest habitats (Cleveland et al. 2006). Despite their importance, little work has focused on assessing the distribution and habitat use of bats in North Dakota. Eleven species of bats have been reported in the state, three of which are listed as *Species of Conservation Priority* by the ND Game and Fish Department. To our knowledge, the most recent peer-reviewed research study on any bat in the state was published in 1978 (Jones and Choate 1978). Further, most previous studies only report the occurrence of a species in one area of the state, contain few capture records, and provide little or no information about habitat use (Genoways 1966, Genoways and Jones 1972, Jones and Choate 1978, Jones and Genoways 1966, Jones and Stanley 1962, Seabloom et al. 1978).

Bat populations are currently facing serious threats, including White Nose Syndrome (WNS), a fungal disease significantly impacting cave-dwelling species (Blehert et al. 2009), as well as anthropomorphic changes, such as suburban sprawl and extensive energy development. Bats have low reproductive rates, making rapid recovery from population disturbances difficult (Barclay and Harder 2003). Given these impending threats to bat populations, it is critical to not only determine where bats are found in North Dakota, but also to understand what types of habitats are essential for the foraging and roosting needs of each species. Gathering such information is crucial for developing an effective bat conservation and management plan for the state.

The primary objectives of this research project were to obtain baseline information about the bat populations present throughout North Dakota. Specific objectives include: 1) confirm the presence/absence of bat species that have previously been recorded in North Dakota, 2) document the current distribution of each bat species in the state. 3) determine the locations and types of key foraging and roosting habitats used by bats in North Dakota, with a focus on primarily surveying state wildlife management areas, 4) establish a library of known bat calls that can be used to identify species recorded from passive acoustic monitoring, which will be useful for the current study, as well as future research, and 5) develop a monitoring protocol for the North Dakota Game and Fish department to follow when conducting future bat surveys. This protocol includes information on survey equipment and setup, as well as appropriate spatial and temporal sampling designs. In this report, we address how we have met each of these objectives.

III. METHODS

We conducted a survey of bat activity, diversity, and habitat use throughout the state of North Dakota in Summers 2009 - 2011. A total of 17 locations were sampled across the state, with 4 to 7 nights of monitoring that occurred at one or more mist netting sites at a given location (see Appendix 1). Selected sites spanned a variety of land types, including wildlife management areas, private land, state parks, federal parks, and wildlife refuges. At each site, both mist-netting and ultrasonic detectors were used to document the presence/absence of species that had been previously reported in the state. At each site, we sampled using two methods: direct capture of bats via mist-netting, and ultrasonic recording of echolocation calls from free-flying bats. Previous studies have found that using both mist-nets and ultrasonic detectors provides a more accurate estimate of species diversity than either one alone (Kuenzi and Morrison, 1998). Further, extensive intraspecific variation in echolocation call structure means that misclassification can occur if one relies solely on ultrasonic detection for species identification (Thomas et al. 1987).

We divided the state into 5 sampling regions, in which bat activity was expected to be greatest. These locales include the Red River Valley, Pembina Gorge, Turtle Mountains, Missouri River Valley, and the Badlands in southwestern North Dakota. These predictions of bat "hotspots" are based on the greater availability of roosting and foraging habitat in these areas. Within each region, we selected 3 – 7 sites at which to survey for bat activity.

III. A. Foraging Ecology

III. A. 1. Direct capture and light tagging

A total of two to five mist-nets were deployed at each sampling location 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. Mist net configurations were also noted. Mist nets 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.

Recordings of the echolocation calls of captured bats, which had been identified in the hand to the species level, were used to build a call library for analysis of unknown calls. To obtain these calls, captured bats were housed in clean cloth bags and transported to an open release site within 2 miles of the capture site. A 1.5" chemoluminescent tag (Rod-N-Bobb's Inc.) was attached between the scapulae of the bat using non-toxic Elmer's glue. The release site was continually monitored for bat activity; when no bats had been detected for >60 seconds, one individual, light-tagged bat was released and tracked with a bat detector (see *Ultrasonic Detection* below for details about the detection and recording system). All bats were released within two hours of capture, and all procedures followed a protocol approved by the North Dakota State University Animal Care and Use Committee.

III. A. 2. Ultrasonic Detection and Sound Analysis
Ultrasonic detection was conducted on every sampling night using two broadband D240X Pettersson bat detectors (Pettersson Elektronik, Uppsala, Sweden). This time-expansion bat detection system records for a short period of time (1.7 or 3.4 seconds) and then broadcasts the recorded calls at one-tenth the original speed. Time-expanded calls were stored as an MP3 file on an iRiver player attached to the detector. Detectors were deployed as either passive or active systems. For the passive system, a detector was housed in a protective casing and placed within 2 miles of the netting site at a location containing high-quality bat habitat. The protected bat detector was manually activated before sunset and automatically recorded sounds when an amplitude threshold was crossed. The active detection system involved monitoring bat activity at mist-net sites for echolocation calls using a second bat detector, and manually recording any bats in the area.

Recorded echolocation calls were analyzed using Sonobat 3 (Sonobat, Arcata, CA). This system constructs a time-versus-frequency display (sonogram) of sound data and uses a decision engine, based on the quantitative analysis of approximately 10,000 known recordings from species across North America, to identify each recording to a species. Since variation in call structure between geographic locations is a possibility, we also included our recordings from light-tagging in the reference database. To construct the sonogram, Sonobat 3 uses fast Fourier (transform) to generate a high-quality representation of time-frequency content. The program then measures 72 parameters that characterize call structure, such as highest frequency, lowest frequency, and duration, of each individual call in the recorded sequence. Using those parameters, Sonobat 3 then employs a series of algorithms, including those for recognizing endings of calls and trends in a sequence, to ultimately make identification assignments to the species level. However, Sonobat 3 also uses a minimum acceptable quality value, which can be adjusted for sensitivity, and any recordings that fall below the desired quality level will not be classified. Sonobat 3 combines the species identification of each call and their associated probability in the sequence to construct a species level classification containing an overall probability of that identification being correct. Classifying an entire sequence will typically provide more reliable results than just analyzing single calls alone, as this method combines information within the sequence and avoids any issues of pseudoreplication.

III. A. 3. Statistical Analysis
We analyzed all recordings collected over the three field seasons using ANOVA to examine if overall bat activity differed between habitat types. We also used ANOVA to determine if habitat preferences differed between bat species. We hypothesized that bat activity would be higher at locations that were forested and/or contained slow running streams.

III. B. Roosting Ecology
III. B. 1. Radio Telemetry
We used radio telemetry to document the roosting ecology of bats in North Dakota. This standard field technique has been used successfully in dozens of field studies

examining the roosting habits of bats. Bats captured using mist nets (as described in III.A.1) had a radio transmitter (Model LB-2N, Holohil Systems, Canada) affixed between the scapulae using Osto-Bond Skin Bonding Latex Adhesive. This bonding agent dries quickly and holds the transmitter in place during flight and rest (Willis and Brigham 2004). Upon adhesion of the transmitter, bats were released at, or close to, the site of capture. Bats were not tracked until one day following their release to allow the animals to recover from their capture and resume normal roosting and foraging behavior. We tracked individual bats to roosts using a standard directional antenna (3 element Yagi) and receiver system (R-1000 receiver, Communication Specialists).

When tagged individuals were re-located, we determined the exact roosting location (if possible) and documented the habitat type in which each bat was found, as well as other key characteristics. Specifically, we documented: roost tree species, height of roost, height of roost tree, diameter at breast height of roost tree, ground cover, and canopy cover. Measurements were also taken at 5, 10, and 15 m increments from the base of the roost tree in the eight cardinal directions, resulting in 24 separate trees within a 15 meter plot to be assessed for the same characteristics of the roost tree (except roost height). We repeated these measurements for every roost that a tagged bat used during the tracking period.

III. B. 2. Random Site Selection

To provide control locations for statistical analysis, random sites were selected for a random-tree comparison of bat preference (Willis et al. 2006). Using a random number generator, GPS coordinates were selected for an area, using the roost tree as the focal point, within 0.5 miles in any direction (~259ha square area). The nearest tree to the randomly generated GPS coordinates was selected and the same measurements listed above were used to describe the focal tree and surrounding vegetation.

III. B. 3. Statistical Analysis

Due to the small size of the tracking dataset and the lack of trees at most random sites (primarily agricultural fields), we chose to qualitatively analyze the characteristics that appear to be preferred by bats when selecting a roost. These data should be interpreted with caution due to very small sample size.

IV. RESULTS

IV. A. Foraging Ecology

IV.A.I. Direct Capture and Light-Tagged Recording

We sampled at 17 locations (38 sites) across the state of North Dakota. In total, we collected data on 69 nights, all of which included both acoustic monitoring and direct capture via mist nets. Time spent at a specific sampling site was determined by the presence/absence of bat activity or environmental constraints (i.e. inclement weather).

We definitively documented 9 bat species (255 captures) using mist nets from Summer 2009 to Summer 2011 across the 69 survey nights (Table 1). These species include: Little Brown Myotis (*Myotis lucifugus*), Small-footed Myotis (*Myotis ciliolabrum*), Long-eared Myotis (*Myotis evotis*), Long-legged Myotis (*Myotis volans*), Hoary Bat (*Lasiurus cinereus*), Eastern Red Bat (*Lasiurus borealis*), Silver-haired bat (*Lasionycteris noctivagans*), Northern Myotis (*Myotis septentrionalis*), and Big Brown Bat (*Eptesicus fuscus*). We physically captured at least one species at 30 of the 38 sites and at 7 sites we captured 3 or more species. The only species known to inhabit the state that were not captured with mist nets were Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*).

Table 1. Number of individuals captured of each species.

Species	Female	Male	# Individuals	# Sites Captured
M. lucifugus	127	12	139	13
M. septentrionalis	10	4	14	3
M. evotis	5	6	11	6
M. ciliolabrum	5	6	11	5
E. fuscus	27	12	39	16
L. noctivagans	38	-	38	6
L. borealis	1	-	1	1
L. cinereus	-	1	1	1
M. volans	1	-	1	1

The Big Brown Bat was the most common species captured in mist nets, while the Eastern Red Bat, Hoary Bat, and Long-legged Myotis were the least commonly encountered species. Of the nine species captured in mist nets, the Little Brown Bat was the most abundant species (n=139), followed by the Big Brown Bat (n=39), Silver-haired Bat (n=38), Northern Myotis (n=14), Small-footed Myotis (n=11), Long-eared Myotis (n=11), Eastern Red Bat (n=1), Hoary Bat (n=1), and Long-legged Myotis (n=1). Bat captures in mist nets were mostly female (84%; 214 individuals) compared to males (16%; 40 individuals). Average mass and forearm length measurements for each species are reported in Table 2.

All 139 captured individuals were light-tagged, and high-quality recordings were obtained from 107 individuals. Details on call characteristics are listed in Appendix E.

Table 2. Average mass and forearm length (SD) of each bat species directly captured using mist nets

Species	Avg. Mass (g)	Avg. FA Length (mm)	Captures (n)
E. fuscus	22.4 (5.6)	46.2 (1.2)	39
L. noctivagans	13.9 (2.8)	41.4 (1.2)	38
L. cinereus	22 (0.0)	54.1 (0.0)	1
L. borealis	15 (0.0)	43.1 (0.0)	1
M. lucifugus	8.0 (1.6)	37.6 (1.6)	139
M. septentrionalis	7.0 (1.8)	36.1 (2.1)	14
M. ciliolabrum	4.7 (1.1)	31.5 (1.2)	11
M. volans	7.5 (0.0)	39.3 (0.0)	1
M. evotis	6.7 (0.9)	38.4 (1.0)	11

IV.A.II. Acoustic Monitoring

Acoustic monitoring was employed at each of the 38 study sites across the state. Of the eleven bat species known to exist in the state, all were detected with the recording equipment. At one study site, "Theodore Roosevelt National Park - North Unit Pond", we acoustically documented 10 species over 3 survey nights. However, all 11 species were never documented at one study site by acoustic monitoring alone. Townsend's Big-eared Bat (n=13) and Fringed Myotis (n=2) both were positively identified using acoustic monitoring, but these were rare occurrences, indicating that these species are not abundant in the state. Townsend's Big-eared Bat was acoustically documented at 10 study sites and Fringed Myotis at only 2 study sites, making it the least encountered species in our survey.

Automated analysis of 1,051 call sequences (> 95% confidence) using Sonobat 3 identified 9 species: Townsend's Big-eared Bat (*Corynorhinus townsendii*), Big Brown Bat (*Eptesicus fuscus*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), Small-footed Myotis (*Myotis ciliolabrum*), Long-eared Myotis (*Myotis evotis*), Little Brown Bat (*Myotis lucifugus*), Fringed Myotis (*Myotis thysanodes*), and Long-legged Myotis (*Myotis volans*). We also analysed some sequences by hand, using parameters from the primary literature, which led to identifications of the Eastern Red Bat (*Lasiurus borealis*) and Northern Myotis (*Myotis septentrionalis*).

Both direct capture and acoustic monitoring revealed a significant increase in species diversity when moving from eastern to western areas in North Dakota (Table 3). Diversity was lowest at Pembina Gorge, with only 3 species identified, and highest in the southwestern Badlands area, with 11 species identified.

Table 3. List of species found at each of the five sampling areas

Species	Red River Valley	Pembina Gorge	Turtle Mountains	MO River Valley	Badlands
E. fuscus	✔	✔	✔	✔	✔
L. borealis	✔		✔	✔	✔
L. cinereus	✔	✔	✔	✔	✔
L. noctivigans	✔	✔	✔	✔	✔
M. lucifugus	✔		✔	✔	✔
M. septentrionalis			✔	✔	✔
C. townsendii			✔		✔
M. ciliolabrum				✔	✔
M. evotis					✔
M. volans				✔	✔
M. thysanodes					✔

IV. B. Roosting Ecology

IV.B.I. Radio tracking

Unfortunately, our Summer 2011 field season was plagued by issues from state-wide flooding and equipment failure. While we tagged 11 bats during the summer, telemetry receiver failure meant that no data was collected for 8 of the 11 individuals. Once tagged, these bats could not be re-located. Attempts to fix the failed equipment were unsuccessful. The three bats that were successfully tracked could only be followed for 4-5 days as a result of the Missouri River and Little Missouri River floods. Due to inundation of the riparian areas with water, and the speed at which the flooding occurred, it was impossible to continue tracking these bats. The roosting ecology study will be continued in Summer 2012, hopefully with much more success.

During Summer 2011, three bats (two Big Brown Bats and one Silver-haired Bat) were successfully tagged and tracked to their roosts. Both Big Brown Bats were captured on May 25, 2011 with mist nets at Cross Ranch State Park on the west side of the Missouri River, which is a cottonwood dominated landscape. Both Big Brown Bats were female and were tracked to their roosts for a period of four days. Results indicate roost preference for mature cottonwood trees (*P. deltoides*) > 9 m and a diameter at breast height > 1 m. Each Big Brown Bat roosted in a cavity ~6 meters off the ground on the south side of the tree. In both Big Brown habitat characterizations, the surrounding vegetation was a mixture of mature cottonwood and green ash, *Fraxinus pennsylvanica*. Also, each roosting site had significant canopy cover and ground cover within 15 m of the roost tree. For both bats, surrounding vegetation was between 5 and 31 m tall and a diameter at breast height between 0.64 and 2.36 m. Neither Big Brown Bat switched roosts during the four days they were respectively tracked.

A Silver-haired Bat was captured on May 19, 2011 with mist nets in Theodore Roosevelt National Park South Unit- Peaceful Valley Ranch. The netting site was on a creek located along the north side of the ranch. Surrounding vegetation was dominated by cottonwood (*P.deltoides*) and juniper (*Juniperus scopulorum*) trees. The Silver-haired Bat was male and was successfully tracked to two separate roosts over a five day period. Results indicate a preference for mature cottonwood trees (*P.deltoides*) > 5 m in height and a diameter at breast height > 1.4 m. For both trees, the roost openings were 5.6 m off the ground on the south side of the tree. The two roost trees were approximately 80 m apart in the same cottonwood-dominated riparian area. In each case, surrounding vegetation was a mixture of *P.deltoides* and *J. scopulorus* that varied in high from 3.8 -15.4 m and diameter at breast height from 0.2 - 2.11 m. Each roost was also characterized as having significant amounts of canopy and ground cover. The Silver-haired bat was tracked to its first roost on May 20, 2011 and remained at the the same location for three nights. The Silver-haired Bat switched roost on May 23, 2011; the reason for this switch is unknown.

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

Limited collection of radio tracking data meant that we could not conduct a robust analysis that had enough statistical power to reveal differences between roost trees and random trees. Future data to be collected in 2012 will involve use of different statistical methods that will permit a thorough analysis of habitat characterization (see Discussion).

V. DISCUSSION

V.A. General Patterns and Conservation Objectives

This study provides new information about the distribution and habitat use of the bat species found in North Dakota. This study resulted in the first documented capture of multiple species in the state, including the Silver-haired Bat, Hoary Bat, Eastern Red Bat, and Northern Myotis, and the second confirmed recording of Fringed Myotis (Lausen 2009). To our knowledge, this is also the first state-wide survey of bats in North Dakota, which offers a more comprehensive picture of the bat communities in the state. Foraging ecology results show that two species, Small-footed Myotis and Townsend's Big-eared Bat are found outside their known range in North Dakota (Appendix B). The Small-footed Myotis is listed as Level III Conservation Priority by the North Dakota Game and Fish Department; documenting this extended range is critical for conserving the populations found in the state.

On a large scale, North Dakota is a heterogeneous landscape ranging from urban environments to vast stretches of badlands. Although bats can often be found in urban settings (Geggie and Fenton 1985), management efforts generally focus on analyzing and documenting the natural habitats used by bat communities. Results of this study show that bat diversity in the state is much greater in areas that contain a range of elevations, vegetation types, and roost types (trees, rock crevices).

The badlands of western ND provide ample foraging and roosting locations, which are used by a greater number of bat species. Areas such as the Red River Valley and the Pembina Gorge, which are relatively flat and contain fewer vegetation types, are still attractive to some species (ie. Hoary Bat and Eastern Red Bat), as evidenced by the number of individuals caught at these locations, but overall diversity is lower. The Missouri River Valley, which contained the second largest number of bat species, has the highest density of cottonwood trees amongst the sampled areas. As roosting habitat results indicate, cottonwood trees have definitively been used as roosts for at least two species. The Missouri River also has many tributaries (i.e. Heart River, Knife River) that could act as migratory corridors to other regions of the state and beyond. The Turtle Mountain Region is a unique habitat type in North Dakota for both its vegetation and isolation. Dominated by broad-leaf deciduous trees and vast agriculture plots, it was found that this region is home to the tree-roosting bat species expected in such a landscape, but also resulted in the first definite recording of a Townsend's Big-eared Bat outside of the badlands region. The presence of this species in the Turtle Mountains is especially surprising given the isolation of this region and the lack of any easily identifiable migration corridors.

Management decisions concerning habitat type should focus on the areas of the state that contain unique vegetation communities, such as those in the Turtle Mountains, as well as large stands of cottonwood trees with ample open space for foraging. Such habitat is particularly important for those species that prefer to forage in open areas. All three species of conservation priority were captured in the badlands region of the state. Since the development of extensive oil drilling in the Bakken region, landscape modification has invariably altered the foraging/roosting habitat of bats, although no research has attempted to quantify this effect. Although Theodore Roosevelt National Park is protected from such development, the National Grasslands and other private lands surrounding the Bakken also include high quality bat habitat for the diverse bat community of the western ND. We recognize that expense is always an issue, but when possible, we recommend that state land acquisition, such as establishment of new WMAs, be focused in western ND. Such habitat preservation would invariably help conserve a variety of species, including non-game and game animals.

In conjunction with natural habitat differences across the state, the change in diversity of bat species across North Dakota can also be explained by agricultural development. The Missouri Coteau and Red River Valley are some of the most heavily farmed regions in the state. Although drift prairie, the natural habitat of this area, probably never supported the diversity of bat species that we see today in the badlands region, it once contained isolated pockets of tall vegetation and water that would have been used by many wildlife species. Agricultural practices have resulted in the loss of most of the tall vegetation and many wetlands have also been converted for agricultural practices (Pimentel et al. 1997). Although certain bat species (Little Brown Bat and Big Brown Bat) have been documented in anthropogenic structures that are readily abundant in farmed areas, these structures are only preferred by a few species. Agricultural practices, simply by removing key habitats from the state, have likely had impacts on bat populations. Future research documenting bat activity in different agricultural landscapes will be valuable for quantifying any such effect.

Agricultural practices concerning the application of pesticides can also have negative impacts on bat species (Clark 1981). All bats found in North Dakota are insectivorous, hence insect abundance can have a substantial impact on bat populations. The eradication of agricultural pest species via pesticide use could potentially be another covariate explaining the change in diversity of bat species across the state. Management decisions in this case should focus on the potential impact of bats on agricultural pest species and provide farmers the information needed to support bat populations on their property, either by using bat houses or planting tree species suitable for roost sites.

The Red River Valley, which contained the smallest number of species found in this study, also contains the largest (Fargo) and third largest (Grand Forks) cities in North Dakota. These cities require large amounts of surrounding resources and have substantial rates of urban sprawl. This could potentially be a factor influencing the species diversity of this region. Future studies should examine bat diversity in areas of western Minnesota that contain very similar habitats to the eastern North Dakota, but contain substantially less human development.

V.B. Ongoing and Future Research

In Summer 2012, we will continue our efforts towards documenting the roosting ecology of bats in North Dakota. In particular, we will focus on: 1) species with targeted conservation needs (Western Small-Footed Myotis, Long-Legged Myotis, Long-Eared

Myotis) and 2) species most significantly impacted by wind energy development (Hoary Bat, Eastern Red Bat, Silver-Haired Bat).

The data gathered will be presence data only (i.e. will not focus on the landscape not being used by bats). The habitat characteristics of the North Dakota landscape prohibit any accuracy in stating absence assumptions, and researchers have suggested that random tree comparisons are not appropriate. Maximum Entropy (MaxEnt) is a program developed to geographically map occurrence data in a landscape and use constructive criteria to determine probability distributions on the basis of partial knowledge. This program allows for the accurate depiction of an environment through prediction maps based on the current or hypothesized important criteria. We will characterize all roost trees and surrounding vegetation characteristics as high importance criteria for the MaxEnt statistical analysis. Aerial photography or LiDAR layers, which contain the same vegetation characteristics for the entire state, will then be uploaded into an ArcGIS environment. By running the MaxEnt program, a statistical inference will be generated that has the ability to be plotted in a GIS environment. By joining the resulting MaxEnt output with the aerial photography/LiDAR, a probability map will be produced in ArcGIS for the entire state of North Dakota for each species that was successfully radio-tracked. Additional ArcGIS data, such as shape files and raster datasets characterizing oil and wind energy development will be used as a covariate in the MaxEnt program. We will run MaxEnt with and without these datasets to determine how the probability of a roosting area being occupied changes with decreasing distance to areas of intense energy development.

With the impending spread of White Nose Syndrome (WNS) across the United States, efforts are required to document the pre-infection characteristics of poorly described bat populations. As WNS is a disease that strikes hibernating bats, we have been focusing our efforts during the winter on determining if bats occupy hibernacula in North Dakota. To date, no hibernacula have ever been described in the state, nor has bat activity been documented during the winter months. In Winters 2009/2010 and 2010/2011, we collected preliminary data to determine if bats were hibernating in the western badlands. Focus is placed on this area of the state, as it is the only region that contains natural habitat that could potentially be used as hibernacula (deep rock crevices and caves). While our initial findings from these two seasons did not indicate the presence of bats during the winter, our sampling was very limited. In Winter 2011/2012, we have quadrupled the number of detectors deployed in the field and focused our efforts in a smaller region where the probability of hibernation is highest (SW ND, specifically TRNP-SU). Current sampling efforts have resulted in the regular detection of bat calls throughout the winter months, indicating that bats are overwintering in western ND. While we do not currently know the location of hibernacula (acoustic monitoring only detects bats when they temporarily arouse from hibernation and search for food/water), future research is needed to characterize these winter populations. Such work is critical not only for understanding the ecology of bats in the state, but also so that appropriate management actions can be taken to limit the impact of WNS on overwintering bat populations in ND.

The completion of this study will lay the foundation for all future work in the state of North Dakota. Future bat survey work should include a more vigorous habitat use study and document key migration routes through the state. Also, the three species of Level III Conservation Priority (*Myotis evotis*, *Myotis ciliolabrum*, and *Myotis volans*) were all captured directly by mist nets and indicate small isolated populations from the Missouri River west. Future work should focus on these species to help provide a clearer picture of their presence in the state as well as more focused distribution data.

VI. ACKNOWLEDGMENTS

We would like to thank the non-game biologists at ND Game and Fish, especially Patrick Isakson, for providing input on the project and for facilitating access to lands that are usually locked or exceedingly difficult to access. We would also like to thank the many wildlife managers around the state who helped us identify sites and provided us with important information about their specific locality, often taking time from their busy schedules to show us around. These individuals include: Dan Swingen (USFS), Mike Oehler (NPS), Jeb Williams (NDGF), Brian Prince (NDGF), Dan Halstead (NDGF), and Kent Luttschwager (NDGF), Mike Duerre (ND Parks and Rec) and Kathy Dutenhefner (ND Parks and Rec). Many thanks to the Department of Biological Sciences and the College of Science and Mathematics at NDSU, as well as the NDSU Environmental and Conservation Sciences graduate program. Finally, this work would not have been possible without the tireless efforts of our assistant for two field seasons, Josiah Nelson.

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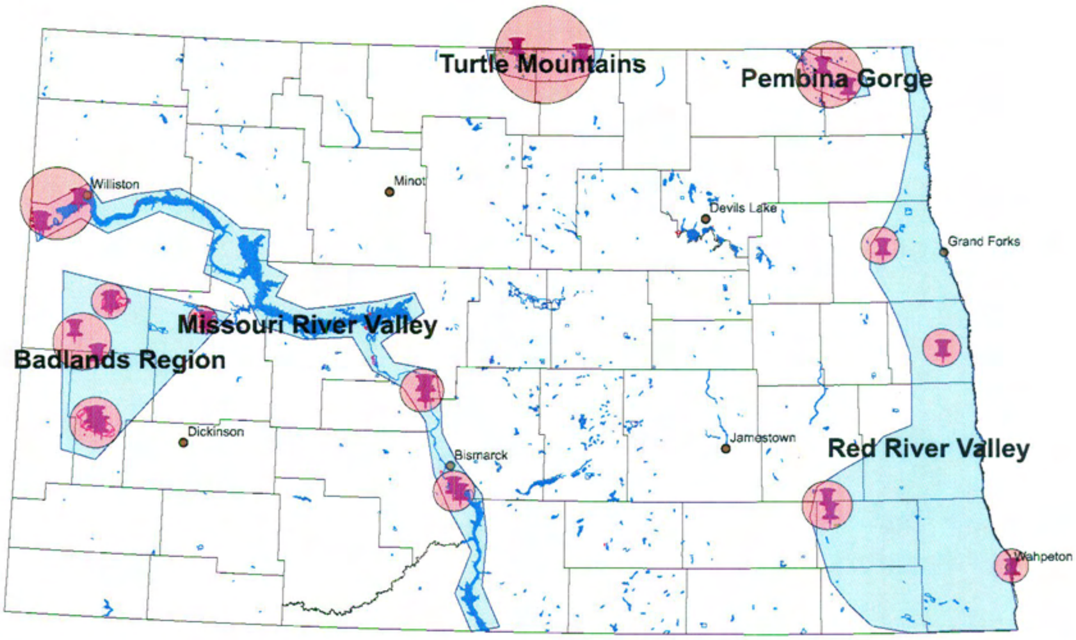
VIII. APPENDIX A: Sampled Locations

VIII.1. Map of sampled locations

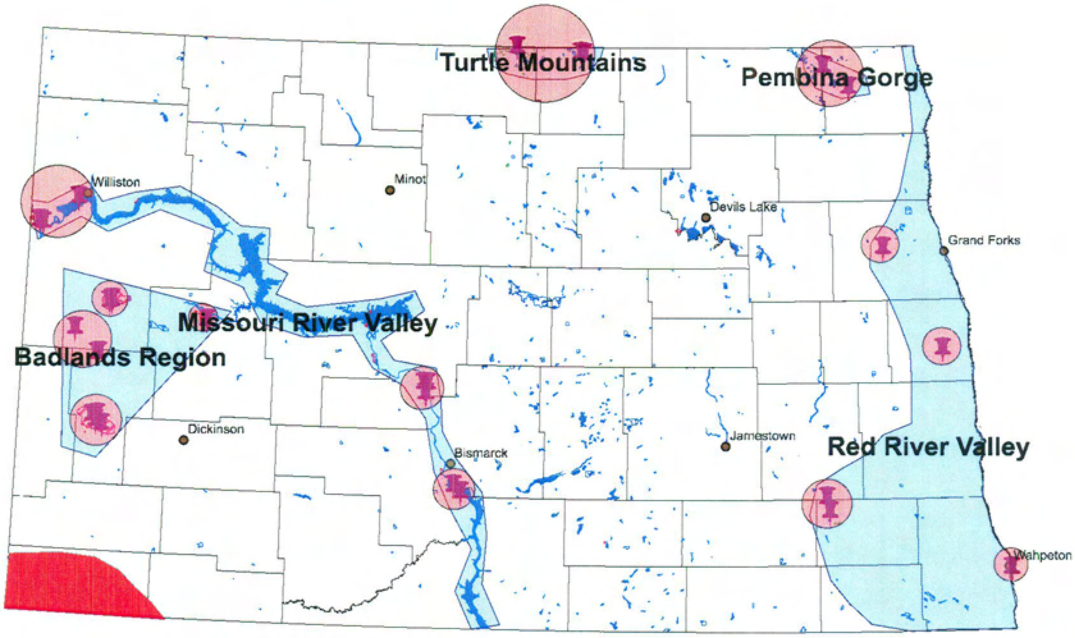


VIII.2. List of sampled locations and specific mist netting sites

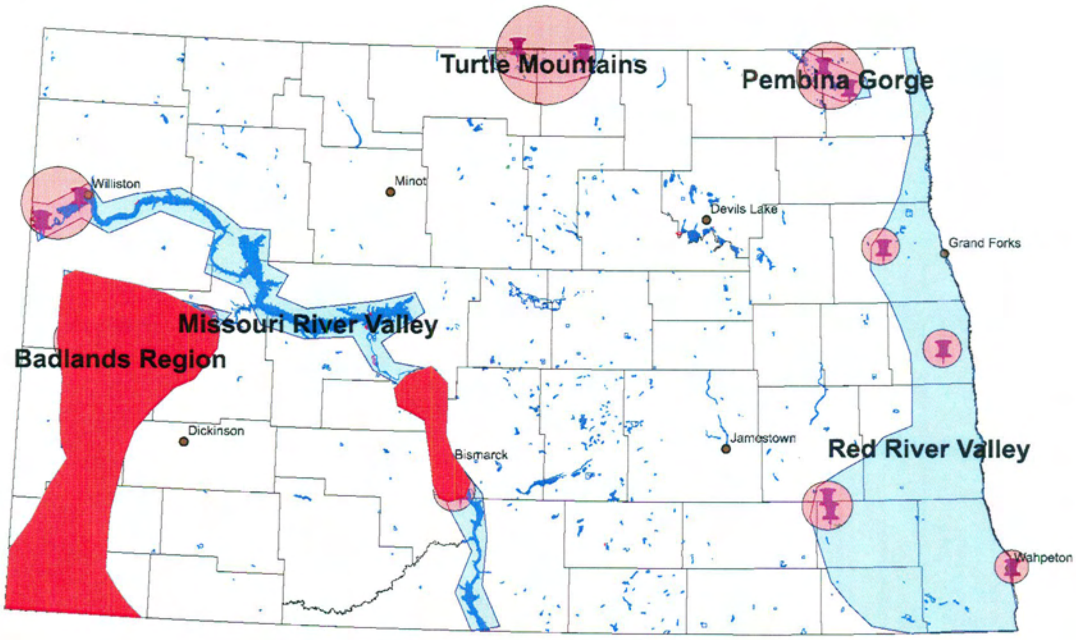
Sampling Location	Site Name	# Nights Sampled	Species Captured Via Mist Net	Species Captured Via Acoustic Detection
Little Yellowstone State Park	Campground	1	Lano	Lano; Epfu; Mylu
Turtle River State Park	Turtle River south of main bridge	3	Lano	Laci; Lano; Epfu; Labo
	Small Creek near campground	3	Lano; Labo	Laci; Epfu; Lano; Labo
	On walking path over Turtle River	2	Lano	Epfu; Labo; Lano
Theodore Roosevelt National Park	South Unit- Picnic Shelter	2	Mylu	Mylu
	South Unit- Lower Talkington Trail	1	Myci	Myci; Epfu; Lano; Coto; Myth
	South Unit- Peaceful Valley Ranch	4	Lano; Mylu; Myse; Myev; Epfu	Epfu; Lano; Labo; Myse; Myev; Mylu
	South Unit- Campground	4	Epfu	Epfu; Labo; Laci; Lano
	South Unit- Prairie Dog Town	3	Myev; Myci; Epfu	Myci; Myev; Epfu; Lano; Laci; Mylu; Coto
	North Unit- Canyon Culvert	2	Mylu; Epfu; Laci; Myci; Myev	Mylu; Epfu; Laci; Myci; Myev; Coto; Lano; Labo; Myci
	North Unit- Pond	3	Epfu; Myev	Mylu; Epfu; Laci; Myci; Myev; Coto; Lano; Labo; Myci, Myvo
	North Unit- Flooded Area	1	Epfu; Mylu	Epfu; Mylu; Myse; Myci; Coto
Oahe Wildlife Management Area	Along River in Campsite	1	None	Lano; Epfu
	Parallel to Little Heart River	1	None	Lano; Epfu
Cross Ranch State Park	Pond near manager's house	4	Mylu; Epfu; Myse	Epfu; Mylu; Myse; Lano; Laci
	Amphitheater	1	Mylu; Epfu	Mylu; Epfu; Laci; Lano; Myse
	Forest edge near large open area	1	Epfu	Epfu; Lano
Painted Woods Wildlife Management Area	Outside Barn	2	Mylu; Epfu	Mylu; Epfu; Lano; Laci; Labo; Myci
	On road that crosses creek	1	Lano; Epfu; Mylu	Lano; Epfu; Mylu; Myse; Myci; Myvo
	In Barn	2	Mylu; Epfu	Mylu; Epfu
	Pond near road	1	Mylu; Epfu	Lano; Epfu; Mylu; Myse
Trenton Wildlife Management Area	Flooded Road south of Trenton	1	None	Epfu; Labo
Neu Wildlife Management Area	Yellowstone River confluence	1	Lano	Epfu; Lano; Labo; Laci
Lewis and Clark Wildlife Management Area	Campsite at end of road	1	Mylu	Mylu; Epfu
Little Missouri State Park	Lower Campsite	2	Myci	Myci; Mylu; Epfu
Smith Grove Wildlife Management Area	Flooded area on North Side of trail	3	Mylu; Myse; Lano	Mylu; Epfu; Lano
Pembina Gorge	On creek near road	2	Lano	Lano; Epfu; Laci
	Over road	1	None	Lano; Epfu; Laci
Lake Metigoshe State Park	Furthest North pond near Canadian border	1	None	Coto; Myse; Mylu; Epfu; Lano; Labo
Toussant Farm	South of Wahpeton North Dakota	1	None	Epfu; Labo; Lano; Mylu
Little Missouri National Grasslands	Magpie Campground	2	Epfu	Coto; Epfu; Laci; Labo; Lano; Myev; Myci; Myse
	Magpie Creek	2	Myci; Epfu	Mylu; Myci; Laci; Lano; Labo; Coto; Epfu; Myth
	Elkhorn Pond	2	Myci; Myev; Epfu	Mylu; Epfu; Myse; Myev; Labo
Theodore Roosevelt National Park	Elkhorn Unit- Pond	2	Myev	Mylu; Myse; Myev; Epfu; Coto; Lano; Laci; Labo
	Elkhorn Unit- Horse Trough	2	Myvo	Mylu; Myse; Myev; Epfu; Coto; Lano; Laci; Labo
Wakopa Wildlife Management Area	Happiness Hyway Trail	1	Mylu	Mylu; Epfu; Lano
	Field Station Lawn across road	1	None	Labo; Mylu; Laci; Epfu
	Pond on service road	1	None	Myse; Mylu; Lano; Labo; Laci
		Total Nights Sampled: 69	**Total Species Captured Via Mist Net: 9**	**Total Species Captured Via Acoustic Detection: 11**

IX. APPENDIX B: Adjusted Species Distributions

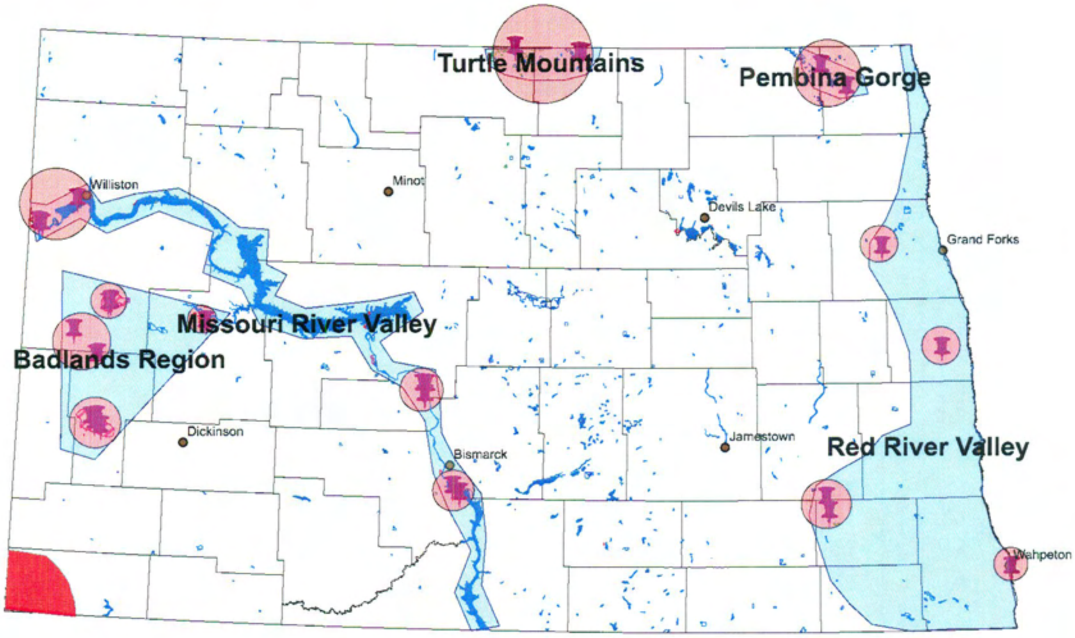
IX.A.1. Historic range for M. ciliolabrum



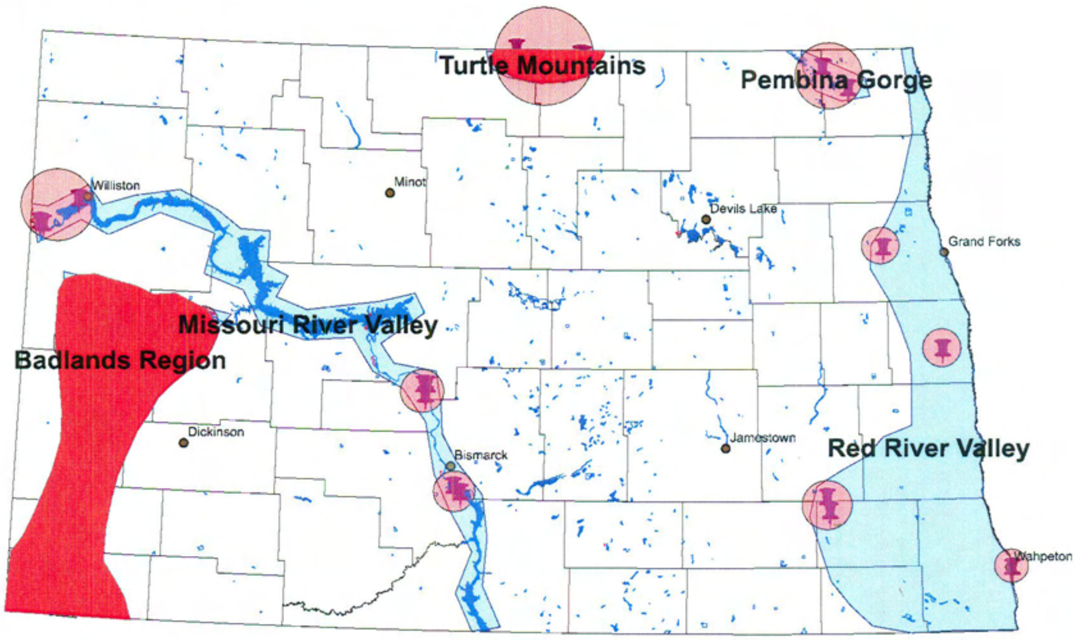
IX.A.2. Proposed range for M. ciliolabrum



IX.B.1. Historical distribution for C. townsendii



IX.B.2. Proposed distribution for C. townsendii



X. APPENDIX C: Local Call Library

Bat	Dur	Fc	MaxF	MinF	BW	PeakF	KneeF
Epfu 1	8.16	28.52	45.68	28.04	17.64	31.44	36.78
Epfu 2	5.89	28.67	45.63	28.02	17.61	30.36	36.97
Epfu 3	4.54	29.06	47.61	27.87	19.75	31.77	37.98
Epfu 4	3.91	29.77	45.10	28.07	17.03	30.70	38.37
Epfu 5	3.81	24.08	50.08	22.02	28.06	30.04	37.64
Epfu 6	2.66	27.45	52.43	27.33	25.10	33.14	37.49
Epfu 7	8.85	26.88	45.14	25.02	20.12	30.16	30.32
Epfu 8	5.17	30.31	49.69	28.36	21.33	32.83	37.26
Epfu 9	4.51	27.62	53.16	25.85	27.30	31.63	37.74
Epfu 10	2.31	26.27	50.30	24.19	26.11	31.16	40.10
Epfu 11	2.56	28.11	49.81	26.49	23.32	32.97	41.50
Epfu 12	2.63	29.14	52.03	26.43	25.61	33.86	40.70
Epfu 13	6.43	27.16	47.43	25.79	21.64	32.85	34.97
Lano 1	4.19	25.26	54.65	23.92	30.73	31.72	34.17
Lano 2	6.32	26.93	45.35	25.55	19.80	29.27	30.48
Lano 3	5.53	26.54	46.91	25.92	20.99	30.78	30.45
Lano 4	5.74	27.68	45.96	27.23	18.73	28.86	32.76
Lano 5	7.28	26.59	43.40	26.05	17.35	28.30	30.44
Lano 6	9.35	26.75	36.35	26.31	10.04	27.71	29.06
Lano 7	6.99	25.94	40.35	25.51	14.84	26.28	29.17
Lano 8	7.31	26.20	41.12	25.63	15.49	26.51	29.34
Lano 9	6.08	21.84	40.54	20.52	20.02	23.01	28.29
Lano 10	6.81	26.21	46.83	25.06	21.77	27.82	30.82
Lano 11	5.53	27.20	45.45	26.48	18.97	29.22	31.72
Lano 12	5.83	27.60	44.46	26.40	18.05	29.23	32.52
Lano 13	5.97	28.09	45.51	25.44	20.06	29.55	32.65
Lano 14	6.01	27.34	43.18	27.07	16.11	28.40	30.63
Lano 15	5.90	27.19	43.26	26.48	16.78	28.94	30.91
Lano 16	6.09	27.71	46.43	26.42	20.01	28.90	33.98
Lano 17	9.34	26.26	45.47	24.40	21.07	28.38	30.68
Lano 18	8.68	25.64	42.19	23.73	18.45	28.34	30.04
Lano 19	8.62	26.74	44.28	25.14	19.14	28.30	29.43
Lano 20	9.59	26.35	43.52	25.69	17.82	27.07	30.04
Lano 21	11.75	26.26	37.54	25.55	11.98	27.15	29.03
Lano 22	8.01	26.95	40.99	26.22	14.77	27.94	30.07
Myci 1	2.93	43.92	99.71	39.72	59.99	48.66	58.76
Myci 2	2.96	41.85	102.74	38.75	63.99	46.46	55.59
Myci 3	3.24	42.52	95.45	38.68	56.77	47.10	57.64
Myci 4	2.99	40.68	99.36	37.58	61.78	47.77	63.60
Myev 1	2.50	32.46	69.86	27.98	41.88	37.09	45.38
Myev 2	2.39	34.22	74.74	28.76	45.97	38.21	49.38
Myev 3	1.91	35.18	59.90	28.65	31.25	36.51	40.63
Myev 4	2.05	34.59	87.03	25.83	61.21	53.45	48.40
Bat	**Dur**	**Fc**	**MaxF**	**MinF**	**BW**	**PeakF**	**KneeF**
Myev 5	4.96	33.02	71.88	28.98	42.90	38.01	46.50

Myev 6	2.01	35.84	59.01	28.25	30.76	39.76	44.20
Mylu 1	8.18	30.78	55.10	27.96	27.13	33.20	39.09
Mylu 2	3.21	39.01	87.15	29.32	57.83	45.61	53.28
Mylu 3	3.08	38.54	89.21	34.20	55.01	44.10	54.36
Mylu 4	3.62	38.85	77.30	34.42	42.87	43.03	53.02
Mylu 5	3.10	38.95	76.09	33.00	43.09	44.15	54.25
Mylu 6	3.38	38.85	82.46	33.00	49.46	44.11	56.33
Mylu 7	3.19	40.99	78.21	37.95	40.26	44.02	57.04
Mylu 8	3.72	41.38	92.49	36.53	55.96	50.94	55.61
Mylu 9	3.37	41.31	88.74	36.66	52.07	49.17	55.41
Mylu 10	2.61	41.73	93.41	37.83	55.57	46.42	62.14
Mylu 11	2.55	40.35	81.59	36.53	45.06	46.79	55.64
Mylu 12	5.36	41.12	75.11	38.02	37.10	44.35	51.24
Mylu 13	4.68	39.78	76.18	36.71	39.47	43.99	54.29
Mylu 14	4.12	40.25	85.38	37.85	47.53	42.36	57.09
Mylu 15	3.68	40.85	87.17	35.05	52.12	45.38	54.70
Mylu 16	3.18	40.91	85.77	37.04	48.73	52.07	57.89
Mylu 17	3.63	39.92	89.94	36.80	53.15	48.50	54.48
Mylu 18	2.86	45.14	85.52	39.55	45.96	48.45	58.57
Mylu 19	4.20	42.41	74.03	38.34	35.69	46.17	56.86
Mylu 20	2.94	38.97	77.50	30.88	46.62	45.21	54.34
Mylu 21	3.61	39.62	82.71	33.25	49.46	44.69	57.79
Mylu 22	3.10	38.52	70.73	34.41	36.31	42.62	52.55
Mylu 23	3.17	40.31	80.21	34.83	45.38	44.37	55.71
Mylu 24	3.47	40.87	87.78	34.97	52.81	47.15	58.02
Mylu 25	3.71	39.24	73.33	34.44	38.89	43.28	53.56
Mylu 26	5.04	39.67	83.43	35.30	48.13	42.63	56.40
Mylu 27	7.90	29.42	50.01	29.07	20.94	33.89	37.72
Mylu 28	7.18	34.39	64.13	32.68	31.45	37.79	46.96
Mylu 29	4.29	36.58	54.68	33.65	21.03	40.42	45.87
Mylu 30	4.18	35.86	84.50	33.95	50.55	46.19	54.26
Mylu 31	3.60	36.09	71.46	33.97	37.49	44.16	51.62
Mylu 32	2.91	36.10	57.42	33.06	24.36	40.99	45.54
Mylu 33	2.84	36.82	91.67	33.98	57.69	44.96	60.01
Mylu 34	5.40	29.47	53.98	27.50	26.48	34.97	37.91
Mylu 35	2.94	36.11	88.66	33.04	55.62	45.54	54.21
Mylu 36	2.69	38.11	86.90	34.48	52.42	48.59	46.93
Mylu 37	2.60	37.77	88.10	33.53	54.56	44.84	54.09
Mylu 38	3.30	37.31	47.65	31.41	16.24	38.21	41.47
Mylu 39	7.52	26.91	51.39	25.33	26.06	31.58	34.78
Mylu 40	4.51	38.37	85.82	33.45	52.37	42.91	55.77
Mylu 41	2.83	39.52	81.41	33.85	47.56	44.80	54.60
Mylu 42	2.83	41.35	87.05	33.71	53.34	48.98	60.03
Mylu 43	3.09	39.47	77.67	33.78	43.89	48.00	57.38
Bat	**Dur**	**Fc**	**MaxF**	**MinF**	**BW**	**PeakF**	**KneeF**
Mylu 44	4.40	40.19	58.59	37.80	20.80	41.88	49.05
Mylu 45	6.17	39.33	72.94	37.45	35.48	43.04	53.65
Mylu 46	4.77	40.33	78.61	36.52	42.10	42.76	52.21

Mylu 47	3.11	40.91	93.79	35.84	57.95	51.93	55.33
Mylu 48	3.81	40.25	86.97	34.28	52.69	43.82	56.19
Mylu 49	3.21	41.48	75.52	37.99	37.54	46.20	54.38
Mylu 50	4.32	35.58	89.44	34.18	55.25	40.27	44.00
Mylu 51	4.48	39.29	81.59	36.27	45.32	47.81	55.31
Mylu 52	2.01	36.08	84.05	31.07	52.98	50.50	37.99
Mylu 53	3.75	42.08	76.45	38.38	38.07	46.84	53.81
Mylu 54	2.97	40.66	77.71	35.28	42.43	45.51	51.70
Mylu 55	2.53	39.16	84.43	33.31	51.12	44.43	49.28
Myse 1	2.67	37.95	77.95	31.90	46.05	43.29	52.46
Myse 2	2.15	36.67	85.46	32.50	52.97	45.47	50.40
Myse 4	3.06	40.32	101.05	35.45	65.60	46.09	53.41
Myse 5	4.37	33.43	89.57	29.78	59.79	43.50	45.11
Myse 6	2.60	33.02	72.59	27.52	45.07	37.46	48.40
Myse 7	2.49	32.80	57.96	26.11	31.85	34.98	38.73
Myse 8	2.88	36.95	103.93	36.94	66.99	46.16	61.51

XI. APPENDIX D: Protocol for Sampling Bats in North Dakota

XI.A. Introduction and Assumptions

Here, we provide 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 NPS' online permitting system). Research occurring on USFS land (i.e. national grasslands in ND) does 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 mistnets, OR the researcher is working with an individual who has this experience. Removing bats from mistnets is a process that requires time and supervision for an individual to become proficient, 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. 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. The decontamination protocol endorsed by the USFWS can be found at:
http://www.fws.gov/WhiteNoseSyndrome/pdf/WNSDecontaminationProtocol_v012511.pdf

XI.B. Sampling Methods

III.B.1. Mist netting

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 mistnets 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 below 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 mistnet 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 mistnets. 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 mistnets on the back of a datasheet, especially if you are identifying what net and shelf where each bat was capture. 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 capture 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.

Upon capture and removal from the net, the following characteristics are 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. Many keys exist for identifying bats to the species level, and should be consulted, especially when multiple *Myotis* species are found in an 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 where 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 ephiphyseal 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.

XI.B.2. Light tagging

Recordings of the echolocation calls of captured bats, which had 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. 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.

XI.B.3. Passive Acoustic Monitoring (Pettersson sampling system) and Analysis

While many different ultrasonic detectors can be deployed for passive acoustic monitoring, here we focus on the time-expansion system employed by the Pettersson D240X bat detector (Pettersson Elektronik, Uppsala, Sweden). Time-expansion detectors record for a short period of time (1.7 or 3.4 sections) 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. Due to the sensitive nature of the detector and the potential for damage during inclement weather, the recording system must be housed in a protective casing. In the past we have housed detectors in a small tub with a 90 degree 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. The recording system can be deployed and manually activated shortly before sunset and allowed to record until the following morning. The Pettersson D240X has many settings that can significantly impact recording, hence it is highly recommended that the researcher read the detector manual. For example, a button on the back of the detector controls whether recording is manually triggered or automatically triggered by exceeding a pre-set amplitude threshold.

Recorded echolocation calls can be analyzed using a wide variety of sound programs, although we primarily used Sonobat 3 (Sonobat, Arcata, CA) for analysis and classification. This system constructs a time-versus-frequency display (sonogram) of sound data and uses a decision engine, based on the quantitative analysis of approximately 10,000 known recordings from species across North America, to identify each recording to a species. Since variation in call structure between geographic locations is a possibility, it is wise to also include recordings made from light-tagging of local bats in the reference database. To construct the sonogram, Sonobat 3 uses fast Fourier (transform) to generate a high-quality representation of time-frequency content. The program then measures 72 parameters that characterize call structure, such as highest frequency, lowest frequency, and duration, of each individual call in the recorded sequence. Using those parameters, Sonobat 3 then employs a series of algorithms, including those for recognizing endings of calls and trends in a sequence, to ultimately make identification assignments to the species level. However, Sonobat 3 also uses a minimum acceptable quality value, which can be adjusted for sensitivity, and any recordings that fall below the desired quality level will not be classified. Sonobat 3 combines the species identification of each call and their associated probability in the sequence to construct a species level classification containing an overall probability of that identification being correct. Classifying an entire sequence will typically provide more reliable results than just analyzing single calls alone, as this method combines information within the sequence and avoids any issues of pseudo-replication.

XII. APPENDIX E. Capture data

Date	Location	GPS	Elev (m)	Cap Time	Species	Age	Sex	RC	Mass (g)	FA (mm)
10/6/2009	Little Yellowstone SP-Camp	N46°34'45.32" W97°53'29.90"	349.3	9:55	LANO	A	F	P	11.5	42.2
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:45	LANO	A	F	P	15	42.07
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:46	LANO	A	F	P	11.5	41.68
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:46	LANO	A	F	P	17	42.84
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:46	LANO	A	F	P	16.5	41.2
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:46	LANO	A	F	P	15	42.48
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:03	LANO	A	F	P	13	40.58
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:20	LANO	A	F	P	13	42.45
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:45	LANO	A	F	P	15.5	43.22
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:15	LANO	A	F	P	15.5	41.07
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:26	LANO	A	F	P	16	40.49
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:32	LANO	A	F	P	15.5	41.31
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:56	LANO	A	F	P	16	42.63
13/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	12:19	LANO	A	F	P	16.5	42.33
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:40	LANO	A	F	P	15.5	41.69
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:42	LANO	A	F	P	11.5	39.41
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:45	LANO	A	F	P	15	38.62
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	9:47	LANO	A	F	P	18	41.13
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:15	LANO	A	F	P	14.5	40.38
14/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:50	LANO	A	F	P	14.5	41.68
15/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:03	LANO	A	F	P	15	41.76
15/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	12:20	LANO	A	F	P	17	41.78
15/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	1:30	LANO	A	F	P	15	41.68
16/6/2009	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	1:45	LANO	A	F	P	17.5	41.86

Date	Location	GPS	Elev (m)	Cap Time	Species	Age	Sex	RC	Mass (g)	FA (mm)
23/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	10:35	EPFU	A	F	NA	13	45.23
23/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	10:35	EPFU	A	F	NA	13	44.94
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:20	EPFU	A	F	P	23.5	43.12
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:20	EPFU	A	F	P	27.5	46.65
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:30	EPFU	A	F	P	29	46.32
10/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	11:25	EPFU	A	F	P	34	46.12
10/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	11:25	EPFU	A	F	P	30	48.27
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:01	EPFU	A	F	P	28	46.11
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:01	EPFU	A	F	P	26	46.35
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:02	EPFU	A	F	P	21	47.1
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:04	EPFU	A	F	P	27	46.99
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:12	EPFU	A	F	P	33	47.41
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:15	EPFU	A	F	P	24	45.01
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	11:20	EPFU	A	F	P	25.5	46.23
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	11:20	EPFU	A	F	P	23.5	45.83
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	11:55	EPFU	A	F	P	25.5	47.6
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	12:20	EPFU	A	F	P	24.5	46.19
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	12:20	EPFU	A	F	P	31	47.5
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	10:00	EPFU	A	M	NA	16	44.78
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	10:30	EPFU	A	M	NA	18	46.51
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	10:30	EPFU	A	M	NA	19.5	47.7
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	11:05	EPFU	A	M	NA	23	48.36
2/7/2010	Grasslands-Buckhorn Pond	N47°18'01.65" W103°35'22.86"	715.67	10:27	EPFU	A	M	NA	18	46.66
13/6/2010	Painted Woods WMA-Road	N47°12'43.61" W100°58'02.01"	505.35	11:20	LANO	A	F	P	19	44.59
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:03	LANO	A	F	NA	14	41.44
15/7/2010	Neu WMA-Pond	N47°58'56.98" W103°57'49.45"	568.14	12:30	LANO	A	F	NA	9	41.28
22/7/2010	Pembina Gorge-Stream	N48°56'20.16" W98°04'28.62"	330.4	10:20	LANO	A	F	NA	10	40.27

22/7/2010	Pembina Gorge-Stream	N48°56'20.16" W98°04'28.62"	330.4	11:50	LANO	A	F	NA	10.5	42.5
16/5/2010	THROS-Lower Talkington	N46°55'25.31" W103°27'53.53"	718.1	10:00	MYCI	A	F	NA	4	31.6
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	10:00	MYCI	A	F	NA	3.5	30.8
1/7/2010	Grasslands-Magpie Creek	N47°18'39.62" W103°28'17.18"	670.25	10:30	MYCI	A	F	P	5.5	29.02
3/7/2010	Grasslands-Buckhorn Pond	N47°18'01.65" W103°35'22.86"	715.67	3:00	MYCI	A	M	NA	4	31.16
6/7/2010	Little Missouri SP-Camp	N47°32'57.85" W102°44"05.72"	724.81	9:40	MYCI	A	F	NA	4	32.04
6/7/2010	Little Missouri SP-Camp	N47°32'57.85" W102°44"05.72"	724.81	12:30	MYCI	A	F	NA	4.5	32.92
6/7/2010	Little Missouri SP-Camp	N47°32'57.85" W102°44"05.72"	724.81	12:30	MYCI	A	M	NA	5	31.72
6/7/2010	Little Missouri SP-Camp	N47°32'57.85" W102°44"05.72"	724.81	12:30	MYCI	A	F	P	7	33.14
15/5/2010	THROS-Peaceful Valley	N46°57'33.05" W103°30'04.55"	684.27	10:09	MYEV	A	M	NA	6.5	39.73
15/5/2010	THROS-Peaceful Valley	N46°57'33.05" W103°30'04.55"	684.27	10:09	MYEV	A	M	NA	6.5	40.1
23/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	11:20	MYEV	A	F	NA	5	38.31
23/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	12:50	MYEV	A	F	NA	7	38.23
23/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	1:15	MYEV	A	F	NA	7	39.23
3/7/2010	Grasslands-Buckhorn Pond	N47°18'01.65" W103°35'22.86"	715.67	9:50	MYEV	A	F	NA	8.5	38.48
3/7/2010	Grasslands-Buckhorn Pond	N47°18'01.65" W103°35'22.86"	715.67	9:58	MYEV	A	M	NA	7.5	36.87
3/7/2010	Grasslands-Buckhorn Pond	N47°18'01.65" W103°35'22.86"	715.67	10:10	MYEV	A	M	NA	6	38.53
14/5/2010	THROS-Upper Talkington	N46°55'55.29" W103°25'56.15"	713.84	10:27	MYLU	A	F	NA	8	40.1
15/5/2010	THROS-Peaceful Valley	N46°57'33.05" W103°30'04.55"	684.27	12:10	MYLU	A	M	NA	7	37.71
19/5/2010	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	11:00	MYLU	A	M	NA	4	28.44
19/5/2010	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	11:05	MYLU	A	F	P	5	34.03
19/5/2010	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	11:46	MYLU	A	M	NA	4	31.04
21/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	9:30	MYLU	A	M	NA	4.5	29.44
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.73
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.4
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6	36.92
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	35.14
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.63
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6	35.43
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	35.78

22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6	39.3
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	8	37.82
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.31
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	38.37
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	5	35.82
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	5	37.27
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.26
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	35.9
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	8	37.59
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	37.31
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	36.08
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	39.51
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6.5	36.49
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	37.99
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	5	35.41
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	5	36.5
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	7	38.28
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	5.5	34.78
22/5/2010	THRON-Picnic shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00-11:00	MYLU	A	F	P	6	37.26
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	10:40	MYLU	A	F	P	8.5	37.58
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	10:40	MYLU	A	M	NA	6	38.01
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	10:45	MYLU	A	F	P	6	38.71
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	10:45	MYLU	A	F	P	7	37.84
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:01	MYLU	A	F	P	9	37.64
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:12	MYLU	A	F	P	7	38.54
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:22	MYLU	A	F	P	10	37.07
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:35	MYLU	A	F	P	10	37.38
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:40	MYLU	A	M	NA	7	37.14
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:30	MYLU	A	F	P	6.5	37.8
8/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	8	37.09

9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	9	37.96
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	9	39.69
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	M	NA	8	37.28
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	9	38.8
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	9	36.18
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	9.5	38.73
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	10	37.52
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	10	37.92
9/6/2010	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:00-10:30	MYLU	A	F	P	10	39.27
9/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:26	MYLU	A	F	P	9.5	37.43
10/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:40	MYLU	A	F	P	11	37.63
10/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:45	MYLU	A	F	P	9.5	37.97
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	8.5	38.25
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	8	37.51
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	10	38.47
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	9	36.49
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	10	37.08
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	10	38.81
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	10	38.69
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	9	38.01
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	10:30	MYLU	A	F	P	11	39.43
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:13	MYLU	A	F	P	7	37.62
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:13	MYLU	A	F	P	7	36.74
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	12:13	MYLU	A	F	P	9	37.01
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	1:45	MYLU	A	F	P	8	38.34

12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	1:45	MYLU	A	F	P	8	38.62
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	1:45	MYLU	A	F	P	9	35.41
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	1:45	MYLU	A	F	P	9	39.52
12/6/2010	Painted Woods WMA-Barn	N47°12'55.22" W100°57'59.22"	508.4	1:45	MYLU	A	F	P	7	34.83
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:00	MYLU	A	F	NA	9	40.19
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:02	MYLU	A	F	NA	10	39.02
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYLU	A	F	NA	8	37.9
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYLU	A	M	NA	7.5	37.58
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYLU	A	F	NA	8	37.56
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:21	MYLU	A	F	NA	7.5	37.75
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:23	MYLU	A	F	NA	8.5	38.46
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:23	MYLU	A	F	NA	8.5	36.38
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:27	MYLU	A	F	P	11.5	38.68
19/7/2010	Turtle Mtn-Gravel Lake	N48°57'48.99" W99°50'07.17"	649.83	10:20	MYLU	A	F	NA	9.5	40.58
19/7/2010	Turtle Mtn-Gravel Lake	N48°57'48.99" W99°50'07.17"	649.83	10:20	MYLU	A	M	NA	8	37.06
19/7/2010	Turtle Mtn-Gravel Lake	N48°57'48.99" W99°50'07.17"	649.83	10:20	MYLU	A	F	NA	7	38.09
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYLU	A	M	NA	9	38.22
19/5/2010	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	10:45	MYSE	A	M	NA	5.5	38.57
19/5/2010	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	11:00	MYSE	A	M	NA	5.5	36.99
21/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	9:33	MYSE	A	F	NA	7	39.13
21/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	9:45	MYSE	A	F	NA	4	32.62
6/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:30	MYSE	A	F	P	7	35.13
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:22	MYSE	A	F	P	9	37.9
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	12:53	MYSE	A	F	P	7	34.92
7/6/2010	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	1:05	MYSE	A	M	NA	9	37.28
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	F	NA	9	36.2
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	F	NA	9	38.22
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	M	NA	7.5	34.76
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	M	NA	8	37.33

7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	F	NA	6.5	35.75
7/7/2010	Smith Grove WMA-Pond	N47°09'42.32" W100°58'50.89"	507.79	10:11	MYSE	A	F	NA	8	34.96
21/5/2010	THRON-Pond	N47°35'40.54" W103°19'03.02"	608.99	9:40	MYLU	A	F	NA	3.5	31.74

Date	Location	GPS	Elev (m)	Cap Time	Species	Age	Sex	RC	Mass (g)	FA (mm)	Tag #	Freq
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:00	EPFU	A	F	P	19	46.79	162869	151.72
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:05	EPFU	A	F	NA	23	45.96		
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:10	EPFU	A	F	P	22	45.62		
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:30	EPFU	A	F	NA	21	46.75		
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:30	EPFU	A	F	P	20	44.61		
25/5/2011	Cross Ranch SP-Pond	N47°12'45.51" W100°59'52.65"	505.05	11:45	EPFU	A	F	P	25	46.08	162740	150.416
22/6/2011	THROS-Halliday Well	N46°57'06.91" W103°29'41.54"	690.06	12:05	EPFU	A	M	NA	22	46.31		
22/6/2011	THROS-Halliday Well	N46°57'06.91" W103°29'41.54"	690.06	12:36	EPFU	A	M	NA	20	43.96		
23/6/2011	THROS-Campsite 52	N46°56'59.45" W103°32'03.56"	684.27	10:00	EPFU	A	M	NA	13	44.76	152738	150.336
20/7/2011	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	10:45	EPFU	A	M	NA	16.5	45.86		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	10:20	EPFU	A	F	P	24	47.07		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	11:50	EPFU	A	M	NA	19	46.39		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	12:05	EPFU	A	F	NA	16	45.83		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	12:55	EPFU	A	M	NA	17	43.41		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	12:55	EPFU	A	M	NA	15	43.69		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	1:00	EPFU	A	F	NA	18	46.53		
15/7/2011	Turtle River SP-Creek	N47°56'27.97" W97°30'02.84"	292.91	10:00	LABO	A	F	Nipples visible	15	43.12		
20/7/2011	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	11:35	LACI	A	M	NA	22	54.13		
19/5/2011	THROS-Peaceful Valley	N46°57'33.05" W103°30'04.55"	684.27	10:20	LANO	J	F	NA	9.5	41.17	162870	151.758
12/7/2011	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	10:45	LANO	A	F	NA	11	40.96		
13/7/2011	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:00	LANO	A	F	P	14	41.02		
13/7/2011	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:00	LANO	A	F	NA	8	40.64		
13/7/2011	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:00	LANO	A	F	NA	9	39.01		
13/7/2011	Turtle River SP-Bridge	N47°56'12.86" W97°29'56.14"	290.17	11:00	LANO	A	F	P	14	39.15		
15/7/2011	Turtle River SP-Creek	N47°56'27.97" W97°30'02.84"	292.91	1:00	LANO	A	F	NA	12	41.31		
15/7/2011	Turtle River SP-Creek	N47°56'27.97" W97°30'02.84"	292.91	1:05	LANO	A	F	NA	14	39.91		
29/7/2011	Turtle River SP-Creek	N47°56'27.97" W97°30'02.84"	292.91	11:30	LANO	A	F	NA	10.5	40.52		

22/6/2011	THROS-Halliday Well	N46°57'06.91" W103°29'41.54"	690.06	11:00	MYCI	A	M	NA	3	30.52	152737	150.317
20/7/2011	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	10:05	MYCI	A	M	NA	5	31.14		
20/7/2011	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	10:30	MYCI	A	F	NA	4.5	31.92		
21/6/2011	THRO Elkhorn-Pond	N47°13'44.62" W103°40'27.67"	717.19	11:15	MYEV	A	M	NA	6	36.78	162864	151.56
22/6/2011	THROS-Halliday Well	N46°57'06.91" W103°29'41.54"	690.06	10:15	MYEV	A	F	NA	7	38.52	152736	150.298
20/7/2011	THRON-Culvert	N47°36'06.47" W103°16'41.06"	595.88	10:30	MYEV	A	M	NA	7	38.07		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7	38.53		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7	37.52		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	38.03		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	9	38		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	9	37.6		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	37.56		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	39.28		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7.5	37.03		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	37.74		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7	34.52		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	36.27		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7	36.91		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	38.06		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	7.5	37.15		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	6.5	40.43		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8	38.37		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	9.5	37.52		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	10.5	37.76		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8.5	39.36		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	10	38.93		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	10	37.15		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8.5	38.75		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	8.5	36.42		
27/5/2011	Cross Ranch SP-Ampit	N47°12'43.75" W100°59'57.41"	507.49	10:10	MYLU	A	F	NA	9	37.78		

19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	M	NA	10	36.89		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	M	NA	7	37.53		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	11	37.37		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	10	37.26		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	9	36.49		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	7	39.32		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	7	37.37		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	10:00	MYLU	A	F	NA	7	37.83		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	9	38.07		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	9	38.23		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	8.5	38.9		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7.5	38.24		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	10	38.24		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	8	38		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7	37.86		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	9	36.66		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	10	39.11		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	6.5	34.85		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7	35.98		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	11	38.2		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	9.5	38.24		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7.5	39.17		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7	38.58		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7	38.69		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	8.5	38.38		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	6.5	38.35		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	6.5	37.4		
19/7/2011	THRON-Picnic Shelter	N47°35'41.71" W103°20'11.86"	597.41	9:46	MYLU	A	F	NA	7.5	36.19		
21/7/2011	THRON-Pond	N47°35'40.54" W103°18'34.94"	608.99	10:50	MYLU	A	M	NA	8	40.34		
17/6/2011	THRO Elkhorn-Trough	N47°13'42.14" W103°38'50.38"	683.66	12:30	MYVO	A	F	NA	7.5	39.33	162868	151.678