Regional Distribution and Monitoring of Bats, Especially Species of Conservation Concern, Along the Lower Missouri River in South Dakota.

BY

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This thesis is approved as creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance for this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

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Mist netting, and acoustic surveys for bats were conducted along the Missouri River and it's tributaries in South Dakota during 2005 and 2006. Seventeen areas were sampled, fifteen of which had not be previous surveyed. One hundred sixty-three bats were captured, representing 7 species. Distribution, morphometric, reproductive, recapture, and capture rate data for the region are presented. As a result *Lasiurus cinereus* and *Lasionycteris noctivagans* are likely summer residents in the region, and *Myotis ciliolabrum* may be present. Species accumulation curves were compiled for eight areas that were repeatedly sampled. Two asymptotic models were fitted to these curves to estimate the effort required to determine bat species richness. The species accumulation models fit capture data well ($r^2 > 0.7681$). The resulting recommended minimum sampling effort is 284 net-hours: approximately 5 nets set up for 4 hours for 14 nights or 70 net-nights. A minimum-effort guideline is important due to the status of bats, the need for better management, and the pervasiveness of short-term predevelopment surveys by wind energy companies in this region. It is concluded, however, that minimum-effort should not be the goal. Radio-tagging/tracking was also conducted. The roosting habits/behavior of six species is presented. Selectivity of different roost characteristics varied among species but the dominate tree selected was *Populus monilifera*. Home-range and habitat selection analyses were conducted for *Myotis septentrionalis* and *Eptesicus fuscus*. The use and importance of gallery forest is likely underestimated. This habitat is important for bats in the region and should be a conservation priority.

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Chapter 1

JUSTIFICATION AND NEED

Insufficient data regarding many aspects of bat natural history hinders conservation efforts associated with bats in South Dakota. At this time, information is mostly limited to bat species in western South Dakota, particularly the Black Hills. Since the inception of the Dakota Territory in 1861, 26 studies (excluding the copious number of intra-agency technical reports) have concentrated on bats in western South Dakota (all land in South Dakota west of approximately W 101° longitude; Kiesow *et al.,* 2004; Swier, 2003 and 2006), beginning with Hayden in 1862. Only four studies of bats have focused on the eastern half of South Dakota. Until the work of Swier (2003) and Lane *et al.* (2003), more than 35 years had elapsed since any studies had been done in the eastern two-thirds of South Dakota (Jones and Genoways, 1967; Findley, 1956).

Data gaps relating to bats in South Dakota include but are not limited to: long-term monitoring of sites or populations, population status, population distribution, foraging habits and habitats, roosting sites, migratory patterns, reproductive strategies, population structure, and genetic structure - particularly in central and eastern South Dakota (Kiesow *et al*., 2004). Information on migration, seasonal distributions, and movement patterns of bats has been mostly limited to small scale seasonal and migratory movements (>100 km maximum linear distance), or to cave utilizing and/or endangered species. Limited (i.e., sample size and spatial distribution) museum and capture records have been used to infer large scale migratory movements (< 100 km) in non-cave utilizing and/or non-endangered species migratory movements (Cryan, 2003).

The dearth of information concerning migratory movements, both large scale and small scale, of South Dakota's bats remain a large gap in our understanding of their natural history. The possible migratory patterns and behaviors of bats among critical maternity roosts, hibernacula, winter ranges, and summer ranges are unknown. Swier (2003) and unpublished data from Tigner (Kiesow *et al.,* 2004) suggest that possible migratory corridors may include the wooded eastern and western state borders and the Missouri River drainage. Data gaps result from a lack of data collection and a lack of interest by biologists and managers concerning bat species. Furthermore, bats are difficult to study, which limits our detailed understanding of their natural history. Factors which make research on bat migration difficult include their extreme mobility, body size, widely dispersed populations (some species), nocturnal activity patterns, and cryptic and/or inaccessible roost sites (Kunz, 1988; Petryszyn, 1995).

To properly understand and conserve bats in South Dakota it is crucial to greatly expand bat related research efforts and data collection. Knowledge of migratory patterns, roosting habits, habitat utilization and home-range size, combined with a better understanding of species distributions will help identify critical conservation time frames and locations in the state for individual species or groups of species. These efforts are critical for data based management decisions and integration of this information into the South Dakota Comprehensive Fish and Wildlife Conservation Plan and the South Dakota Bat Management Plan.

STATUS

Much of the natural history of South Dakota's species of bats remains unknown. Currently twelve species of bats (officially recognized; Choate and Jones, 1981; Lane *et al.,* 2003), are found in South Dakota. Table 1.1 lists the current scientific name (American Society of Mammalogists), common name, and abbreviated names used throughout this thesis for each bat species (Table 1.1). Of these twelve, six are considered rare (S1, S2, S3[1]) and monitored by the South Dakota Natural Heritage Program (SDNHP, 2004). In addition, three species of bats (*Myotis septentrionalis*, *M. thysanodes pahasapensis*, and *Corynorhinus townsendii*) are identified as species of greatest conservation need by the South Dakota Comprehensive Fish and Wildlife Conservation Plan. Of these three species, the northern myotis (*M. septentrionalis*) is restricted to riparian habitats along the Missouri River. Furthermore, Swier (2003 and 2006) showed that the seven species of bats (*M.ciliolabrum, M. septentrionalis, M lucifugus, Eptesicus fuscus, Lasionycteris noctivagans, Lasiurus cinereus,* and *L. borealis*) found in eastern South Dakota were concentrated along the Missouri River drainage. The work of Lane *et al.* (2003) added *Nycticeius humeralis* to the species known to utilize this region. Continued efforts along the Missouri River drainage area were a significant part of this present research.

[1] S1 = Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction. S2 = Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range. S3 = Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.

OBJECTIVES

The objectives of this study were to:

1. Determine migratory behaviors/patterns and migratory timing of bats in South Dakota, specifically those that may use the Missouri River drainage and its tributaries as corridors.
2. Determine the distribution, seasonal activity patterns, and habitat selection of bats utilizing the Lower Missouri River drainage in South Dakota.
3. Calculate a minimum mist netting/live capture sampling effort for eastern and central South Dakota that can be used for wind-power predevelopment surveys.

Table 1.1. Scientific name, common name and abbreviated names (American Society of Mammalogists) for all bats recorded as being present in South Dakota (officially recognized; Choate and Jones, 1981; Lane *et al.*, 2003)

Scientific name	Common Name	Abbreviated Name
Myotis evotis Δ	Long-eared Myotis	*M. evotis, M. evo*
Myotis septentrionalis • Δ	Northern Myotis	*M. septentrionalis, M. sept*
Myotis lucifugus •	Little Brown Myotis	*M. lucifugus, M. luc*
Myotis thysanodes Δ	Fringe-tailed Myotis	*M. thysanodes, M. thy*
Myotis volans	Long-legged Myotis	*M. volans, M. vol*
Myotis ciliolabrum •	Western Small-footed Myotis	*M. ciliolabrum, M. cilio*
Lasionycteris noctivagans • Δ	Silver-haired Bat	*L. noctivagans, L. noc*
Eptesicus fuscus •	Big Brown Bat	*E. fucus, E. fus*
Lasiurus borealis •	Eastern Red Bat	*L. borealis, L. bor*
Lasiurus cinereus •	Hoary Bat	*L. cinereus, L. cin*
Corynorhinus townsendii Δ	Townsend's Big-eared Bat	*C. townsendii, C. tow*
Nycticeius humeralis • Δ	Evening Bat	*N. humeralis, N. hum*

• Indicates species found in Eastern and Central South Dakota
Δ Indicates species monitored by South Dakota Natural Heritage Program

EXPECTED BENEFITS

The South Dakota Bat Working Group (SDBWG) in cooperation with South Dakota Game, Fish, and Parks (SDGFP) recently designed a State Bat Management Plan (Kiesow *et al.,* 2004) that outlines several objectives and strategies. The goal of this research was to aid in the fulfillment of strategies 5.2B, 5.2C, and 5.2E of objective 5.2 in the Bat Management Plan:

> **Strategy 5.2B.** Continue to gather information on reproductive rates, home ranges, and movement patterns of each species, particularly rare species, in each region of the state. Continue to save and process bats tested by SDDOH (South Dakota Department of Health) each year (important for distribution, and reproductive data). Create GIS maps of high bat activity (e.g., roosting, foraging, or hibernating) and bat distributions in South Dakota for purposes of planning.
>
> **Strategy 5.2C.** Census bats along non-urban riparian corridors to understand the value of these habitats for foraging and roosting, and as migration routes. Monitor bats along the Missouri River and identify the importance of this river system for migrating bats. Survey bridges and box culverts along these riparian corridors to determine location and type (e.g., swallow nest or crevices) of bat roosts.
>
> **Strategy 5.2E.** Create a database of reference calls using AnaBat and Pettersson bat detection systems.

In addition to providing information to help fulfill the objectives of the South Dakota Bat Management Plan, this project was to provide much needed information on bats in riparian areas along the Missouri River because few data are available on bats in

South Dakota, especially in regions outside of the Black Hills. With this study, I expect to gain additional knowledge about bat populations along the Missouri River and learn more about the importance of floodplain forests in this region.

Herein, I provide information on the distribution and habitat use of bats along the Missouri River, the possible migration routes of bats in this region and what constitutes adequate sampling effort. The latter subject is important due to the increased interest shown by wind energy companies and developers with regard to wind power in this region. Wind farms directly impact bats (e.g., mortality; especially migratory bats; *L. cinereus, L. noctivagans, and L. borealis*; Osborn *et al.,* 1996; Johnson *et al.,* 2003), which tend to use corridors (e.g., rivers) during migration. Therefore, information collected in this study can and should be directly applied towards bat management as well as provide data for the use in environmental reviews of proposed wind farm locations.

Chapter 2

This chapter is divided into two sections. The first section covers the general survey results of the 2005 and 2006 field seasons, and is presented in a traditional format. The second section is the result of the first capture record of a Western Small-footed Myotis (*Myotis ciliolabrum*) along the Lower Missouri River in South Dakota and is presented in Note format to provide a detailed account of this capture and its importance.

Section 1

INTRODUCTION

LIVE CAPTURE

The use of mist nets to capture live bats is a traditional method used in bat research. While harp traps are an alternative and can be more efficient within a very narrow range of applications (e.g., caves), mist nets are more adaptable under a greater range of circumstances, and are more cost effective (Kunz, 1988). The success of mist-netting, like other live capture methods for bats, can be dependent upon site specific conditions and individual species of bat ecologies being conducive to their application. As such, efforts often provide samples that are habitat biased and species biased (Kunz, 1988). The effectiveness of mist nets may be over-rated - Larsen *et al.* (2006, *In press*) found that actual capture rate of mist nets may be below 5% of bats utilizing a given air space (fly-way). Mist netting in South Dakota may also underestimate population size and biodiversity due to strong and ever present winds in the region (Pedersen *et al.,* unpubl.). Wind can cause movement in mist nets, which makes them easier for bats to detect with their echolocation, thus reducing capture rates (Sedlock, 2001). Rain or mist droplets adhering to mist nets can also make them easier to detect. Other location dependent variables that can influence capture success include light-levels and habitat complexity. Aspects of the natural history of individual species affecting capture success include but are not limited to: foraging/commuting behavior, spatial memory, flight agility/maneuverability and the plasticity of echolocation behavior (Lang *et al.,* 2004). When hand nets, hand-capture, and funnel traps are not feasible for obtaining live captures, there are no ethical alternatives to deploying mist-nets.

RECAPTURE

The use of bands to individually mark captures for the study of bat biology started in 1916 by Allen (1921), and has been refined over the years to provide information on bat movements and migrations. Griffin (1945) used bat bands to document the movements of six facultative cave species of bats in the Northeastern United States. Griffin had 39 recoveries at distances of 16 km or greater, with seven of those recoveries at a distance of 100 km or greater. Movements between summer and wintering areas, as well as inter-seasonal movements were documented (Griffin, 1945). Early banding efforts also documented long-distance migrations in *Tadarida brasiliensis mexicana* - Glass (1958) reported that *Tadarida brasiliensis mexicana* banded at summer colonies in Oklahoma had been recovered in Texas at distances up to 805 km from their summer colony. Davis and Hitchcock (1965) documented seasonal migrations in *Myotis lucifugus* as far as 277 km. Tuttle and Stevenson (1977) noted that increases in band recoveries, both captures and reported recoveries in, near, and away from caves, of *Myotis grisescens* coincided with the spring and fall migrational movements of this species. With juvenile mortality being significantly higher, Tuttle and Stevenson (1977) concluded that stress of migration is likely a significant source of mortality in this species.

Band recovery rates for flying vertebrates are notoriously low, especially for chiropteran species as they respond adversely to handling (Kunz, 1988). Tuttle and Stevenson (1977) banded 40,182 *Myotis grisescens* between 1961 through 1974, with only 71 (0.20%) ever being recovered at non-cave locations. However, 19,691 *Myotis grisescens*, a cave-obligate species, were recaptured at cave sites, home cave sites and other cave locations, at a rate of 49.07%. Davis and Hitchcock (1965) reported band recovery rates for *Myotis lucifugus* between 1.55% and 1.04% during consecutive years at a cave in Vermont.

ACOUSTIC SAMPLING

Bats have evolved the ability to utilize echolocation to gain information about their surroundings. Echolocation is the emission of high frequency sound by bats that reflect off of objects and back to the bats ears (Griffin, 1958). Acoustic sampling is the recording of bat echolocation calls for later analysis. In addition to mist-netting bats, acoustic sampling was preformed during this study to detect feeding (the rapid and increasing calls used during prey capture) and search (the often species-specific vocalizations used for navigation) phase bat calls in various areas. Combining these two methods increases the likelihood of detecting a species (Kuenzi and Morrison, 1998). Acoustic sampling methods are problematic but allow tentative species identification

(Kuenzi and Morrison, 1998; O'Farrel *et al.,* 1999), as each species has a "vocal fingerprint" which can be described using call parameters such as: characteristic slope, characteristic frequency, maximum, high, and low frequency, frequency of knee (heel), and duration of the call. Additionally, acoustic sampling can assist in the estimation of animal/habitat use patterns without capturing, handling, and possibly harming the animals. Mist-netting locations provide samples that are habitat-biased, whereas acoustic sampling can provide an independent population estimate that is not as restricted by habitat variables that may limit the use of mist-netting or harp trapping techniques (O'Farrell and Gannon, 1999). The acoustic sampling conducted during this project was to add to an existing Anabat (low-resolution zero-crosssing sonograms) and Pettersson (high-resolution sonograms) acoustic library as laid out in the South Dakota Bat Management Plan (Kiesow *et al.,* 2004) for the Missouri River drainage and to supplement data collected from mist netting.

MATERIALS AND METHODS

LIVE CAPTURE AND RECAPTURE

Bats were captured by mist-netting riparian areas along the eastern and western borders of the Missouri River in South Dakota. Mist nets (Avinet, New York) varied in length (3, 6, 9, and 18 m) and height (3 and 6 m), and were deployed to obtain the greatest capture rate at each individual net location by selecting the best fit for adjacent vegetation and suspected fly-ways (Francis 1989; Kunz, 1988). Nets were set one hour before dusk then removed before dawn or as conditions dictated. Nets were constantly monitored to reduce the stress incurred by ensnared animals. In areas that were netted repeatedly, nets were moved within the area in subsequent nights to avoid decreases in capture rates (Gram and Faaborg, 1997; Larsen *et al., In press;* Kunz, 1988). Once bats were captured and identified to species, various measurements were taken, including sex and reproductive status, forearm length, age, and body weight. Species identification was accomplished using field keys (van Zyll de Jong, 1985; Higgins *et al.,* 2000; Schwartz & Schwartz, 2001; Adams, 2003). Sex was determined by visual inspection and reproductive status was determined by visual inspection and palpation (Racey, 1988). Forearm lengths were obtained using a wing rule (Avinet, New York). Bats were aged into relative age classes (juvenile, sub-adult, adult) by epiphyseal ossification of the metacarpals (Anthony, 1988). Additionally, individuals were checked for visible ectoparasites. Captured bats were weighed using either a spring scale (Pesola AG, Switzerland) or electronic scale (Acculab®, New York). Individuals were fitted with a forearm band [blue oxidized aluminum lipped South Dakota Game, and Parks (SDGFP) 05300-05450 series bands or split ring plastic bands series 200P-400P] for later identification in the case of recapture to prevent duplication of data, document site fidelity and movements. In keeping with SDGFP doctrine, female bats were banded on the right forearm and males on the left forearm. Mine and cave surveys in the South Dakota portion of the Black Hills were conducted to aid in the determination of migratory destination. Selected individuals were outfitted with Holohil® LB-2 or LB-2N radio-trasmitters for later radio-tracking (see Chapter 4). Global Positioning System (GPS) location, canopy cover, and a description of surrounding vegetation species were also recorded for each netting location.

ACOUSTIC SAMPLING

Pettersson (Pettersson Elektronik AB, Sweden) bat-detectors (D240x) were connected to either a laptop computer (M725; Gateway Inc., California) running Sonobat™ (Sonobat™, California) versions 2.5 and 2.5.5 software or a digital recorder (Olympus VN-240) and later imported to Sonobat™ (2.5 and 2.5.5). Detectors were placed at separate locations to record bat calls over an extended period of time as conditions dictated. The Pettersson bat-detector (D240x) and Sonobat™ (2.5 and 2.5.5) combination was selected because it would produce and enable the analysis of high-resolution sonograms. Species identification was made through comparative analysis (Fig. 2.3 and 2.4) using known reference calls (Sonobat™; www.batcalls.org, 2006). This was possible because Sonobat™ software renders full spectrum high-resolution sonograms. Characteristics used in analyses included: characteristic slope, characteristic frequency, maximum, high, and low frequencies, frequency of knee (heel), and duration (Table 2.3). GPS locations of each sampling were taken and the number of occurrences (or passes) was recorded when possible.

RESULTS

LIVE CAPTURE

During the 2005 field season, 63 days/nights of field work were conducted in South Dakota which involved a total of 192 hours of netting and 178 net nights (NN).

Seventeen areas were sampled during the 2005 field season (Fig. 2.1), three of which were sampled in previous work by Swier (2003). This brought the total number of areas sampled along the Lower Missouri River at the end of 2005 to 27. An average of 0.489 bats per net per night (BNN) were captured during 2005, with a range from 0.00 BNN at Lower Brule Sioux Reservation sites (LBSR) and Running Water GPA (Game Production Area) to 1.50 BNN at Karl Mundt National Wildlife Refuge (NWR). If sub-optimal sites (locations with a BNN equal to zero) are excluded, then the average BNN increases to 0.64. Bats per net per night for each sample site are presented in Figure 2.2. The sites with the highest BNN's (0.6 and above) for the 2005 field season where: Arikara GPA, Farm Island RA (Recreation Area), Oahe Downstream RA, Byre GPA, Black Buffalo site at Lewis and Clark Boy Scout Camp, and Karl Mundt NWR. A total of 87 bats were captured and tagged in 2005. Six different species were captured: 50.6% (n = 44) Northern Myotis, *Myotis septentrionalis*; 4.6% (n = 4) Little Brown Myotis, *Myotis lucifugus*; 27.6% (n = 24) Big Brown Bat, *Eptesicus fuscus*; 2.3% (n = 2) Silver-haired Bat, *Lasionycteris noctivagans*; 11.5% (n = 10) Eastern Red Bat, *Lasiurus borealis*; and 3.4% (n = 3) Hoary Bat, *Lasiurus cinereus.*

The average "catchability" of each individual species as determined by total number captured of that species during the 2005 field season divided by the total net nights during the 2005 field season were: 0.247 BNN for *Myotis septentrionalis*; 0.0225 BNN for *Myotis lucifugus*; 0.135 BNN for *Eptesicus fuscus*; 0.011 BNN for *Lasionycteris noctivagans*; 0.0562 BNN for *Lasiurus borealis*; and 0.0169 BNN for *Lasiurus cinereus*. If the sub-optimal sites, sites with a 0.00 BNN due to intrinsic properties of the site (e.g., vegetative structure, winds), are excluded then the BNN for each species is increased by a factor of 1.31X.

During the 2006 field season, 111 days/nights of field work were conducted in South Dakota that included a total of 66 hours of netting and 84 net nights (NN). This brought the total number of nets nights, including all areas from both seasons, up to 262 net nights (NN). Four areas were sampled during the 2006 field season; each of which had been previously sampled in 2005 (Fig. 2.1). This was due to redirection of the project from sampling new areas to capturing bats for radio-tagging and radio-tracking (see Chapter 4). The total number of areas sampled along the Lower Missouri River at the end of 2006 was 27 when combined with Swier (2003; Table 2.3). An average of 0.897 bats per net per night (BNN) were captured during 2006, with a range from 0.643 BNN at Arikara GPA, to 1.14 BNN at Fort Randall Spillway (Fig. 2.2). However, on one occasion (20 July, 2006), Oahe Downstream RA had a capture rate of 4.4 BNN. A total of 76 bats were captured and tagged in 2006 with a combined two-season total of 163 bats (Table 2.1). Seven different species were captured during 2006: 60.5% (n = 46) Northern Myotis, *Myotis septentrionalis*; 6.6% (n = 5) Little Brown Myotis, *Myotis lucifugus*; 1.3% (n = 1) Western Small-Footed Myotis, *Myotis ciliolabrum*; 23.7% (n = 18) Big Brown Bat, *Eptesicus fuscus*; 1.3% (n = 1) Silver-haired Bat, *Lasionycteris noctivagans*; 5.3% (n = 4) Eastern Red Bat, *Lasiurus borealis*; and 1.3% (n = 1) Hoary Bat, *Lasiurus cinereus.* This brought the total number of species captured during this project to seven (Table 2.1 and Table 2.3). The average total species specific catchability 2006 field season: 0.5476 BNN for *Myotis septentrionalis*; 0.0588 BNN for *Myotis* *lucifugus*; 0.0119 BNN for *Myotis ciliolabrum*; 0.214 BNN for *Eptesicus fuscus*; 0.0119 BNN for *Lasionycteris noctivagans*; 0.0476 BNN for *Lasiurus borealis*; and 0.0119 BNN for *Lasiurus cinereus*.

Morphometric, sex, and age ratio data from bats captured during the 2005 and 2006 field seasons is summarized in Table 2.1. Generally, adults were caught more frequently than juveniles for each of the seven species (even those with a limited sample size) giving an overall ratio of approximately 7/3 adults to juveniles. The sex ratio for both *Myotis lucifugus* and *Lasiurus borealis* was nearly 50/50. In *Eptesicus fuscus*, *Lasionycteris noctivagans* (limited sample size, n = 3) and *Myotis ciliolabrum* (limited sample size, n = 1) the sex ratio was skewed to males; whereas in *Myotis septentrionalis* and *Lasiurus cinereus* (limited sample size, n = 4) the sex ratio was skewed to females. The dates of palpably pregnant females, volant young, lactating females, and post lactating females of each species captured are shown in Table 2.2. Species in which some part of the reproductive data was not available through the captures of this project are noted.

RECAPTURE

I had two recaptures during the 2005 field season. The first was an adult lactating female *Myotis septentrionalis* (band number 202P) that was first captured on 1 July, 2005 at Byre GPA (Game Production Area). Bat 202P was recaptured at the same location two nights later (3 Sept., 2005) and was in excellent condition. The second was a subadult male *Myotis lucifugus* (band number SDGFP-05311) that was first captured on 10 June, 2005 at the Oahe Downstream Recreation Area. Bat SDGFP-05311 was recaptured 91 days later at the same location. The specimen was in excellent condition and had gained 1.9 g of body mass, a 33% increase.

Two recaptures were made during the 2006 field season, bringing the total recaptures for the project up to four, with an overall recapture rate of 2.45%. The first recapture of 2006 was an adult male *Myotis septentrionalis* (band number SDGFP-05312) that was first captured on 11 June, 2005 at Oahe Downstream RA (Recreation Area). Bat SDGFP-05312 was recaptured 374 days later, on 20 July, 2006 a distance of approximately 1.6 km from the original capture site, in excellent condition and had gained 2.5 g of body mass, a 31.25% increase. The second recapture of 2006 was an adult female *Myotis septentrionalis* (band number SDGFP-05343) that was first captured on 13 May, 2006 at Oahe Downstream RA. Bat SDGFP-05343 was recaptured on 20 July, 2006, a distance of approximately 1.8 km from the original capture site but still within Oahe Downstream RA. The bat was in good condition despite having lost 1.0 g of body mass, most likely due to lactation.

ACOUSTIC SAMPLING

Acoustic sampling during the 2005 season proved to be problematic due to acoustic interference, primarily from insects. Adjustments were made to compensate for interference and these adjustments (e.g., changes in sensitivity settings, changes in placement of detectors) differed nightly and even inter-nightly (within the same night/sampling period) as conditions dictated. These adjustments affected the effective range of detection by the recording equipment. The recording time was also variable due to multiple factors: interference, weather, etc. Due to these shortcomings it would be improper to use these particular acoustic samplings for population indices of these areas, as replication would not be possible. The best call recordings were used to help determine species presence/absence through comparative analysis (Figs. 2.3 and 2.4; Table 2.3) using known reference calls (Sonobat™; www.batcalls.org, 2006). Characteristics used in analysis included: characteristic slope, characteristic frequency, maximum, high, and low frequencies, frequency of knee (heel), and duration (Table 2.3). For example, the call characteristics of *Lasiuris cinereus* are a low frequency of 13-24 kHz, a high frequency of 40-18 kHz, a characteristic frequency of 13-24 kHz, a maximum frequency intensity of 30-17 kHz, and a duration of 4-20 msec (Fig 2.3). The call characteristics of *Lasionycteris noctivagans* are a low frequency of 20-26 kHz, a high frequency of 32-55 kHz, a characteristic frequency of 26-28 kHz, a maximum frequency intensity of 26-40 kHz, and a duration of 5-15 msec (Fig 2.4).

For the 2006 field season adjustments where made to the acoustic sampling efforts through the use/integration of new interference filtering (anti-katydid filters) software in the updated Sonobat™ Version. 2.5.5. This resulted in many more useable calls per unit effort than in 2005, however, acoustic interference was still a major issue. Acoustic sampling was a very useful tool in my surveys and added to our understanding of the distribution of bats in South Dakota. This can be readily seen in Table 2.3, where species were detected that were not captured in mist nets, and at some locations, species were detected long before they were captured in mist nets (Table 2.3 and Fig. 2.3). Nonetheless, acoustic sampling remains problematic along the lower Missouri River in

South Dakota, undoubtedly, further advancements in bat detectors and sound analysis software may resolve many of these problems.

SAMPLING LOCALITIES

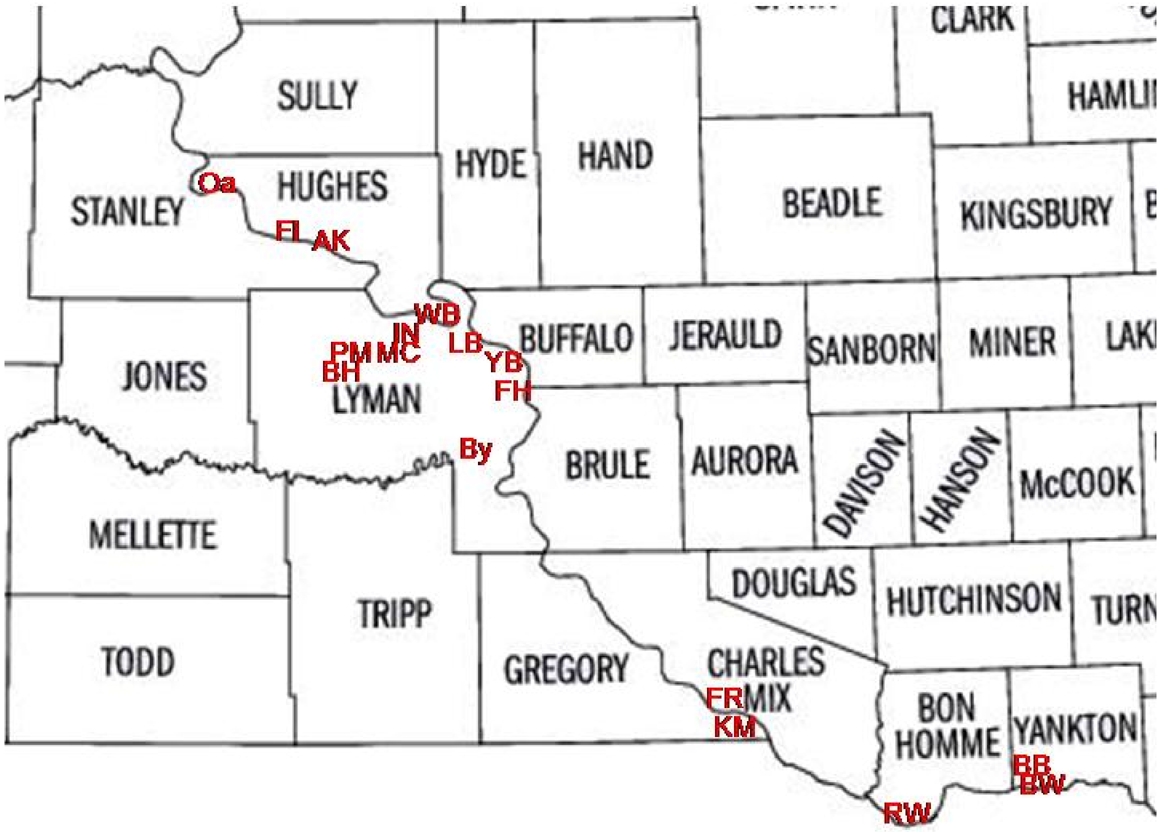

Figure 2.1. Sampling localities, acoustic and mist netting, from the 2005 and 2006 field seasons: AK (Arikara GPA; UTM: 14-0403209-4909867), BB (Lewis and Clark Boy Scout Camp, Black Buffalo; UTM: 14-0613856-4747621), BH (Bad Horse Creek LBSR; UTM: 14-0440901-4878399), BW (Lewis and Clark Boy Scout Camp, Backwater; UTM: 14-0613866-4747510), BY (Byre GPA; UTM: 14-0457516-4843880), FH (Fort Hale LBSR; UTM: 14-0471100-4868599), FI (Farm Island R.A.; UTM: 14-0398726-4910068), FR (Fort Randall Spillway; UTM: 14-0537339-4767102), IN (Iron Nation Rec. Area LBSR; UTM: 14-0444300-4882999), KM (Karl Mundt NWR; UTM: 14-0580765-4736743), LB (Lower Brule Wildlife Refuge LBSR; UTM: 14-0453100-4884999), MC (Medicine Creek LBSR; UTM: 14-0441100-4879599), Oa (Oahe Downstream R.A.; UTM: 14-0389518-4920200), PM (Pond near Medicine Creek LBSR; UTM: 14-0441301-44880398), RW (Running Water GPA; UTM: 14-0584299-4736400), WB (West Bend R.A.; UTM: 14-0441868-4891529), YB (The “Y” LBSR; UTM: 14-0454700-4879398)

Table 2.1. Summary of number of bats captured and morphological data from Eastern and Central South Dakota during 2005 and 2006*

Species	Number Captured	% ♂	% ♀	% adult	% juv.	Average Mass (g) ± 1 SD	Average Forearm Length (mm) ± 1 SD
M. septentrionalis	90	37.78	62.22	77.78	22.22	7.07 ± 0.98	35.38 ± 1.00
M. lucifugus	9	44.44	55.56	55.56	44.44	6.96 ± 1.14	35.69 ± 1.10
M. ciliolabrum	1	100.00	NA	100.00	NA	5.6 ± NA	34 ± NA
E. fuscus	42	61.90	38.10	73.80	26.20	17.38 ± 2.52	45 ± 1.77
L. noctivagans	3	66.67	33.33	66.67	33.33	13.33 ± 3.82	41 ± 1.00
L. borealis	14	46.15	53.85	61.54	38.46	12.84 ± 4.03	39.41 ± 1.88
L. cinereus	4	NA	100.00	75.00	25.00	26.75 ± 4.10	55.75 ± 0.50

* Sub-adults are counted as adults for the purpose of this table

Table 2.2. Summary of reproductive data from Eastern and Central South Dakota during 2005 and 2006

Species	Period When Pregnant Females Captured	Period When Lactating Females Captured	Period When Juvinies Captured	Period When Post Lactating Females Captured
Myotis septentrionalis	9 Jun - 10 Jun	1 Jul - 12 Jul	20 Jul - 17 Sept	20 Jul - 28 Jul
Myotis lucifugus	NA	NA	10 Aug - 9 Sept	20 Jul
Myotis ciliolabrum	NA	NA	NA	NA
Eptesicus fuscus	10 Jun	16 Jul	10 Jul - 17 Sept	20 Jul - 2 Aug
Lasionycteris noctivagans	10 Jun	NA	17 Sep	NA
Lasiurus borealis	3 Jun - 12 Jun	NA	9 Jul - 9 Sept	NA
Lasiurus cinereus	NA	NA	19 Jul	10 Jul

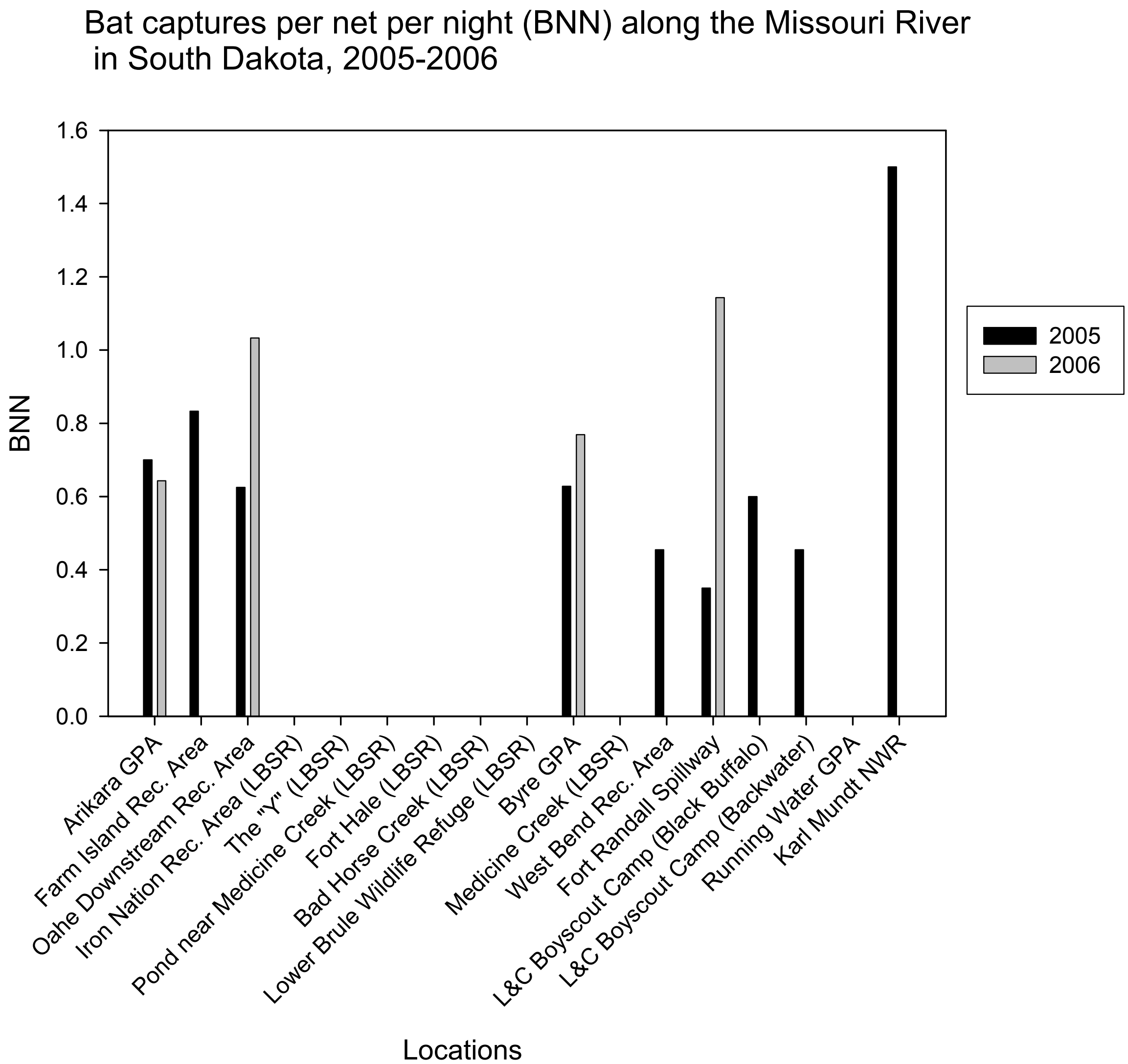

Figure 2.2. Bat captures per net per night (BNN) by locality, along the Missouri River and select tributaries in South Dakota

TABLE 2.3. Distribution of bat species along the Missouri River in South Dakota. A = acoustic detection, C = live capture. Black = field work done by Swier (2003), Gold = areas in common with Swier, Red = new areas that were sampled during this study.

Location	Species							
	E. fus	*L. bor*	*L. cin*	*L. noc*	*M. cilio*	*M. luc*	*M. sept*	*N. hum*
Adams Home Park	A	A	A	A				
American Creek Rec. Area	A	A	A	A				
Arikara GPA	AC	AC					AC	
Bad Horse Creek (LBSR)	A							
Byre GPA	AC	AC	AC	AC		AC	AC	
Clay County Rec. Area	A	A		A				
Cotton Park-Vermillion	AC	A						
Farm Island Rec. Area	AC	AC	A	A	A	AC	AC	
Fort Hale (LBSR)	A		A	A				
Fort Randall Spillway	AC	AC	A	A		A	AC	
Iron Nation Rec. Area (LBSR)	A	A						
Karl Mundt NWR	AC	AC	AC	A		C	C	
L&C Boyscout Camp (Backwater)	C		C				C	
L&C Boyscout Camp (Black Buffalo)	AC	A	AC	A		A	AC	
L&C Rec. Area	C		A				C	
La Framboise Rec. Area				C		C		
Lower Brule Wildlife Refuge (LBSR)	A	A						
Medicine Creek (LBSR)	A	A	A	A		A	A	
Oahe Downstream Rec. Area	AC	AC	A	AC	C	AC	AC	
Platte Creek Rec.Area	A							
Pond near Medicine Creek (LBSR)	A		A					
Running Water GPA								
The "Y" (LBSR)	A		A					
West Bend Rec. Area	AC	AC	AC	A		A	AC	
West Whitlocks Rec. Area		A	A			C		

*LBSR, Lower Brule Sioux Reservation

Lasiurus cinereus reference call and recorded call

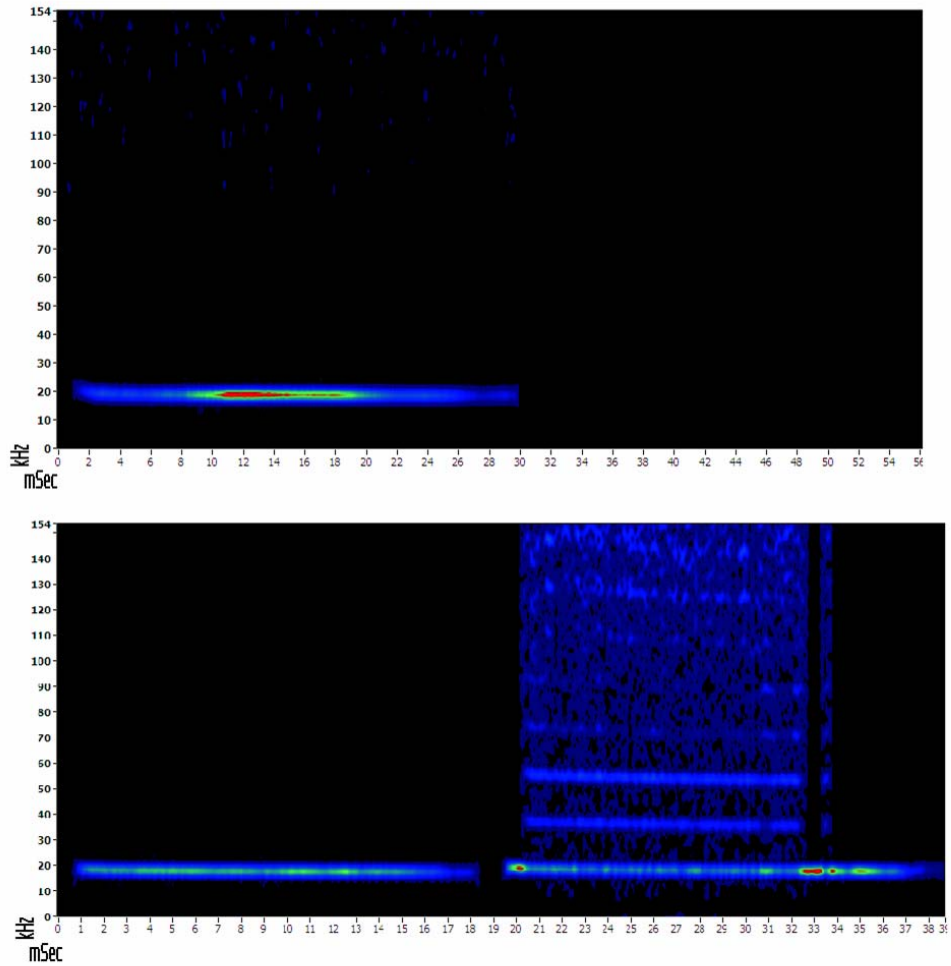

Fig. 2.3. A comparison between a *Lasiurus cinereus* reference call (top) and a call recorded at Byre GPA on 1 July, 2005 (bottom) identified as a call from *Lasiurus cinereus*. The y-axis is frequency kilohertz and the x-axis is duration in milliseconds. It should be noted that *Lasiurus cinereus* was not captured at the Byre GPA until 15 June, 2006

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Lasionycteris noctivagans reference call and recorded call

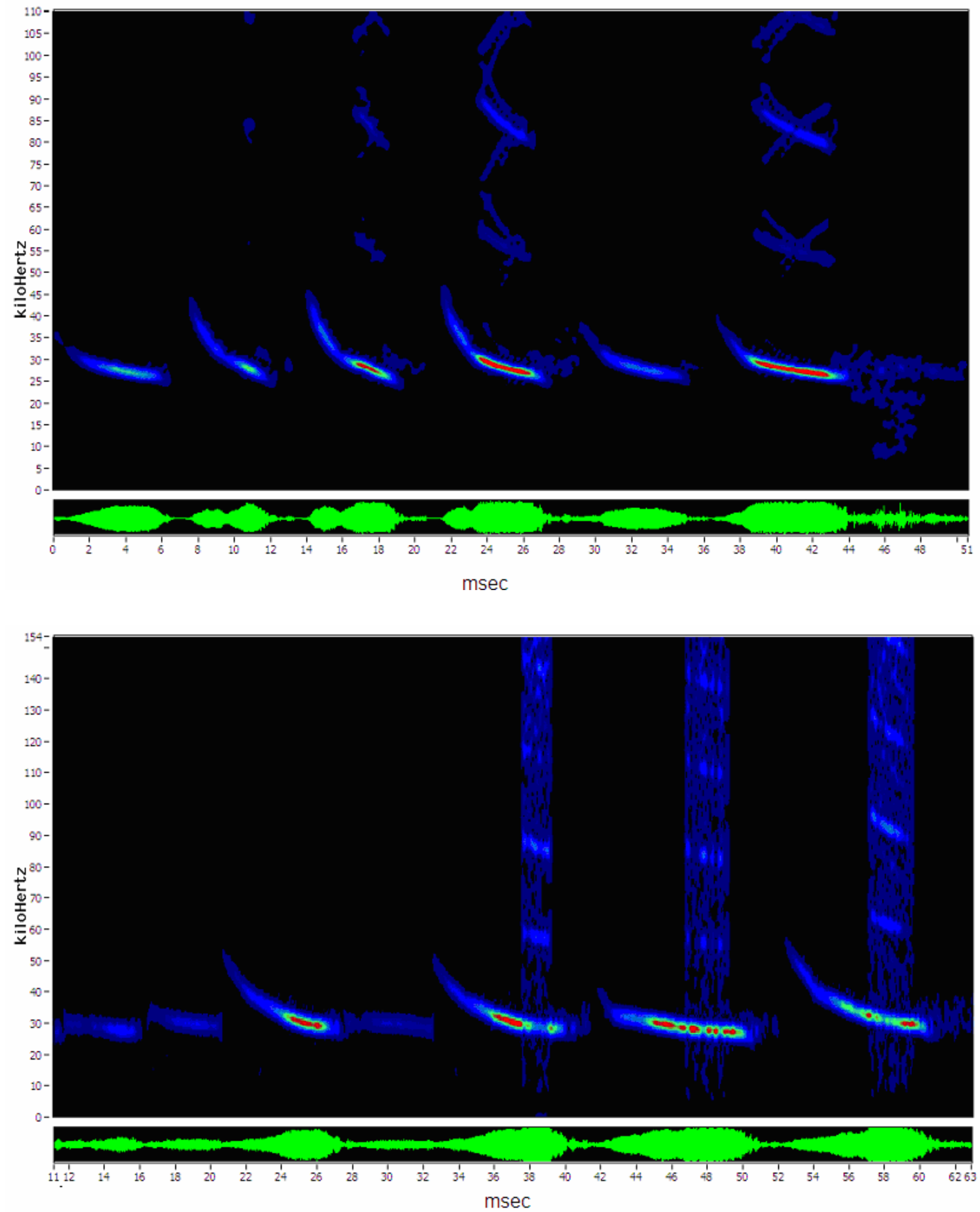


Fig. 2.4. A comparison between a *Lasionycteris noctivagans* reference call (top) and a call recorded at Fort Randall Spillway on 17 April, 2006 (bottom) identified as a call from *L. noctivagans*. The y-axis is frequency in kilohertz and the x-axis is duration in milliseconds. It should be noted that no *L. noctivagans* were captured at Fort Randall Spillway, and the calls represent the earliest record of *L.* noctivagans in Eastern and Central South Dakota.

DISCUSSION

The importance of riverine gallery forest in Eastern and Central South Dakota to bat species can not be over stated. Of the twelve species of bats known to inhabit South Dakota (SDNHP, 2004; Choate and Jones, 1981; Lane *et al.,* 2003), eight have been documented in Eastern and Central South Dakota along the Lower Missouri River drainage and select tributaries (*Nycticeius humeralis*, *Eptesicus fuscus*, *Myotis ciliolabrum*, *Myotis septentrionalis*, *Myotis lucifugus*, *Lasionycteris noctivagans*, *Lasiurus cinereus*, and *Lasiurus borealis*; Jones and Genoways, 1967; Findley, 1956; Swier, 2003 and 2006; Lane *et al.,* 2003; capture and acoustic data from my study). This is despite the fact that riverine gallery forest represents only 1.5% of the total land coverage in Eastern and Central South Dakota (Smith *et al.,* unpubl.). This comparatively high bat species richness is likely due to an abundance of trees in the floodplain, corridor effect (Stauffer and Best, 1980), available water sources, rich soils, and the creation of roosting habitat through periodic flooding and fires, together making this an ecologically rich area. The riverine gallery forest in Eastern and Central South Dakota along the Missouri River and its tributaries should be protected and conserved; even more than they are presently.

Myotis septentrionalis was the predominate bat species captured along the Missouri River; 42% of all captures in the region by Swier (2003 and 2006) and 55% of all captures in my study during the 2005 and 2006 field seasons. The discrepancy in percentages is likely arbitrary and probably due to the sampling of different locations. This does however show the importance of riverine gallery forest to *Myotis* *septentrionalis* in South Dakota, as its current distribution is restricted to these habitats along the Missouri River and its tributaries in Eastern and Central South Dakota (Swier 2003 and 2006). The possibility of a netting bias for *Myotis septentrionalis* based on the assumption that it is an interior forest species and that these areas were disproportionately sampled, is countered by the fact that areas with an ample forest interior area are absent in the region and that the second and third most frequently captured species were *Eptesicus fuscus* and *Lasiurus borealis*, both of which are considered forest edge (ecotone) species (Carroll *et al*, 2002).

The differences in capture rates for individual species between years, 2005 and 2006, was likely due to a shift in focus from sampling new areas in 2005 to sampling only optimal sites (i.e., more bats per less effort) to capture individuals for radio-tagging and tracking in 2006 (see Chapter 4). This resulted in increased capture rates, with average bats per net per night (BNN) increasing from 0.489 in 2005 to 0.897 in 2006 (an increase by a factor of almost two). Species-specific rates increased as well. For example the individual capture rate for *Eptesicus fuscus* went from 0.135 to 0.214 per net night and *Myotis septentrionalis* went from 0.247 to 0.5476 per net night. This shift in focus could have resulted in a reduction of captures of less common species, e.g., *Laisurus borealis* capture rates decreased from 0.0562 to 0.0476. However, this idea is contradicted by the capture of the very rare (regionally) *Myotis ciliolabrum* in 2006. These results are likely specific to this study area and methodology. Additionally, capture rates and species-specific catchability are mist net specific and undoubtedly the inclusion or use of harp traps in these areas may produce different results. For example, future efforts looking to study *Myotis ciliolabrum* in this region may wish to sample intensively with harp traps, as they are less affected by wind and maybe less detectable to *Myotis ciliolabrum*, a small agile flyer with excellent (clutter) echolocation abilities.

Morphometric, sex, and age ratio data are summarized in Table 2.1. In each of the seven species, even those with a limited sample size, adults were caught more often than juveniles. The general 7/3 adult/juvenile ratio may indeed reflect the actual age ratio in these populations, however, this ratio may be slightly inflated towards adults due to the shorter period in which juveniles are available for capture during the field season, but this maybe countered by the increased catchability of juveniles. The reproductive data found in Table 2.1 and Table 2.2 clearly increases our understanding of the biology of the bats found in Eastern and Central South Dakota, as data from the Lower Missouri River has been lacking. The sex and age ratio, morphological, and reproductive data (Table 2.1 and Table 2.2) for *Myotis septentrionalis* captured during this study represent the largest sample of this species ever collected in this region, and provide our first glimpse into the population dynamics and reproductive ecology of this species of concern (SDNHP, 2004).

The band recovery rate for my study of 2.45% (4 out of 163) is most likely due to the intensive sampling that occurred at the locations where recaptures occurred and indicate at least multi-year seasonal residency. Of the 104 bats banded by Swier (2003 and 2006), 52 of those along the Missouri River, and 163 bats banded during this project in Central and Eastern South Dakota, no recaptures have been made of these bats in Western South Dakota or the Black Hills, despite numerous bat and hibernacula surveys

(Tigner, unpublished reports to SDGFP: 2000, 2001, 2002, 2003, 2004, 2006 and 2007). This is, however, not unexpected given the low band recovery rates of bats (Davis and Hitchcock, 1965). Given the decreasing probability of band recovery as distance increases from the banding site and the limited scope and breadth of hibernacula surveys in the region, these data should in no way be seen as conclusive one-way or the other about whether bats from Central and Eastern South Dakota migrate in and out of the Black Hills.

Previously, the earliest record of *Lasionycteris noctivagans* in Eastern South Dakota was 21 April from Brookings, South Dakota (Swier 2006), however, *L. noctivagans* calls were recorded on 17 April, 2006 at Fort Randall Spillway (Fig 2.4). This record was within a suspected migratory corridor, the Lower Missouri River, and likely within the spring migratory period. Swier's (2003 and 2006) assertion that *L. noctivagans* is a summer resident of Central and Eastern South Dakota may indeed be correct as three additional captures of this species were made during the 2005 and 2006 field seasons; two of which were outside of known migratory periods. Additionally, *L. noctivagans* may even be present as a breeding population in this region, instead of being a transient species. A late-term pregnant adult female *L. noctivagans* was captured on 10 June, 2005 at Oahe Downstream RA, and an adult male was captured on 5 July, 2005 at Byre GPA.

On 7 June, 2006, a grounded female *Lasiurus cinereus* with two pups was found after a storm in Dell Rapids, South Dakota by Dwyane Moory. From the photographic evidence, the young were estimated to be approximately three weeks old, putting the estimate for a parturition date in the middle of May. This is similar to what Mullican (1999) documented for a female *L. cinereus* and her pup found in Mitchell, South Dakota on 1 June, 1998. The estimated parturition date for that pup was the middle of May and represents the earliest record of reproduction in *L. cinereus* in the Northern Great Plains. When combined with previous records from Swier (2003), Lane *et al.* (2003), and the data from this study (Table 2.1 and Table 2.2), there is compelling evidence that *L. cinereus* (once thought to be a migrant in the region of central and eastern South Dakota) is in fact, a full summer resident in the area.

Acoustic sampling and mist netting are, not without their limitations and biases (O'Farrell and Gannon, 1999), the best non-lethal methods available for studying bats in Eastern and Central South Dakota. Species identification of species through acoustic sampling is much more time consuming and complex than with live capture (mist netting). Acoustic sampling has, nonetheless, added to the understanding of the distribution of bats in South Dakota. As can been readily seen in Swier (2003 and 2006) and in this study (Table 2.3), there were species that were detected but were not captured, the best examples of this can be seen in sample locations on the Lower Brule Sioux Reservation where acoustic sampling accounted for 100% of species detected (Table 2.3). Indeed, acoustic sampling during this project detected 85% of species present, while mist netting detected only 55% of the species present. This difference is likely due to the effectiveness of acoustic sampling in open-unprotected areas in which mist netting is clearly ineffective. This can be seen in the sampling efforts at Lower Brule Wildlife Refuge (LBSR) and Medicine Creek (LBSR), as well as other sites, where only acoustic sampling produced results (Table 2.3). Furthermore, at some locations, species were detected long before they were captured (Fig. 2.3). Acoustic sampling will continue to be and important tool for gathering information on bat species distributions, ecology and population status.

Chapter 2

Section 2

NOTES ON WESTERN SMALL-FOOTED MYOTIS IN CENTRAL SOUTH DAKOTA

The western small-footed myotis (*Myotis ciliolabrum;* formerly *M. leibii*) occurs in suitable habitat throughout much of the western United States, from the Badlands and Black Hills of South Dakota, west to the Pacific coastal plain, and from southwestern Canada to northern and central Mexico (Holloway and Barclay, 2001). According to the literature, this species is primarily found in the Badlands and Black Hills of South Dakota (Jones and Genoways, 1967; unpublished voucher specimens in the SDSU Natural History Collection). While Jones and Genoways (1967) speculated on the occurrence of *Myotis ciliolabrum* along eastward-flowing rivers in South Dakota, including the Missouri River, there was no evidence to substantiate this until a single adult male *M. ciliolabrum* was shot and collected near the Missouri River at Farm Island Recreation Area, Hughes County South Dakota (approximately 4 km south, 6.5 km east of Pierre) on the evening of 2 July, 1975 by Hugh H. Genoways as part of a mammal survey. The specimen was not reported in the literature, but was deposited in the mammal collection at Texas Tech University (TK 926721). I obtained this individual reconfirm its identification (Adams, 2003; van Zyll de Jong, 1985). Hugh H. Genoways' collection notes recorded this animal as an adult male, mass 4.9 g, total length 84 mm, tail length of 38 mm, forearm length of 32 mm, hind-foot length of 8 mm, ear length of 16 mm, tragus length of 9 mm. These measurements were reconfirmed on the loaned voucher specimen. An additional record of this species in central South Dakota came from Swier (2003 and 2006), who reported two acoustic recordings of this species at Farm Island Recreational Area on 25 July, 2002. The nearest record of *Myotis ciliolabrum* comes from Philip, South Dakota, approximately 135 km west of Farm Island Recreational Area (SDSU-NHC 234, collected by Ernest J. Huggins on 6 June, 1956).

As part of this masters thesis project, I captured bats using mist nets at Oahe Downstream Recreation Area, Stanley County, South Dakota (5.3 km west, 7 km north of Pierre) during both the 2005 and 2006 field seasons. This site is downstream of the Missouri River's Oahe Dam and consists of riparian gallery forest dominated by Plains Cottonwoods (*Populus deltoides monilifera*). There are bluffs and rock crevices along the Missouri River that are situated approximately 730m from the netting site. Total effort at the area was 237.3 net-hours or 56 net nights. Universal Transverse Mercator (UTM) coordinates were recorded for every capture/locality. At this location, several individual bats, typically *Myotis septentrionalis* and *Eptesicus fuscus* were netted and fitted with Holohil Systems Ltd. LB-2 or LB-2N radio transmitters and radio-tracked.

On 20 July 2006, I captured a single non-scrotal adult male *Myotis ciliolabrum* at 2350 hr at this location. The individual was in good health and lacked noticeable ectoparasites (most *M. ciliolabrum* across their range are ectoparasite free; Dooley *et al*., 1976). Morphometric data were collected from this individual (mass 5.6 g, forearm length of 34 mm, total length 84 mm, tail length of 32 mm, and hind-foot length of 6 mm; Bales, *In Press*) and these measurements fall within the range of measurements for this species (Holloway and Barclay, 2001). Sex was determined by visual inspection and reproductive status was determined by visual inspection and palpation (Racey, 1988). Age was determined by epiphyseal ossification of the metacarpals (Anthony, 1988). To verify species identification, I keyed out the individual using two keys (Adams, 2003; van Zyll de Jong, 1985) and the individual was well documented with photographs currently cataloged in the South Dakota State University Natural History Collections (SDSU-NHC 2091) and the Museum of Texas Tech University (TK 145309, TTU-M 88965; Bales, *In Press*).

Before release on 22 July 2006 at 1900 hr, I fitted this individual with a blue anodized aluminum South Dakota State Game, Fish and Parks wing band (serial number SDGFP 05369) and a Holohil Systems Ltd. LB-2N radio-transmitter (#103006, 0.36 g, 12-day lifespan, frequency 173.183 MHz). Due to weather and logistics, radio-tracking was initiated on 25 July 2006 at 1800 hr. The *M. ciliolabrum* was tracked to a location under the bark of a dead limb of a Plains Cottonwood having a DBH of 56 cm. It began foraging at approximately 2158 hr. I lost its signal shortly thereafter possibly due to the limited range of the transmitter, but it was later reacquired and the bat was found night-roosting in a different Plains Cottonwood having a DBH of 69 cm, approximately 160 m southwest of its previous day-roost (25 July 2006) at 0030 hr on 26 July 2006. On 28 July 2006, I was unable to locate the bat, but it was reacquired on 30 July 2006 day-roosting in the same location as on 25 July 2006. I lost the signal shortly after the animal began to forage at approximately 2200 hr and the signal was not reacquired on that night. I attempted to reaquire the telemetry signal on 1 August 2006 but was unsuccessful. After 3 August 2006, I assumed the loss of battery/transmitter function.

Very little bat research, only five bat studies (Bales and Ke, 2007; Lane *et. al*, 2003; Swier, 2003 and 2006; Jones and Genoways, 1967; Findley, 1956), have been done in the region of central and eastern South Dakota; an area including all land in South Dakota east of approximately W 101° longitude. Of these five studies, only two (Bales and Ke, 2007; Swier, 2003 and 2006) have included fieldwork in central South Dakota, with additional unpublished fieldwork by Hugh H. Genoways in 1975; all three have recorded the presence of *Myotis ciliolabrum*. The dates in which *M. ciliolabrum* has been detected or captured (two adult males) in central South Dakota, all in the month of July, would seem to indicate that their presence is not associated with any known spring or fall migration activity, natal dispersal, or reproductive behavior. Therefore, it is likely that there may exist, a relatively small summer resident population of *Myotis ciliolabrum* along the Missouri River in South Dakota and along eastward-flowing rivers in western South Dakota that provide adequate habitat as was hypothesized by Jones and Genoways (1967). *Myotis ciliolabrum* is known to occur in riparian areas (Holloway and Barclay, 2000) and can utilize a variety of potential roost sites including rock crevices (Tuttle and Heaney, 1974), abandoned swallow nests (Merriam, 1886), buildings (Jones, 1964), and under loose bark (Jones, 1964), that are all readily available in these areas. This record may represent abnormal migratory behavior or a range extension for *M. ciliolabrum,* or may simply reflect the increase in the bat survey/research efforts in this area.

The dearth of data concerning *Myotis ciliolabrum* in this region of South Dakota is either due to low population levels or low catchability rates. This species is a highly agile fliers with the ability to hover (Norberg and Rayner, 1987). South Dakota's open spaces and high winds increase the detectability of mist nets by bats and contribute to the difficulty and general lack of bat research in these areas. No *M. ciliolabrum* were captured (of the 104 bats captured) during the 2000, 2001, and 2002 field seasons by Swier (2003 and 2006) in central and eastern South Dakota. The single capture of *M. ciliolabrum* reported herein was one of 163 bats caught during the 2005 and 2006 field seasons in 253 net nights at various locations along the lower Missouri River and may be an indication of the difficulty of capture and rarity of *M. ciliolabrum*. This species is currently not listed as a species of concern by the South Dakota Natural Heritage Program (SDNHP). Perhaps it should be considered for status as a species of concern in the central region of the state, given our lack of knowledge, and especially in light of the growing interest in wind-power development (Bales, *In Press*).

Chapter 3

ABSTRACT

Mist netting surveys for bats were conducted along the eastern and western borders of the Missouri River and select tributaries in South Dakota during the 2005 and 2006 field seasons. Nets varied in configuration (e.g., length and height) to obtain the greatest possible capture rate, and were set an hour before dusk, then removed before dawn or as conditions dictated. Nets were constantly monitored to reduce the stress incurred by ensnared animals. Unpublished data from 2000 and 2001 field seasons were included in the analysis. Species accumulation curves were compiled for eight different areas that were repeatedly sampled. Sampling effort was cumulatively measured in net-hours (N*hr). Two asymptotic models (linear dependence model and Clench model) were fitted to the species accumulation curves to estimate the sampling effort required to determine bat species richness for each area. The species accumulation models fit capture data well ($0.9759 > r^2 > 0.7681$) for all areas. The minimum amount of effort required to obtain the lower estimate of bat species richness had a mean of 152.99 net-hours (N*hr) with a mean species richness of 5.80, which was lower than the seven species recorded in this study. For the upper estimate of bat species richness, the total amount of effort required had a mean of 1208.76 net-hours (N*hr) with a mean species richness of 8.75, which was higher than the seven species actually recorded. The development of a minimum-effort sampling guideline is important due to the need for better management

and the pervasiveness of short-term predevelopment surveys employed by wind energy companies in this region.

INTRODUCTION

Wind power development is of growing interest in South Dakota and other prairie states, due to the potential of this renewable resource in this region. Wind power farms directly impact bats, especially migratory bats, which tend to use rivers and topographical corridors during migration (Osborn *et al*., 1996; Johnson *et al*., 2003). South Dakota currently has 44 mega-watts of wind turbines online with plans to add an additional 200 to 400 mega-watts, and is ranked 4th in the U.S. in wind energy potential (AWEA, 2006). Currently, there is no set standard for predevelopment surveys in South Dakota, siting guidelines for wind-power projects recommend only considering the biological setting and to conduct preliminary reconnaissance (SDGFP, 2005). These lackluster guidelines are similar to those of many other states (reviewed by USFWS, 2007). Such vague language often allows for regulatory agency expediency at the cost of prudent predevelopment risk analysis. Short term, low effort, predevelopment surveys are often the result; such surveys cannot possibly glean enough information about the species assemblage of an area to presumably evaluate potential impacts. My goal was to quantify a minimum mist netting/live capture sampling effort for eastern and central South Dakota, that would also be relevant throughout the region, for use in wind-power predevelopment surveys (Bales *et al*., *In press*).

Species accumulation curves can be used to measure inventory efficiency and completeness within a study area and allow between study area comparisons when based upon a standardized measure of sampling effort. The use of species accumulation curve models to provide estimates of the minimum sampling effort required to achieve an efficient and reliable inventory can result in better sampling protocols and more effective resource allocation (Soberon and Llorente, 1993). Species accumulation models reach an asymptote as the probability of catching a new species approaches, but never reaches, zero as an infinite amount of effort would be required. An extensive effort expenditure is often unrealistic in real-life applications, but a pragmatic solution would be to sample until the species accumulation curve reaches an asymptote. Once the asymptote is reached, the probability of adding a new species is greatly reduced, and can be considered to be the base-line minimum estimate of species richness with a minimum effort expenditure, albeit this can be substantial but necessary given the conservation status of many species of bats and our current lack of knowledge. The purpose of this study was to estimate the minimum effort required to reach a predetermined minimum level of inventory completeness, (90%) of probable species recorded present, for Eastern and Central South Dakota (Bales and Ke, 2007; Bales *et al., In Press*).

METHODS

1. FIELD SAMPLING METHODS

The state of South Dakota has twelve species of vespertilionid bats (SDNHP, 2004; Choate and Jones, 1981; Lane *et al.,* 2003), however, if unofficial reports and incidental occurrences are considered, there may be 15 species of bats in the state, and many of these are found elsewhere throughout the northern prairie region. Currently six of the twelve species of bats found in South Dakota are considered rare (S1, S2, S3[2]) and monitored by the South Dakota Natural Heritage Program (SDNHP, 2004). In addition, three bats (*Myotis septentrionalis*, *M. thysanodes pahasapensis*, and *Corynorhinus townsendii*) are identified as species of greatest conservation need by the South Dakota Comprehensive Fish and Wildlife Conservation Plan. Of these three species, the Northern Myotis (*M. septentrionalis*) is restricted to riparian habitats along the Missouri River (Kiesow *et al.,* 2004), an area slated for several wind-power developments. Much of the natural history and distribution of bats in South Dakota, and other prairie states, remains unknown.

As part of the larger study, mist netting for bats was conducted along the eastern and western borders of the Missouri River and select tributaries in South Dakota (approximately Fort Pierre, South Dakota to Yankton, South Dakota) during the 2005 and

[2] S1 = Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction. S2 = Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range. S3 = Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.

2006 field seasons (May and October), totaling 253 net nights. This study area was selected because seven species of bats (*Myotis ciliolabrum, M. septentrionalis, M lucifugus, Lasionycteris noctivagans, Lasiurus cinereus,* and *L. borealis*) are concentrated along the Missouri River drainage, making this locality unique in South Dakota in terms of both species richness and population numbers (Swier, 2003). The study area includes an array of habitat types: Plains Cottonwood (*Populus deltoides monilifera*) dominated riparian forest, agricultural lands with shelter belts, remnant bur oak (*Quercus macrocarpa*) forest and open prairie. Net sets varied in configuration with regard to net length (3, 6, 9 and 18 m) and height (3 and 6 m; all with 38 mm mesh), to obtain the greatest capture rate at each individual net location by selecting the best fit for adjacent vegetation and suspected fly-ways. Different numbers of nets (1-15) were set each evening at each sampling site, depending on time, weather (wind), available personnel, and site characteristics. Nets were set one hour before dusk and removed before dawn or as weather conditions dictated. Nets were constantly monitored to reduce the stress incurred by ensnared animals (Bales and Ke, 2007; Bales *et al., In press*). Nets were moved within the area in subsequent nights to avoid decreases in capture rates (Gram and Faaborg, 1997; Larsen *et al., In press;* Kunz, 1988). Unpublished data from the 2000 and 2001 field seasons (Swier, 2003) totaling 51 net nights was included in the analysis. Individual bats were identified to species with field keys (van Zyll de Jong, 1985; Higgins *et al*., 2000; Schwartz and Schwartz, 2001; Adams, 2003). Bats were marked with forearm bands (oxidized aluminum lipped South Dakota Game, and Parks 05300-05450 series bands or split ring plastic bands series 200P-400P) and released at site of capture. Acoustic sampling was conducted concurrently with mist-netting, using a Pettersson (D-240X) ultrasound detector and Sonobat™ software (Ver. 2.5 and 2.5.5), to augment the netting data in determining a species inventory (Table 3.4).

2. MEASUREMENT OF SAMPLING EFFORT

Different methods have been used to quantify sampling effort in chiropteran research such as: number of surveys (variable number of nets, unknown number of nights; Weller and Lee, 2007), number of netting nights regardless of number of nets used (Fleming *et al.,* 1972), bats captured per net per night (BNN: Findley and Wilson, 1983; Pedersen *et al.,* 2006), number of net-nights where a constant number of nets are used (Findley and Wilson, 1983), number of individuals captured (Brosset *et al*., 1996; Rautenbach *et al*., 1996), net hours with a specified number of nets (Fenton *et al*., 1992; Estrada *et al*., 1993), sampling time (dos Reis and Muller, 1995), and net meters per hour (Medellin, 1993; Moreno and Halffter, 2000). While it may seem advisable to express sampling effort in an effort/area relationship such as net-hours/km^2 or net-hours/ha, this would incorporate false accuracy as the effective area of any mist net, sampling technique or survey for bats is indeterminate. This is because each species of bats has a different ecology, natural history, and foraging strategy making them differentially catchable and heterogeneously distributed on the landscape. I used the product of nets and the total number of hours that the nets remained open for a given site, e.g. 5 nets up for 4 hours would equal 20 net-hours (N*hr). The approach of using total nets per hour (N*hr) allowed me to account for variation among sampling periods and treat each net set as an equal and independent unit, as net size in this region is not indicative of efficacy, regardless of net length or height configuration used (Bales *et al., In press*).

DATA ANALYSIS

1. SPECIES ACCUMULATION MODELS

Species accumulation models can be used to estimate the sampling effort required to reach a satisfactory level of completeness. Two asymptotic models, the linear dependence model and the Clench model, were used to fit the capture species accumulation data (Bales and Ke, 2007; Bales *et al.*, *In press*). By their definition and statistical probability, species accumulation curves would require an indefinite amount of effort to reach 100% richness, where species detected per unit effort decreases rapidly as the species accumulation curve nears its asymptote. I followed Moreno and Halffter (2000) in accepting 90% (herein q = 0.90) of total species richness as a pragmatic level of survey completeness.

1.1. THE LINEAR DEPENDENCE MODEL

The linear dependence model is given by:

$$S(t) = a/b\ [1 - \exp(-bt)]$$

where t is a measure of sampling effort (in our case, the number of net-hours), $S(t)$ is the predicted number of species at t, a represents the rate of increase at the beginning of the sampling, b is a parameter related to the shape of the accumulation curve of new species during the sampling, and a/b is the asymptote which is the total richness of the site that can be obtained when t (effort) goes to infinity. This model assumes that the probability of adding a new species to the list depends linearly on the size of the list. As the species list grows, the probability of adding a new species to the list decreases proportionally to the current size of the list. Based on the model, the sampling effort t_q required to register a proportion of the total fauna $q = S/(a/b)$ is given by:

$t_q = -1/b \ln(1 - q)$

where q is the desired proportion (90%) of the total fauna for which the required time t_q is estimated. Soberon and Llorente (1993) recommended this model for locations were the species assemblage being studied is well known or the study area is reasonably small, a relative term, and could over a finite period of time reach an asymptote; in theory (Moreno & Halffter, 2000).

1.2 THE CLENCH MODEL

The Clench model is given by:

$S(t) = at/(1 + bt)$.

The Clench model is based on theory that the probability of accumulating new species to the list decreases with the number of species previously recorded, but increases with additional effort (Moreno and Halffter, 2000). Based on this model, the sampling effort t_q required to register a proportion of the total fauna $q = S/(a/b)$ is given by:

$t_q = q/[b(1 - q)]$.

The Clench model was recommended by Soberon and Llorente (1993) for larger (relative term) study areas than those where the linear dependence model could be applied, or for less well known taxa or species assemblages for which the probability of accumulating a new species is likely to increase as sampling effort increases (time), until an upper limit is reached (Moreno and Halffter, 2000). Considering the nature of the two models, Moreno and Halffter (2000) recommended using the linear dependence model to calculate the 'floor' or lower limit estimate of species richness and sampling effort, and using the Clench model to calculate the 'ceiling' or upper limit of species richness and sampling effort, where the true species accumulation curve should lie between the two limits.

2. MODEL FITTING AND PARAMETER ESTIMATION

I used a non-linear regression (SAS/STAT 9.1) to fit the two models to the observed data. Both species accumulation models fit the observed data well at all locations ($0.97 > r^2 > 0.76$). The linear dependence model predicted lower asymptotes and the Clench model predicted higher asymptotes than the previously recorded species richness. The fitted models for species accumulation curves for eight different locations are shown in Figures 3.1 and 3.2. The parameters a, b, and r^2, as well as the asymptotes a/b, were estimated for the two models and the results are listed in Tables 3.1 and 3.2.

3. PREDICTION OF SAMPLING EFFORT

The sampling effort tq required to register a desired proportion (90%) of the total fauna can be predicted by using the two models. The formulas are:

$t_q = -1/b \ln(1 - q)$ for Linear dependence model (LDM)

$t_q = q/[b(1 - q)]$ for Clench model

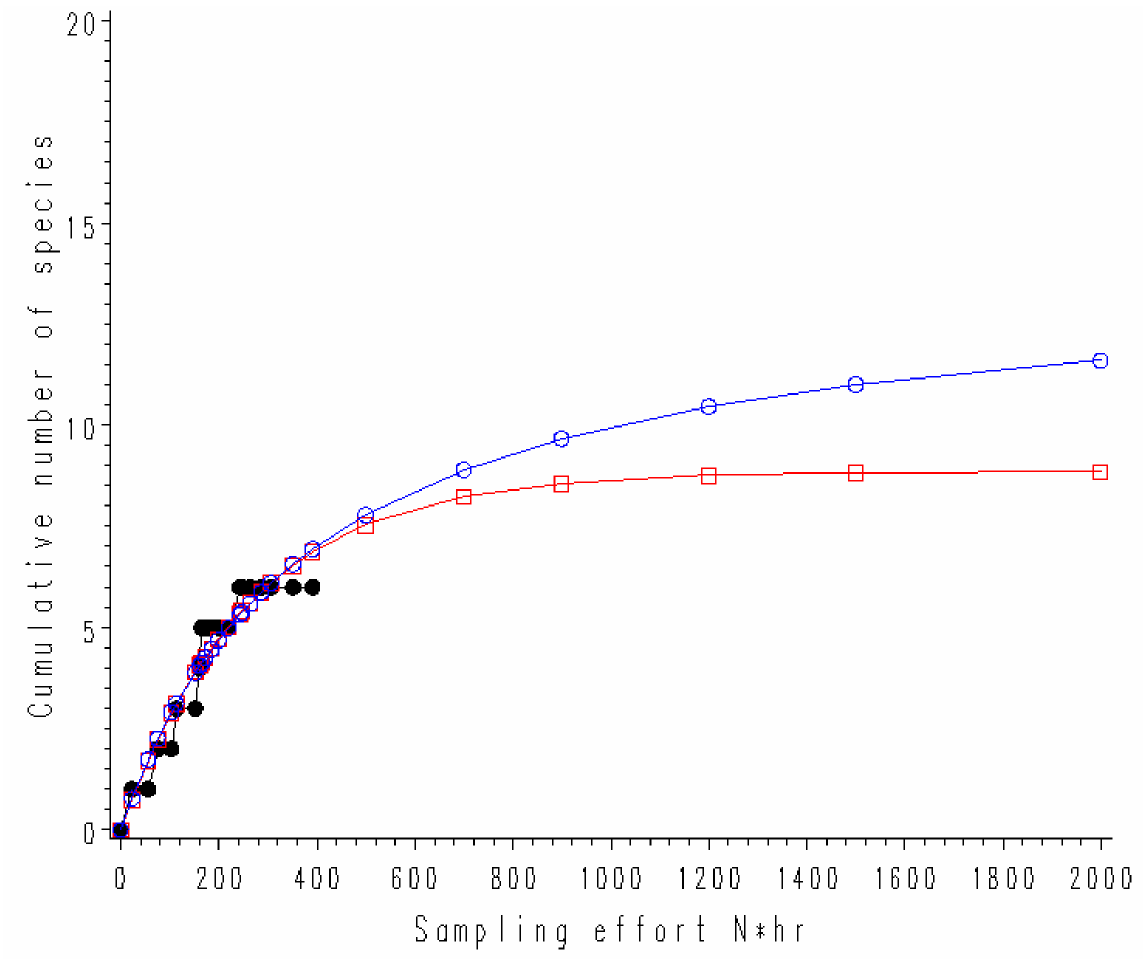
where q is the predetermined proportion of the total fauna to be estimated. Parameter b can be derived when these models are fit to the observed data. As suggested by Moreno and Halffter (2000), the sampling efforts estimated from the linear dependence model can be used as minimum efforts whereas those estimated from the Clench model can be used as maximum efforts. The estimated sampling efforts required to record 90% of the total fauna are listed in Table 3.3 for different locations.

Figure 3.1. Original and fitted bat species accumulation curves for different locations. (a) Byre Game Production Area, (b) Oahe Downstream Recreation Area, (c) Fort Randall Dam Spillway, (d) Lewis and Clark Boy scout Camp, (e) Arikara Game Production Area, (f) Farm Island Recreation Area, (g) Karl Mundt National Wildlife Refuge, and (h) West Bend Recreation Area

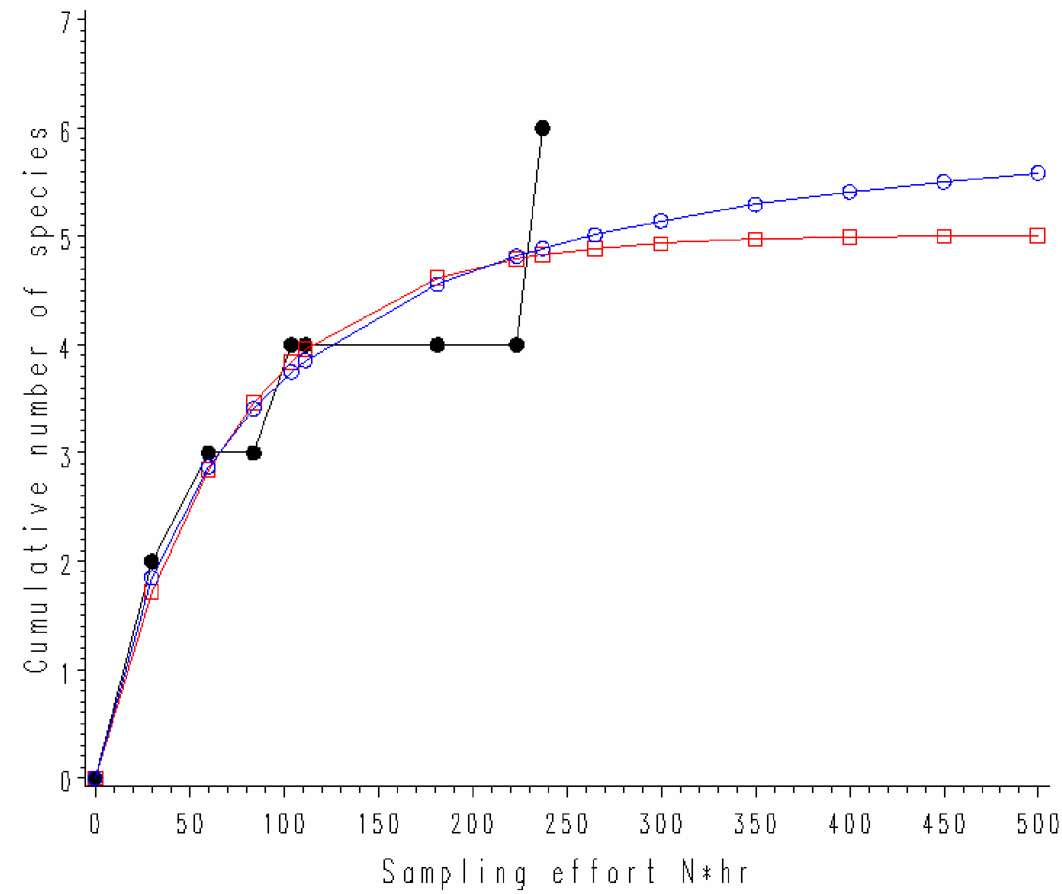
● = observed data

○ = prediction of the Clench model

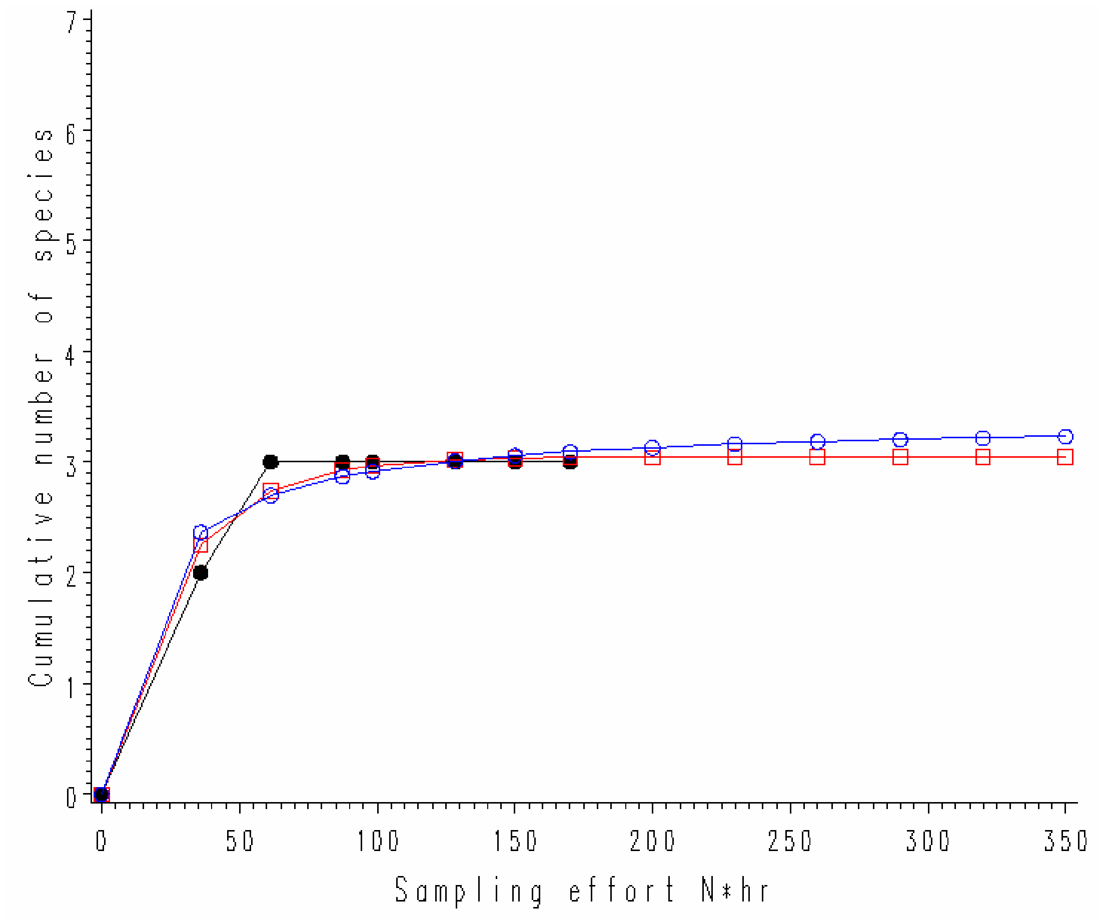
□ = prediction of the linear dependence model



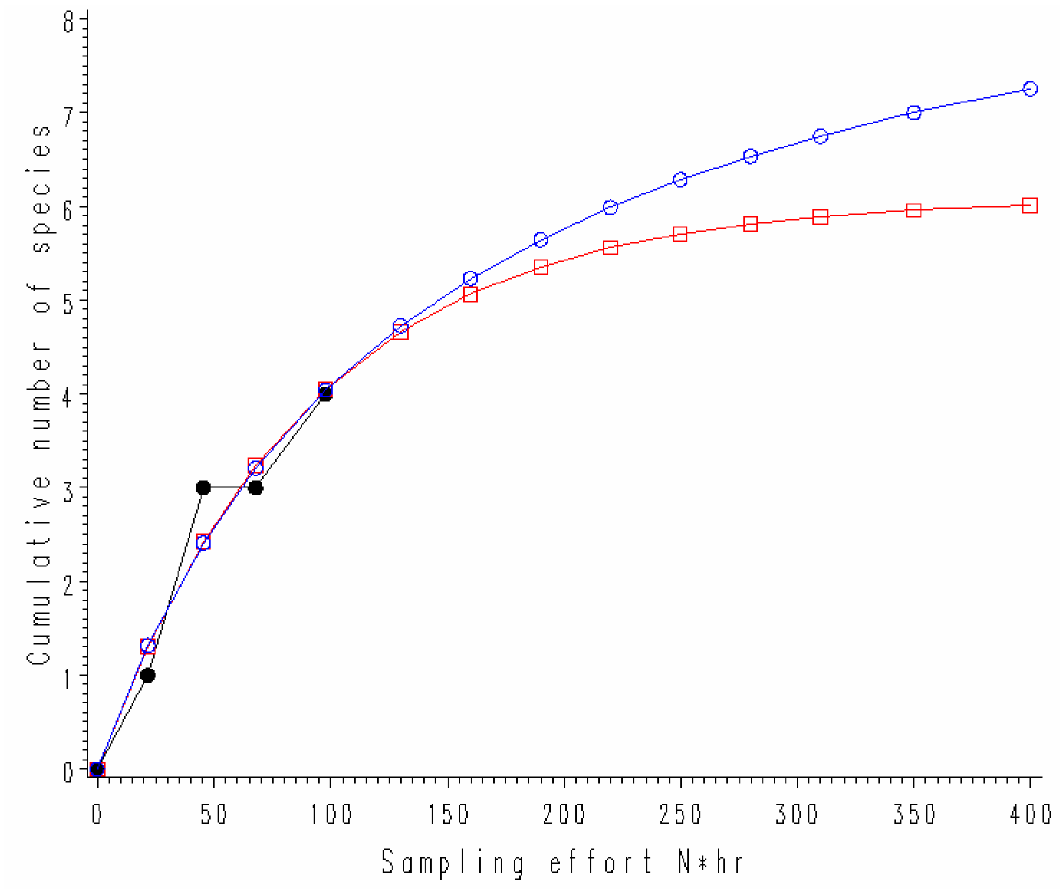
(a) Byre Game Production Area



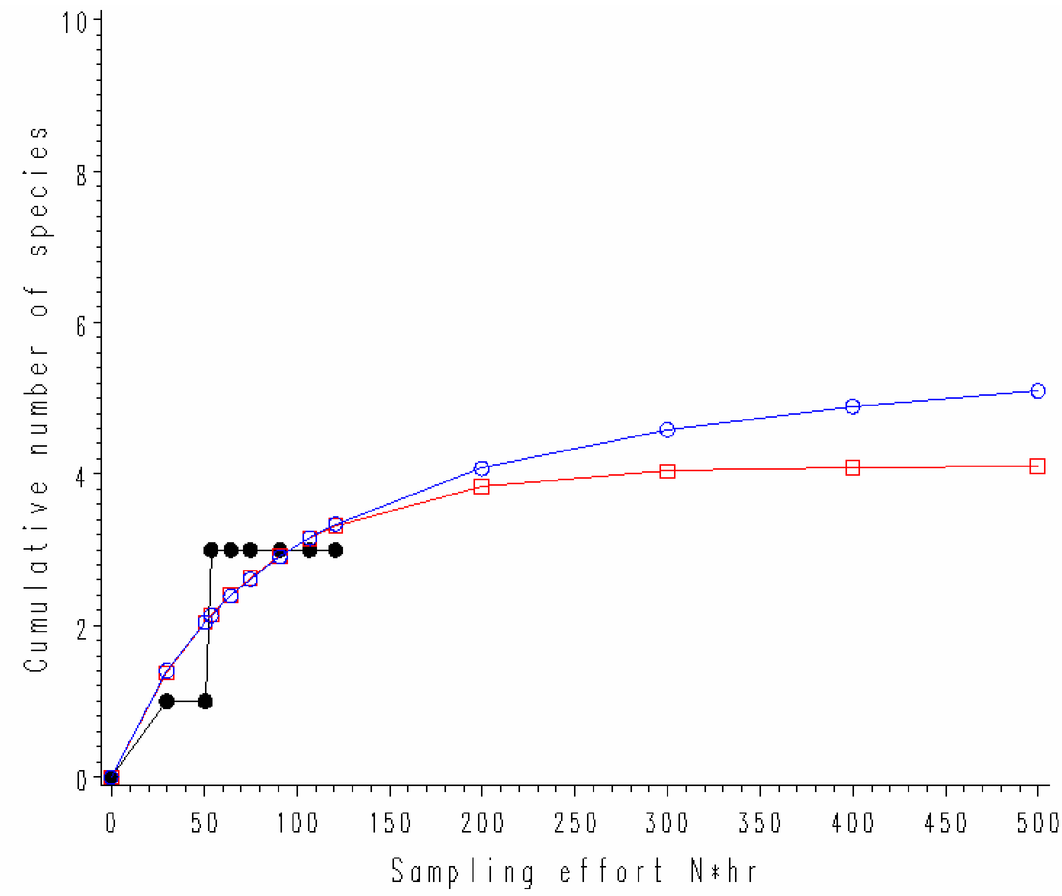
(b) Oahe Downstream Recreation Area



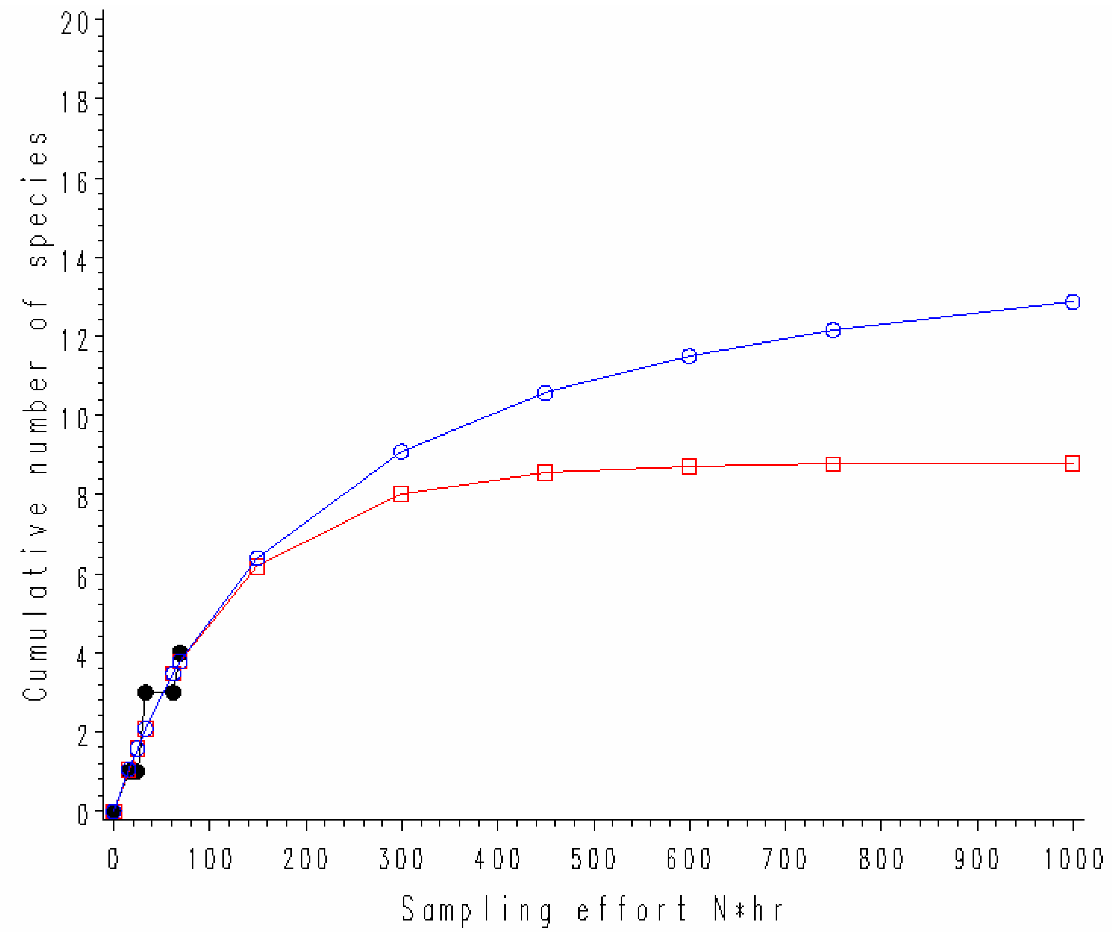
(c) Fort Randall Dam Spillway



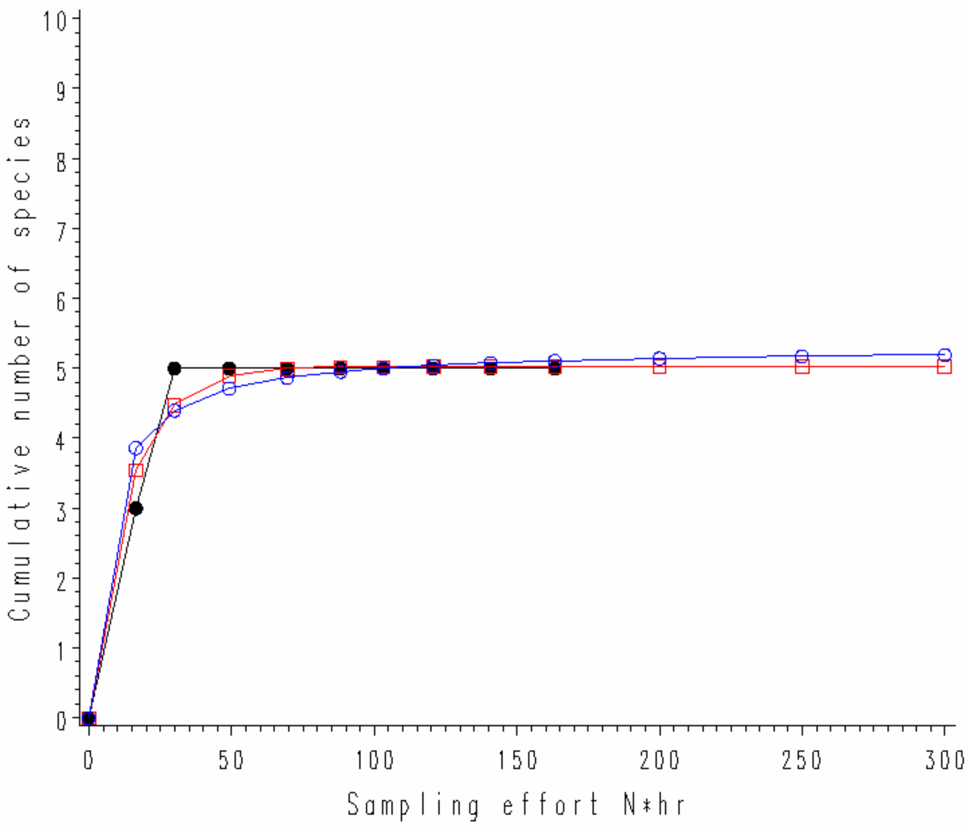
(d) Lewis and Clark Boy Scout Camp



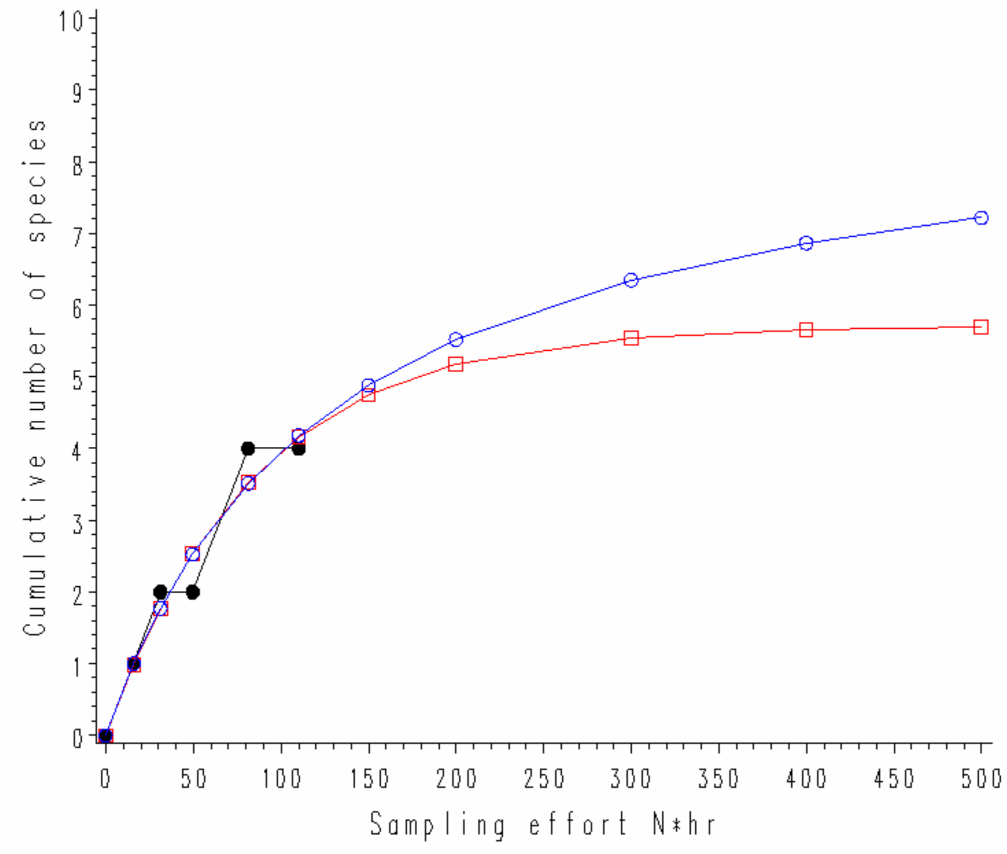
(e) Arikara Game Production Area



(f) Farm Island Recreation Area



(g) Karl Mundt National Wildlife Refuge



(h) West Bend Recreation Area

Figure 3.2. Fitted bat species accumulation curves for different locations using the Linear Dependence Model.

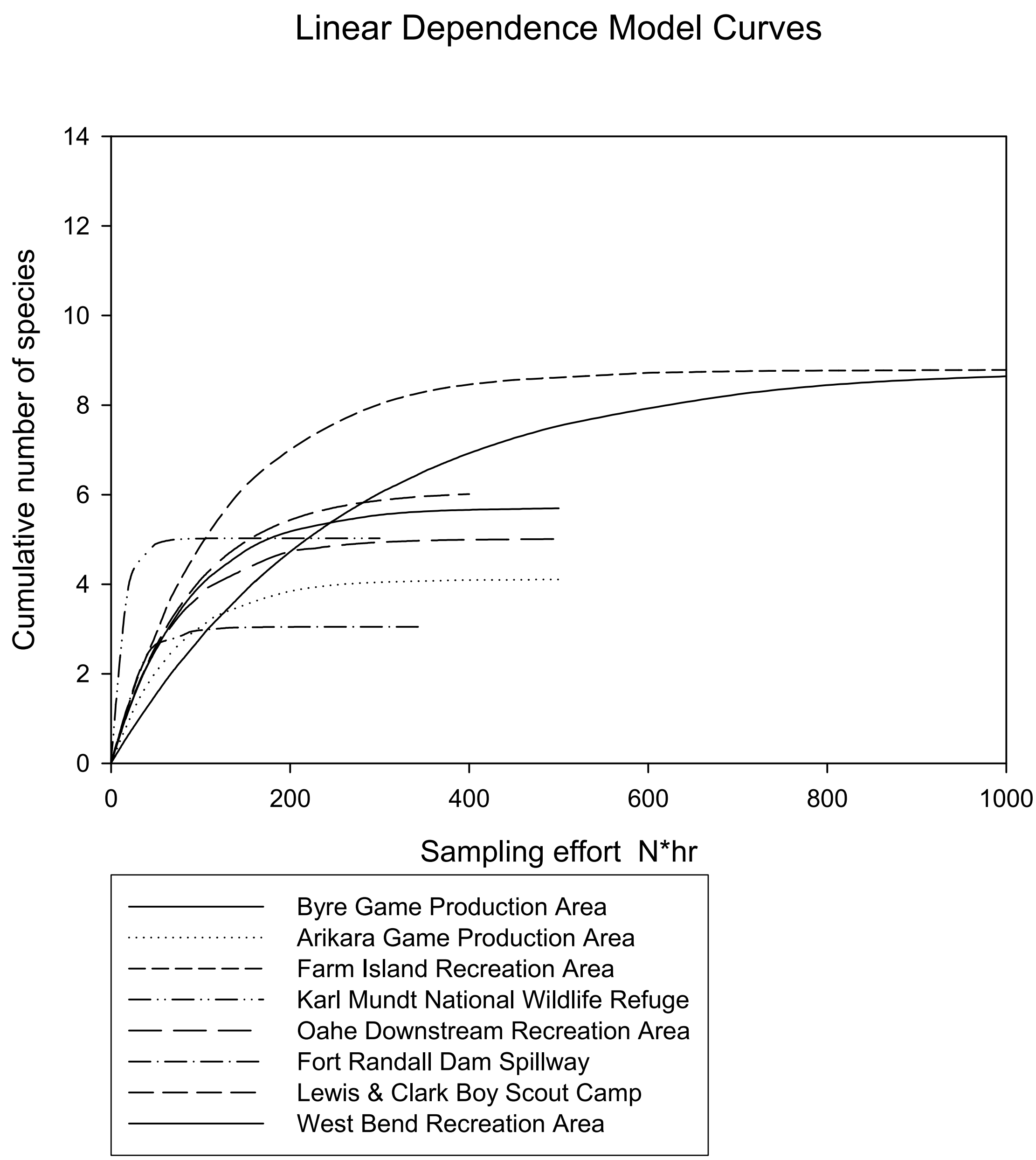


Figure 3.3. Fitted bat species accumulation curves for different locations using the Clench Model.

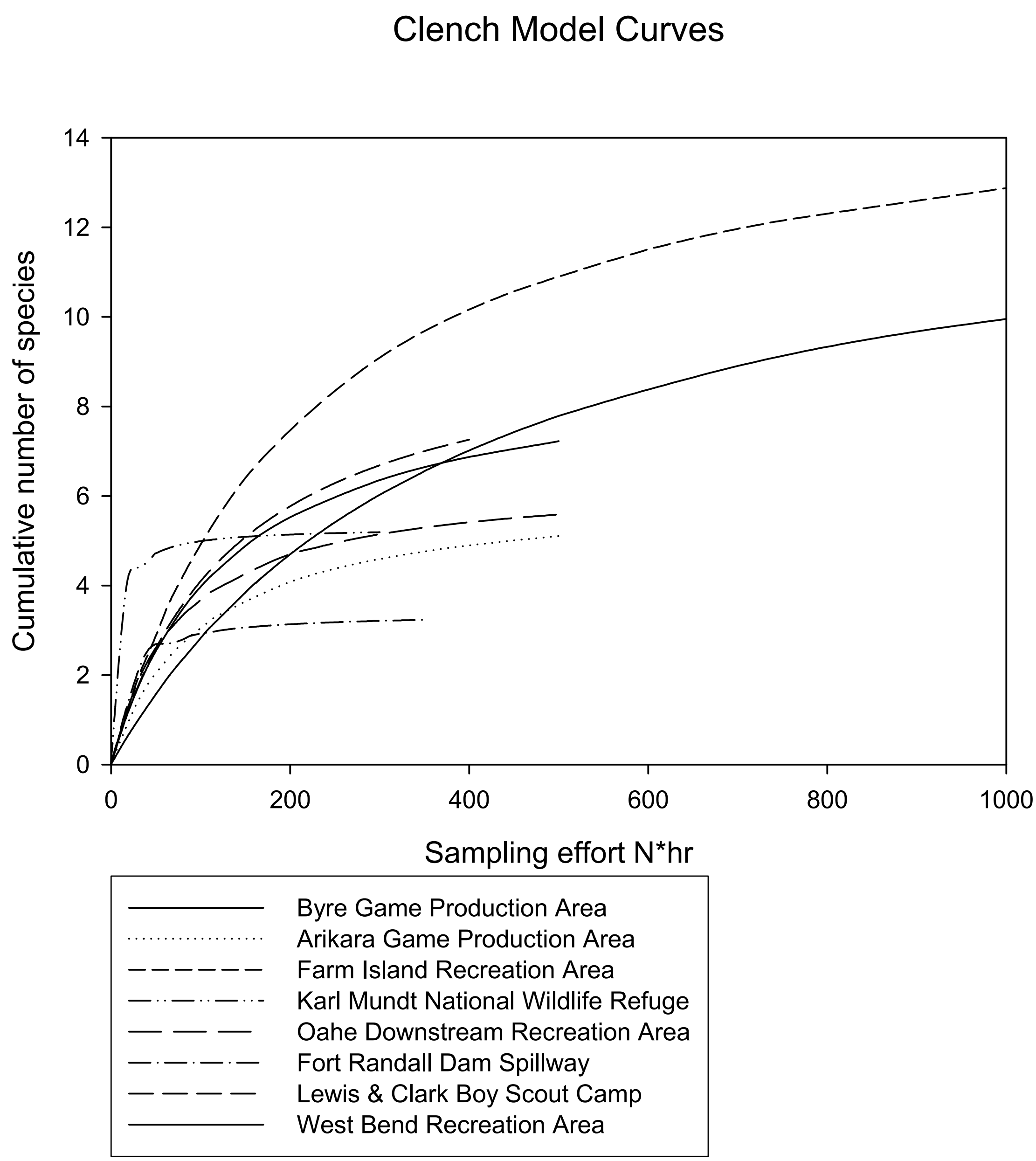


Table 3.1. Parameter and asymptote estimation for linear dependence model.

Location	Linear dependence Model: $S(t) = a/b[1-\exp(-bt)]$			
	a	*b*	*a*/*b* units = species	r^2
(a) Byre	0.0337	0.0038	8.9	0.9242
(b) Oahe	0.0701	0.0140	5.0	0.8765
(c) Fort Randall	0.1139	0.0374	3.0	0.9824
(d) Lewis & Clark Boyscout Camp	0.0681	0.0112	6.1	0.9549
(e) Arikara	0.0560	0.0136	4.1	0.7745
(f) Farm Island	0.0715	0.0081	8.8	0.8789
(g) West Bend	0.0677	0.0119	5.7	0.9542
(h) Karl Mundt NWR	0.3715	0.0740	5.0	0.9759
Mean			5.8	

Table 3.2. Parameter and asymptote estimation for Clench model.

Location	Clench Model: $S(t) = at/(1 + bt)$			
	a	*b*	*a*/*b* units = species	r^2
(a) Byre	0.0354	0.0025	14.2	0.9185
(b) Oahe	0.0868	0.0135	6.4	0.8861
(c) Fort Randall	0.2189	0.0649	3.4	0.9676
(d) Lewis & Clark Boyscout Camp	0.0704	0.0072	9.8	0.9540
(e) Arikara	0.0607	0.0099	6.1	0.7681
(f) Farm Island	0.0721	0.0046	15.7	0.8787
(g) West Bend	0.0704	0.0077	9.1	0.9536
(h) Karl Mundt NWR	0.8654	0.1635	5.3	0.9490
Mean			8.75	

Table 3.3. Estimated sampling effort required to record 90% of the total fauna

Location	Proportion of the asymptote q	Linear Dependence Model	Clench Model
		Sampling effort required (minimum effort) $t_q = -1/b \ln(1 - q)$ units = net-hours (N*hr)	Sampling effort required (maximum effort) $t_q = q/[b(1 - q)]$ units = net-hours (N*hr)
(a) Byre	90 %	114	3525.3
(b) Oahe	90 %	164.5	666.7
(c) Fort Randall	90 %	61.6	138.7
(d) Lewis & Clark Boyscout Camp	90 %	205.6	1250
(e) Arikara	90 %	169.3	909.1
(f) Farm Island	90 %	284.3	1956.5
(g) West Bend	90 %	193.5	1168.8
(h) Karl Mundt NWR	90 %	31.1	55.0
Mean		152.99	1208.76

Table 3.4. Bat species present/absent at select areas in South Dakota. A = acoustic detection, C = live capture. Black = field work done by Swier (2003), Gold = areas in common with Swier study, Red = new areas that were sampled during this study.

Location	Species						
	E. fus	*L. bor*	*L. cin*	*L. noc*	*M. cilio*	*M .luc*	*M. sept*
Arikara GPA	AC	AC					AC
Byre GPA	AC	AC	AC	AC		AC	AC
Farm Island Rec. Area	AC	AC	A	A	A	AC	AC
Fort Randall Dam Spillway	AC	AC	A	A		A	AC
Karl Mundt NWR	AC	AC	AC	A		C	C
L&C Boyscout Camp	C	A	AC	A		A	AC
Oahe Downstream Rec. Area	AC	AC	A	AC	C	AC	AC
West Bend Rec. Area	AC	AC	AC	A		A	AC

Table 3.5. Bats captured along the Missouri River in South Dakota during 2005 and 2006 field seasons

Species	Number captured (n)	Portion of capture
Myotis septentionalis	90	55%
Myotis lucifugus	9	5.50%
Myotis ciliolabrum	1	0.60%
Eptesicus fuscus	42	25.8%
Lasionycteris noctivagans	3	2%
Lasiurus borealis	14	8.60%
Lasiurus cinereus	4	2.50%
Total	163	

RESULTS

Through the use of mist netting I captured[3] and banded 163 bats along the Missouri River in South Dakota and recorded the presence of seven species of bats (*Myotis ciliolabrum, M. septentrionalis, M. lucifugus, Eptesicus fuscus, Lasionycteris noctivagans, Lasiurus cinereus,* and *L. borealis*; Table 3.5). Of those bats captured during the 2005 and 2006 field seasons 55% were *Myotis septentrionalis* (Northern Myotis), 5.5% were *Myotis lucifugus* (Little Brown Myotis), 0.6% were *Myotis ciliolabrum* (Western Small-footed Myotis, 25.8% were *Eptesicus fuscus* (Big Brown Bats), 2% *Lasionycteris noctivagans* (Silver-haired Bats), 8.6% were *Lasiurus borealis* (Eastern Red Bats), and 2.5% were *Lasiurus cinereus* (Hoary Bats*;* Table 3.5). This is in contrast to Swier (2003) who sampled 10 areas along the lower Missouri river and found: *Myotis*

[3] No mortality was incurred during this project.

septentrionalis 42%, *Eptesicus fuscus* 35%, *Myotis lucifugus* 15%, *Lasiurus borealis* 4%, and *Lasionycteris noctivagans* 4%. These data suggest that the results across years are relatively comparable.

These mathematical models are predictive based on the accumulation/effort pattern, allowing extrapolation of the curve to determine the effort required to reach the asymptote of the species accumulation curve. The models fit the observed data well for all areas ($0.97 > r^2 > 0.76$). The fitted species accumulation curve models (Fig. 3.2 and Fig. 3.3) all reached an asymptote (90%). As expected, the linear dependence model predicted the lower limit while the Clench model predicted the upper limit. Using the linear dependence model and Clench model, I calculated the minimum amount of effort required for a bat survey to reach a predetermined level of completeness (90%). The total amount of effort required to obtain the lower (linear dependence model) estimate of bat species richness ranged from 31.10 to 284.30 net-hours, with a mean of 152.99 net-hours (N*hr; Table 3.3). For the upper (Clench model) estimate of bat species richness, the total amount of effort required ranged from 55.0 to 3525.3 net-hours, with a mean of 1208.76 net-hours (N*hr; Table 3.3). For the linear dependence model, the predicted bat species richness (*a/b*) ranged from 3.0 to 8.9 species, with a mean of 5.8 species (Table 3.1), whereas the Clench model ranged from 3.4 to 15.7 species, with a mean of 8.75 species (Table 3.2). The actual range of bat species richness, as detected using mist netting was 3 to 6 species, and when acoustic sampling is included, bat species richness ranged from 3 to 7 (Table 3.4).

DISCUSSION

Given our data and the predictions of the Linear dependence and Clench models, the minimum effort required to register 90% of bat species present at any particular site varied considerably: 31.1 to 284.3 net-hours for the Linear dependence model and 55.0 to 3525.3 net-hours for the Clench model. Based on my mean values, I would expect to capture between 5.80 and 8.75 bat species with an average effort expenditure between 152.99 and 1208.76 net-hours. These values are subject to variation in the data and are influenced by: species assemblage, species-specific catchability, specific site conditions, species abundance and evenness, mist net bias, and/or wind. This can be seen in the shape of the various curves in Figures 3.2 and 3.3. As with other species accumulation curves (e.g., Moreno and Halffter, 2000), common species are rapidly added while rare or migratory species generally require additional sampling effort to be registered. A general observation from my mist netting data is that the common bats for the region (*Myotis* septentrionalis, *Eptesicus fuscus*, and *Myotis lucifugus* or *Lasiurus borealis*) are easily registered while rare or migratory bats (*Lasiurus cinereus*, *Lasionycteris noctivagans*, and *Myotis ciliolabrum*) take much longer to be detected. It should be noted that *Myotis septentrionalis* in this region is distributed only along the Missouri River and its tributaries and is the predominant *Myotis* species in those areas; whereas *Myotis lucifugus* (35%) is the predominant *Myotis* species in other parts of the region (Swier, 2003). I may have imposed a strong netting bias for *Myotis septentrionalis* as it is an interior forest species, and that these areas were disproportionately sampled during this study. However, this possible bias is countered by the reality that areas with an ample forest interior area are lacking in the region and that the second and third highest captured species was *Eptesicus fuscus* and *Lasiurus borealis* – both of which are considered to be edge species (Carroll *et al*., 2002). This indicates that both edge and 'interior' habitats were adequately sampled or that *Myotis septentrionalis* in the region readily utilize both habitats.

The capture of 163 bats with an effort expenditure of 253 net nights (1360.97 net-hours) may seem low, but the success of mist-netting is dependent upon site specific conditions and species ecologies being conducive to the application of mist-nets. Larsen *et al*. (2006*, In press*) found that actual capture rate of mist nets was 4.2%. This data was, however, collected on the Caribbean island of Montserrat with ten species of bat; five frugivores, three insectivores, one omnivore and one carnivore. These results should not be compared directly to the strictly insectivorous bats found in South Dakota and the northern regions of North America. Insectivorous bats in general have better developed echolocation abilities as they require more precise and accurate sensory information from their environment than do fruit-bats. Thus, the capture rate for an entirely insectivorous bat assemblage like that of South Dakota should be well below those reported by Larsen *et al*. (2006, *In press*).

Another source of sampling error in South Dakota, and possibly the region, that leads to underestimations of bat activity is the ever present wind (Pedersen *et al.,* unpubl.). Wind can cause movement in mist nets, making them easier for bats to detect with echolocation, and thus, reducing capture rates (Sedlock, 2001). Rain or mist droplets adhering to mist nets can make them easier to detect. Other location-dependent variables that can influence capture success include ambient light-levels and habitat complexity.

Aspects of individual species ecologies that affect capture success include but are not limited to: foraging/commuting behavior, spatial memory, flight agility/maneuverability, and the plasticity of echolocation behavior (Lang *et al*., 2004). Thus, the upper end estimate (3525.3 net-hours) for the total amount of effort required to register a 90% level of completeness may well be necessary in areas presumed to have great species richness.

Given the problems with mist-netting, in the region, and in the interest of efficiency and completeness, acoustic sampling should be part of any survey conducted in this region. For the areas sampled in this study, mist net captures documented 72.4% of the total species present recorded, while acoustic sampling documented 91.5% (Table 3.4). For example, when capture and acoustic records are combined for Oahe Downstream Recreation Area and Farm Island Recreation Area, all seven species of bats that were expected to be there based on previous work done in the area were present (Table 3.4; Jones and Genoways, 1967; Swier, 2003). It should be noted that in two of the localities (Byre GPA and Farm Island RA), the Clench model predicts greater species (*a/b*) richness (14.2 and 15.7 respectively; Table 3.2) than the recorded number of bat species in the entire state of South Dakota (n = 12). This is despite the expenditure of 391.72 net-hours at Byre GPA and 69.24 net-hours at Farm Island RA. Additional sampling may bring the upper estimate of species richness down to a more realistic number, but may not be an effective allocation of resources. The linear dependence model, however, predicts bat species richness for these areas of approximately nine, which is more realistic.

While passive and active acoustic sampling methods are attractive alternatives to mist netting, there are, however, no pragmatic alternatives for obtaining the morphological, reproductive, and demographic data that live captures can provide. For example, acoustic data can not determine the presence of lactating females or when juveniles are becoming volant. Additionally, separation/identification of closely related species is often extremely difficult. Not all species are readily detectable due to widely varying species-specific call characteristics and air-space utilization. As such, O'Farrell and Gannon (1999) came to the conclusion that the most accurate inventory of bats species was provided by combining both acoustic and capture sampling methods. Similar to the problems encountered by mist netting, the effectiveness of acoustic sampling in this region may be decreased by factors such as acoustic interference by insects or wind (Bales *et al., In press*).

While the minimum amount of effort predicted for a bat survey in this region varied (31.1 to 284.3 net-hours), those conducting a bat survey should, ideally, continually track species accumulation with the linear dependence, Clench models, or other asymptotic models - sampling until the models come reasonably close together (100% completeness). Sampling beyond the point at which the asymptote is reached is often unpractical; therefore, reaching the asymptote of the species accumulation curve should be the practical goal. These mathematical models should be revised as new data are collected, allowing an ever changing extrapolation of the curve to determine what additional effort may be required to reach the asymptote of the species accumulation curve (Moreno and Halffter, 2001). This, however, may be unrealistic for practical and regulatory reasons as surveys are often time-constrained and would not allow for an open-ended commitment. In lieu of using the linear dependence model, Clench model (our recommended model due to its higher effort estimates and species richness estimates) or other asymptotic models, and given the species richness and the conservation status of bats in the region, surveys should err on the high side of the range of effort predicted herein by these two models (Bales *et al., In press*). I suggest that a minimum of 284 net-hours (high effort estimate from the linear dependence model) for a generic study area (the effective area of a bat survey for is indeterminate) when combined with acoustic sampling might be an appropriate compromise given the difficulty of working with bats in the region, the lack of information, and the conservation status of some bats in the region, e.g., 284 net-hours: approximately 5 nets set up for 4 hours for 14 nights or 70 net nights (Bales *et al., In press*). Additionally, a survey should, preferably, be conducted when volant juveniles are present as this increases the number of active individuals of a species within an area (Maier, 1992; Hayes, 1997; Erickson and West, 2002; Weller and Lee, 2007) thus, increasing the likelihood of detecting rare, and possibly threatened or endangered, species. While regulatory agencies may wish to have results and recommendations presented in terms of net-hours/km^2, net-hours/ha, or another effort/area relationship that would allow them to compute *X* effort needed for *Y* area of development, this would be tantamount to imposing false accuracy on the data - the effective area of a mist net [like any other sampling method of bats], or a survey is indefinable, and bat species, bat activity patterns, and bat habitats are neither randomly nor evenly distributed in space (Bales *et al., In press*).

Short term predevelopment bat surveys less than or significantly less than 40 net nights (significantly less than the recommended 284 net-hours proposed herein) of sites planned for wind-power development will most probably yield misleading data. This is of immediate concern due to the prevalence of interest in wind energy companies and developers with regards to wind power in this region. Wind farms directly impact migratory bats, which tend to use river and topographical corridors during migration (Osborn *et al*., 1996; Johnson *et al*., 2003). Information on migration, seasonal distributions, and movement patterns of bats has been mostly limited to short distance (>100 km), cave utilizing and/or endangered species, with only inferences from museum and capture records to demonstrate large scale (< 100 km), migratory movements of non-cave obligates and/or non-endangered species (Cryan, 2003). Bat deaths at the nearby Buffalo Ridge, Minnesota wind power development were estimated to range between 0.07 and 2.04 per turbine per year, with Hoary Bats (*Lasiurus cinereus*) and Eastern Red Bats (*L. borealis*) being the most common fatalities (Johnson *et al*., 2003). Given the lack of information on the species most affected by wind power development, minimum-effort quick fix surveys should not be the goal, as they will not provide the data needed for responsible bat management. Nevertheless, information regarding minimum sampling effort can be directly applied towards bat management as a baseline for survey protocols, as well as provide data for the use in environmental reviews of wind farm locations in this region (Bales *et al., In press*).

Chapter 4

INTRODUCTION

The development and implementation of effective conservation plans and management programs for bat species and populations have been hindered by the lack of information regarding habitat requirements (Fenton, 1997; Kunz and Fenton, 2003). Perhaps the most critical components of a habitat are roost sites as they provide a place to rest, digest meals, raise young and interact (and potentially hibernate) and seek protection from the elements and predators (Neuweiler, 2000; Kunz, 1988; Kunz and Fenton, 2003). Therefore, determining roost abundance and roost characteristics for bat species in Eastern and Central South Dakota (in particular the biodiversity rich lower Missouri River and its tributaries) is a conservation priority.

Bats can be grouped according to the different type of roosts they utilize (caves, crevice, foliage, etc.) and described as either roost specialists or generalists. Generalists (e.g., *Eptesicus fuscus*) will utilize a variety of roost types, with selection likely based on availability, proximity to foraging habitat and water sources, and physiological requirements (e.g., temperature, humidity); while, specialists (e.g., *Myotis grisescens*) consistently select a particular roost type probably based on rigid physiological requirements (Kunz and Fenton, 2003).

Of the bats found in Eastern and Central South Dakota, *Lasiurus borealis* and *L. cinereus* are deemed foliage roosting specialists, whereas *Eptesicus fuscus, Nycticeius humeralis, Lasionycteris noctivagans, Myotis septentrionalis, M. lucifugus*, and *M.*

ciliolabrum are considered generalists. The characteristics that can influence the selection of a roost tree are circumference, height, stage of decay, and canopy cover. Numerous studies have compared bat roost trees to other trees in the vicinity to determine differences that may affect roost selection (Cryan *et al.,* 2001; Foster and Kurta, 1999; Swier, 2003; Vonhof and Barclay, 1996). In some cases the circumference of roost trees were larger (Cryan *et al.,* 2001) and taller than surrounding trees (Vonhof and Barclay, 1996), both of which are related the age and stage of decay of the tree. Canopy cover and the stage of decay of occupied roost trees vary among species of bats. Foster and Kurta (1999) found *M. septentrionalis* utilizing live trees with a high percent of canopy cover, while Cryan *et al.* (2001) found that *E. fuscus* utilized dead or dying trees with less canopy cover.

The only previous study to investigate roosting habitat of bat species in Eastern and Central South Dakota was by Swier (2003), although her sample size was small (n = 14, four species). Through the use of radio-telemetry, Swier (2003) found that the selectivity of different roost characteristics varied among bat species. The dominant tree species selected by the bats was, however, Plains Cottonwoods (*Populus deltoides monilifera*). This is not surprising as they are the most common tree in the riparian habitats of Eastern and Central South Dakota and the dominance of this species in some cases may limit roost selection. However, Plains Cottonwoods have many potentially favorable attributes: rapid growth, deeply furrowed bark, major branches, readily exfoliating bark, and ease of cavity creation.

Additional factors that govern bat populations and bat distributions are foraging habitat, prey availability and abundance, and access to water (Kunz and Fenton, 2003; Furlonger *et al.,* 1987; Adams and Thibault, 2006). All of these habitat components vary along the Lower Missouri River and its tributaries in South Dakota. The riverine gallery forest represents only 1.5% of the total land coverage in Eastern and Central South Dakota (Smith *et al.,* unpublished). Despite its limited area, this habitat has comparatively high bat species richness and abundance (Swier, 2003 and 2006) that is likely due to an abundance of trees in the floodplain, corridor effect (Stauffer and Best, 1980), available water sources, the creation of roosting habitat through periodic flooding and fires, and rich soils. Though temporal-spatial partitioning of bat activity at isolated water holes has been demonstrated (Adams and Thibault, 2006), it is unlikely that water is a limiting factor for bats in Eastern and Central South Dakota, except possibly under extreme conditions. Proximity to water may influence roost selection and habitat utilization. Thus, the limited distribution of this critical resource makes the spatial use of these habitats equally important. Bats were radio-tagged and tracked to gain a better understanding of roost selection, home range, habitat selection utilization by several species of bats in this region.

METHODS

FIELD SAMPLING METHODS

During the 2005 and 2006 field seasons, several bats that were mist netted at Byre Game Production Area (GPA), Fort Randall Dam Spillway, Lewis and Clark Boy Scout Camp, and Oahe Downstream Recreation Area (Chapter 2) were outfitted with radio-transmitters (Holohil® Systems: LB-2N and LB-2 transmitters). Age and sex of each bat to be radio-tagged was determined as described in Chapter 2. These Holohil® transmitters are the smallest available in the commercial market and have an estimated active life of 14 days and 21 days, respectively. Each radio-transmitter was attached to a bat's fur using surgical skin-glue (Skin Bond®: Pfizer, Florida) to the mid-scapular region after a small patch of fur was trimmed away, as conducted by Swier (2003). Because radio-transmitters are attached to the animal's fur via surgical skin-glue, these transmitters eventually detach from the bat as the glue decomposes, thereby not permanently affecting the animal. Case in point, Kiesow (unpubl. data) recaptured a *M. septentrionalis* in 2004 that was previously banded and radio-tagged by Swier (2003) - there was no evidence of wing-membrane damage from the band and no evidence of a radio-transmitter having been attached to this bat. In addition, this bat was post-lactating thereby indicating it was still reproductively active (Kiesow, unpubl. data). Radio-transmitters weigh approximately 0.36 g (LB-2N) and 0.42 g (LB-2), while most insectivorous bats along the Missouri River in South Dakota range from 6 - 14 grams. Typically, radio-transmitters should comprise no more than 5 – 10 % of the bats' total body mass to prevent adverse changes in flight agility and thus, activity patterns (Aldridge and Brigham, 1988). Within this present study, radio-transmitters typically comprised less than 5% and no more than 7% (range of approximately 2-7%) of each bats' total body weight.

Radio-tagged bats were radio-tracked by foot and vehicle, using three element Yagi-antennas attached to either Communications Specialist Inc. (California) R1000 receivers or an Advanced Telemetry Systems Inc. (Minnesota) R4500S receiver. The goal of this tracking was to find roost sites (day, night, and temporary), foraging locations, foraging areas, home-ranges, potential migratory routes/patterns, and to establish habitat use and composition. Bats were tracked until the transmitter fell off the bat or batteries were presumed to have failed.

Global Positioning System (GPS) locations were recorded (Universal Transverse Mercator (UTM) zone 14, projection WGS 1984) with Garmin® (Kansas) Rhino-120 units were three-dimensionally accurate to three meters under optimal conditions. The UTM coordinates of foraging locations were determined by following individual bats and the triangulation of locations and compass bearings (Silva®: Ranger®, Wisconsin) using the program LOCATE III (Pacer Computing, Nova Scotia). Most foraging locations were recorded during the assumed first period of activity, dusk to roughly 1:00 am, and over intervals never shorter than 15 minutes to insure independence among recorded positions to avoid serial autocorrelation (Otis and White, 1999).

Radio-tagging and tracking was conducted between May and September of both the 2005 and 2006 field seasons. Upon tracking a bat to a roost tree, a GPS location was recorded, and roost tree measurements such as diameter breast height (cm), height (meters), percent of adjacent canopy cover, and state of decay were taken. Diameter breast height (DBH) was determined using a diameter tape (Forestry Suppliers Inc., Mississippi). Total height of a roost tree was visually estimated. The percent canopy at each roost was determined using a concave densimeter (Geographic Resource Solutions, California). Upon further review, canopy cover was categorized into two groups - 0-50% and 51-100% - because tree-cover fell almost exclusively into 0-25% and 75-100% categories. Roost trees were first classified as dead or alive and then classified as to their state of decay wherein: Stage 1 trees were alive, Stage 2 trees were declining, Stage 3 trees were dead, Stage 4 trees had loose bark, Stage 5 trees were clean of bark, Stage 6 trees were broken, and Stage 7 trees were decomposed (Thomas *et al.,* 1979). Furthermore, the roosts were classified as being in cavities, under loose bark, on top of the bark, amongst the foliage, on the trunk of the tree, or on the major limbs, based on visual observation using 8x40 roof prism binoculars (Cabela's Inc., Nebraska), in combination radio-transmitter signal location and signal strength.

DATA ANALYSIS

The adaptive kernel method (AKM), using BIOTAS® 1.03 alpha (Ecological Software Solutions LLC., Switzerland), was used to determine the size of the home-range of each animal because this method permits the representation of multimodal distributions (Worton, 1989). The adaptive kernel method was used to determine the size of the 95% and 75% habitat use distribution and home-range polygons were superimposed over satellite imagery taken from Google™ Earth 4.0.2693 (beta; images accessed May 2007; Google Inc., California) for visual representation (Figs. 4.1-16). Home-range size comparisons were made with the Wilcoxon two-sample test. Additionally, the 95% adaptive kernel home-range polygons produced by BIOTAS® were overlaid on vegetation maps from the South Dakota GAP analysis project (The Nature Conservancy© vegetation alliances applied to 30-meter Landsat 5 Thematic Mapper satellite imagery). A 2 km (approximately the longest documented distance moved by either species during this study) buffer was added to the 95% adaptive kernel home-range to include available habitat(s) and coverage was extracted using ArcGIS® (Environmental Systems Research Institute Inc. (ESRI), California). The proportion of each vegetation type within each bat's home-range was calculated using BIOTAS®. Habitat type selection indices were constructed for each bat and for each bat species at each study site (available habitat(s) defined as all 95% AKM home-ranges united with a 2 km buffer) by comparing habitat use and availability using Neu's method (Neu *et al.,* 1974) and compositional analysis (Aebischer *et al.,* 1993) that are available in the BIOTAS® program.

Neu's method (Neu *et al.,* 1974) requires three assumptions: all observations are independent; that the samples are large enough to approximate normal distribution; and for individuals grouped for analysis (e.g., species) that habitat availability is the same for each individual. Alldredge and Ratti (1986) showed that the assumption of 'same habitat availability' may be violated as other methods that do not assume this, return results similar to Neu's method. Differences between observed and expected habitat use were tested with a Chi-squared test. Habitat types that should not be included in analysis (e.g., towns) were excluded and habitat types with low (< 5) expected use values were combined (based on structural similarities) or eliminated (based on likelihood of non-utilization) from the analysis to remove a possible source of bias in the habitat selection ratios. Compositional analysis requires three assumptions: each individual provides and independent measure of habitat use within the population; contributions from each individual are equally representative; and that residuals after model fitting are multivariately normal (Aebischer *et al.,* 1993). As suggested by Aebischer *et al.* (1993), I replaced available habitat types not being utilized (0%) with a value of 0.001 for computational purposes, as zero-percent habitat use is too low to be documented. A multivariate analysis of variance (MANOVA) was used to determine a Wilk's Λ value to evaluate differences in habitat use and habitat selection among individuals and species. Simplified ranking matrices were generated for individuals and species to demonstrate habitat selection.

Differences in continuous variables, diameter breast height and tree height, were analyzed using the two-tailed Mann-Whitney (Wilcoxon) test with the standard normal deviate Z, or depending on the sample size, the χ^2 approximation to the Kruskal-Wallis test. For dichotomous and categorical variables, chi-squared tests were used. The level of rejection for all tests was $p \leq 0.05$. Statistical analyses were preformed using SAS/STAT (9.1).

RESULTS

I radio-tagged 48 bats during the 2005 (n = 5) and 2006 (n = 43) field seasons representing six species: *Myotis septentrionalis* (n = 29), *M. ciliolabrum* (n = 1), *M. lucifugus* (n = 1), *Eptesicus fuscus* (n = 11), *Lasiurus cinereus (n = 2)* and *L.* borealis (n = 4). I was able to collect roost data from the majority of these bats (Table 4.1). Roost tree height estimates proved too unreliable and not analyzed. Insufficient roost data was collected on *Myotis lucifugus* (n = 1) and *Myotis ciliolabrum* (n = 1) for analysis.

Myotis septentrionalis changed roosts every 2.6 days (SD (standard deviation) = 0.2) on average with an average distance moved of 182 m (SD = 175). *Myotis septentrionalis* selected plains cottonwood trees (*Populus deltoides monilifera*) trees (χ^2 = 42, df = 3, p < 0.001) and roosted under bark (χ^2 = 102, df = 3, p < 0.001) located on main tree limbs (69.8%; χ^2 = 46.4, df = 2, p < 0.001). No selection was shown for trees categorized as alive or dead and no selection was shown for either category of canopy cover (χ^2 = 0.78, df = 2, p = 0.38). Roost trees had a significantly larger (*Z* = 1.81, p < 0.05) circumference than surrounding trees. *Myotis septentrionalis* selected trees in the second stage of decay (55.55%) and did not utilize trees in stages one, five, six or seven (χ^2 = 199, df = 6, p < 0.001; Table 4.1).

Eptesicus fuscus changed roosts every 3.1 days (SD = 0.1) days on average with an average distance moved of 136 m (SD = 86). *Eptesicus fuscus* selected plains cottonwood trees (χ^2 = 11.3, df = 3, p = 0.01) and roosted in cavities (χ^2 = 19.9, df = 3, p < 0.001). Roosts were located in tree trunks or main limbs (χ^2 = 8.6, df = 2, p = 0.014); there was however no difference in selection (χ^2 = 0.0588, df = 1, p = 0.81) between the two. No selection was shown for trees categorized as alive or dead and no selection was shown for either canopy cover category ($\chi^2 = 0.0588$, df = 1, p = 0.81). Roost trees had a significantly larger circumference than surrounding trees ($Z = 1.76$, $p < 0.05$). *Eptesicus fuscus* selected trees in the second (47%) and third (41.2%) stages of decay and did not utilize trees in stages one, five, six or seven ($\chi^2 = 31.6$, df = 6, $p < 0.001$; Table 4.1).

Lasiurus cinereus changed roosts every 1.5 days (SD = 0.5) with an average distance moved of 835.8 m (SD = 177.4). *Lasiurus cinereus* did not show a select for a particular tree species ($\chi^2 = 5.21$, df = 3, p = 0.16) but did select foliage roosts (85.7%; $\chi^2 = 14.1$, df = 3, $p < 0.003$). Selection was shown for trees categorized as alive ($\chi^2 = 7.0$, df = 1, p = 0.008) and slight selection for trees in canopy cover category 50-100% ($\chi^2 = 3.57$, df = 1, p = 0.059). Roost trees with larger circumferences than surrounding trees were not selected ($\chi^2 = 7.91$, p = 0.6). *Lasiurus cinereus* selected for trees in the first and second stages of decay ($\chi^2 = 18$, df = 6, p = 0.006), however, there was no difference in selection between the two ($\chi^2 = 0.143$, df = 1, p = 0.705), and trees in stages three, four, five, six and seven were not utilized (Table 4.1).

Lasiurus borealis changed roosts every 1.2 days (SD = 0.3) on average with an average distance moved of 388.55 m (SD = 281.57). *Lasiurus borealis* showed no selectivity for a particular species of roost tree as compared to expected ($\chi^2 = 4.42$, df = 3, p = 0.22), however 66% of roosts were found in plains cottonwood trees. *Lasiurus borealis* selected foliage as a roost type (100%, $\chi^2 = 36.0$, df = 3, $p < 0.0001$). Selection was shown for trees categorized as alive (100%, $\chi^2 = 12.0$, df = 1, p = 0.001) and selection was shown for canopy categorized as 50-100% (83.3%, $\chi^2 = 5.33$, df = 1, p =

0.021). Roost trees were not significantly larger than surrounding trees ($Z = 0.77$, $p > 0.77$). *Lasiurus borealis* selected for trees in the first and second stages of decay ($\chi^2 = 34.8$, df = 6, $p < 0.001$); there was no difference in selection between the two ($\chi^2 = 1.33$, df = 1, $p = 0.248$), however trees in stage two represent 66.66% of roosts; trees in stages three, four, five, six and seven were not utilized (Table 4.1).

Sufficient location data (> 30) were obtained from 16 (12 *Myotis septentrionalis*; 4 *Eptesicus fuscus*) individuals to begin determining home-range and habitat use. The average tracking period for these bats (n = 16) was 6.4 days (range 4-10, SD = 2). LOCATE III calculated average error of triangulation at 168 m^2 (SD = 41). The mean 95% adaptive kernel method (AKM; Worton, 1989) home-range for *Myotis septentrionalis* (n = 12) was 91.34 ha (range 65.91-118.35, SD = 23.58) and the mean 75% AKM home-range was 45.16 ha (range 21.54-65.34, SD = 13.96; Table 4.2). The 95% and 75% AKM home-ranges for *Myotis septentrionalis* are visually represented in Figures 4.1 through 4.12. There was no significant difference in the size of the 95% AKM home-range ($p = 0.9$) or the 75% AKM home-range ($p = 0.99$) between male and female *Myotis septentrionalis*. There was no significant difference in 95% AKM home-range ($p = 0.63$) or the 75% AKM home-range ($p = 0.99$) between adult and subadult female *Myotis septentrionalis*. *Myotis septentrionalis* at the same location had similar home-range sizes (Table 4.2). The mean home-range (95% AKM) at the Arikara Game Production Area (GPA) was 61.53 ha with a standard deviation of 21.44, Byre GPA was 66.64 ha with a standard deviation of 1.03, Fort Randall Dam Spillway was 97.92 ha with a standard deviation of 21.46, and Oahe Downstream Recreation Area was 107.32 ha with a standard deviation of 10.78. The mean 75% AKM for Arikara GPA was 27.49 ha with a standard deviation of 8.41, Byre GPA was 33.5 ha with a standard deviation of 0.24, Fort Randall Dam Spillway was 53.94 ha with a standard deviation of 16.11, and Oahe Downstream Recreation Area was 52.01 ha with a standard deviation of 9.80.

The mean 95% AKM (Worton, 1989) home-range for *Eptesicus fuscus* (n = 4) was 187.54 ha (range 145.63-259.64, SD = 53.80) and the mean 75% AKM home-range was 73.14 ha (range 37.59-113.1, SD = 31.69; Table 4.2). The 95% and 75% AKM home-ranges for *Eptesicus fuscus*' are visually represented in Figures 4.13 through 4.16. There was a significant difference in 95% AKM home-range (p = 0.0001) between *Myotis septentrionalis* and *Eptesicus fuscus* but no significant difference in the 75% AKM home range (p = 0.1). *Eptesicus fuscus* at the same location had similar home-range sizes (Table 4.2). The mean 95% AKM for Byre GPA was 228.66 ha with a standard deviation of 43.81, and Fort Randall Dam Spillway was 146.43 ha with a standard deviation of 1.13. The mean 75% AKM for Byre GPA was 96.23 ha with a standard deviation of 23.85, and Fort Randall Dam Spillway was 50.05 ha with a standard deviation of 17.62.

Neu's method (Neu *et al.,* 1974) and compositional analysis (Aebischer *et al*., 1993) of habitat selection for the radio-tracked bats with sufficient locations (30+: n = 12 *Myotis septentrionalis* and n = 4 *Eptesicus fuscus*) showed that observed habitat use was significantly (p < 0.05) different than expected use based on availability (habitats within the 95% AKM home-range with 2km buffer) for all individuals and species at all areas (Tables 4.3 – 4.46). Neu's method and the compositional analysis returned differing results likely due the particular grouping of habitats employed during the application of Neu's method. Individuals of the same species at the same location frequently differed in their habitat use and selection as indicated by both Neu's method and compositional analysis. Additionally, species habitat use frequently differed from individual analyses. Habitat selection analysis for individual bats using Neu's method and compositional analysis can be found in Tables 4.3 through 4.18 and Tables 4.25 through 4.40 respectively.

Using Neu's method (Neu *et al.,* 1974) of habitat selection analysis, *Myotis septentrionalis* (n = 2) at Arikara GPA selectively used the agriculture and hayland habitat group (Table 4.19), whereas compositional habitat selection analysis (Aebischer *et al.,* 1993) indicated that the top four selected habitats were deciduous woodland, hayland, agricultural land, and pastureland (Table 4.41). Using Neu's method of habitat selection analysis, *Myotis septentrionalis* (n = 2) at Byre GPA selectively used the high cover grassland and medium cover grassland habitat groups (Table 4.20), but compositional habitat use analysis indicated that the top four selected habitats were water, unvegetated badlands, high cover grassland, and creeping juniper dwarf-shrubland (Table 4.42). Using Neu's method of habitat selection analysis, *Myotis septentrionalis* (n = 2) at Fort Randall Dam Spillway selectively used the agriculture and pastureland habitat groups (Table 4.21), but compositional habitat selection analysis indicated that the top four selected habitats were agricultural land, idle grassland, pastureland, and deciduous woodland (Table 4.43). Using Neu's method of habitat selection analysis, *Myotis septentrionalis* (n = 6) at Oahe Downstream Recreation Area selectively used the low cover grassland habitat groups (Table 4.22), but compositional habitat selection analysis showed that the top four selected habitats were barren ground, shale barren slope sparse vegetation, low cover grassland, and high cover grassland (Table 4.44).

Using Neu's method (Neu *et al.,* 1974) of habitat selection analysis, *Eptesicus fuscus* (n = 2) at Byre GPA preferentially used the high cover grassland and medium cover grassland habitat groups (Table 4.23), but compositional habitat selection analysis (Aebischer et *al.,* 1993) indicated that the top four ranking selected habitats were xeric shrubland, water, high cover grassland, and barren ground (Table 4.45). Using Neu's method of habitat selection analysis *Eptesicus fuscus* (n = 2) at Fort Randall Dam Spillway selectively used the agriculture and pastureland habitats (Table 4.24), whereas compositional habitat selection analysis indicated that the top four ranking selected habitats were pastureland, low density development, idle grassland, and deciduous woodland (Table 4.46).

Table 4.1. Roost trees, habits, and behavior of radio-tagged *Myotis septentrionalis* (n = 29), *Myotis lucifugus* (n = 1), *Myotis ciliolabrum* (n = 1), *Eptesicus fuscus* (n = 11), *Lasiurus cinereus* (n = 2), and *Lasiurus borealis* (n = 4) during the 2005 and 2006 field seasons.

Species	***M.sep***	***M.luc***	***M.cil***	***E.fus***	***L.cin***	***L.bor***
Number Tagged	29	1	1	11	2	4
Sex						
Male	9		1	6		1
Female	20	1		5	2	3
Number of Diurnal Roost	63	1	1	17	7	12
Character						
Species of tree						
Cottonwoods	63	1	1	17	3	8
Elms					3	4
Maples						
Others					1 (Am. Basswood)	
Type of roost						
Cavity	14	1		11		
Under bark	49		1	6		
On bark					1	
Foliage					6	12
Location of roost						
Tree trunk	19	1		9	1	
Major limb	44		1	8		
Foliage					6	12
Alive or dead						
Alive	35		1	8	7	12
Dead	28	1		9		
Canopy cover						
0-50%	28	1		9	1	2
51-100%	35		1	8	6	10
Diameter of tree (cm)						
Cottonwoods	51.37 ± 21.48	33	56	63.34 ± 21.66	45.59 ± 14.45	57.89 ± 13.87
Elms					33.8 ± 10.35	34.27 ± 3.96
Maples						
Others					52 (Am. Basswood)	
Stage of decay						
Stage 1					3	8
Stage 2	35		1	8	4	4
Stage 3	17			7		
Stage 4	11	1		2		
Stage 5						
Stage 6						
Stage 7						
Frequency of changes	1/2.6 days ± 0.2	NA	NA	1/3.1 days ± 0.1	1/1.5 days ± 0.5	1/1.2 days ± 0.3
Distance moved (m)	182 ± 175 (n=38)	NA	NA	136 ± 86.2 (n=7)	835.8 ± 177.44 (n = 5)	388.55 ± 281.57 (n = 9)

Table 4.2. Transmitter number, number of locations, body mass, age, sex, reproductive status, transmitter mass (percent body mass), date transmitter affixed, date transmitter lost, days in contact, 95% and 75% adaptive kernel method (AKM) home-range estimates for *Myotis septentrionalis* (*M.sep*) and *Eptesicus fuscus* (*E.fus*) at Arikara GPA (AK), Byre GPA (BY), Fort Randall Dam Spillway (FR), and Oahe Downstream Rec. Area (OA) in South Dakota during May-September 2006.

	Transmitter	Study Area	Total locations	Body Mass	Age	Sex	Reproductive	Transmitter mass	Date		Days	AKM (95%)	AKM (75%)
Species	No.		n	g			status	g (%body mass)	Affixed	Lost	In Contact	ha	ha
M.sep	102990	AK	35	6.7	A	F	rec-Lac	0.42 (6.3%)	7/12/2006	7/23/2006	5	76.69	33.44
	102985	OA	44	7.1	A	M	Non	0.36 (5.1%)	5/12/2006	5/25/2006	7	97	42.64
	103002	OA	41	7	subA	F	Non	0.42 (6%)	5/12/2006	6/1/2006	10	118.35	65.12
	103004	OA	34	6.5	subA	F	Non	0.42 (6.5%)	5/12/2006	6/1/2006	10	111.27	40
	103003	OA	34	7	A	F	Non	0.42 (6%)	5/12/2006	5/30/2006	9	106.7	53.36
	102987	OA	34	6	A	F	Non	0.42 (7%)	5/13/2006	5/28/2006	8	118.12	60.52
	102999	FR	37	7	A	F	Non	0.42 (6%)	6/3/2006	6/20/2006	5	113.09	65.34
	102974	BY	36	7.7	A	F	Lac	0.42 (5.5%)	6/15/2006	7/8/2006	8	67.37	33.33
	102991	AK	38	7.2	A	F	Non	0.42 (5.8%)	7/12/2006	7/23/2006	5	46.37	21.54
	102972	OA	37	7	A	F	Non	0.36 (5.1%)	7/21/2006	8/3/2006	4	92.48	50.44
	103007	BY	37	7.5	subA	F	Non	0.36 (4.8%)	8/15/2006	8/25/2006	4	65.91	33.67
	103021	FR	34	7	A	M	Scr	0.42 (6%)	8/31/2006	9/20/2006	5	82.74	42.55
E.fus	103023	FR	39	18	A	F	Non	0.42 (2.3%)	8/31/2006	9/21/2006	5	145.63	62.51
	103025	FR	36	20	A	M	Scr	0.42 (2.1%)	8/31/2006	9/20/2006	5	147.23	37.59
	102973	BY	34	17.5	A	M	Non	0.42 (2.4%)	5/24/2006	6/14/2006	6	259.64	113.1
	102996	BY	41	21.8	A	F	Non	0.42 (1.9%)	6/15/2006	7/6/2006	6	197.68	79.37

102990 an adult female *Myotis septentrionalis*

Figure 4.1. BIOTAS® produced 95% (red) and 75% (blue) adaptive kernel home-range for 102990 at Arikara Game Production Area, overlaid onto Google™ Earth satellite imagery.

102985 an adult male *Myotis septentrionalis*

Figure 4.2. BIOTAS® produced 95% (green) and 75% (yellow) adaptive kernel home-range for 102985 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

103002 a subadult female *Myotis septentrionalis*

Figure 4.3. BIOTAS® produced 95% (green) and 75% (yellow) adaptive kernel home-range for 103002 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

103004 a subadult female *Myotis septentrionalis*

Figure 4.4. BIOTAS® produced 95% (purple) and 75% (yellow) adaptive kernel home-range for 103004 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

103003 an adult female *Myotis septentrionalis*

Figure 4.5. BIOTAS® produced 95% (green) and 75% (orange) adaptive kernel home-range for 103003 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

102987 an adult female *Myotis septentrionalis*

Figure 4.6. BIOTAS® produced 95% (purple) and 75% (yellow) adaptive kernel home-range for 102987 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

102999 an adult female *Myotis septentrionalis*

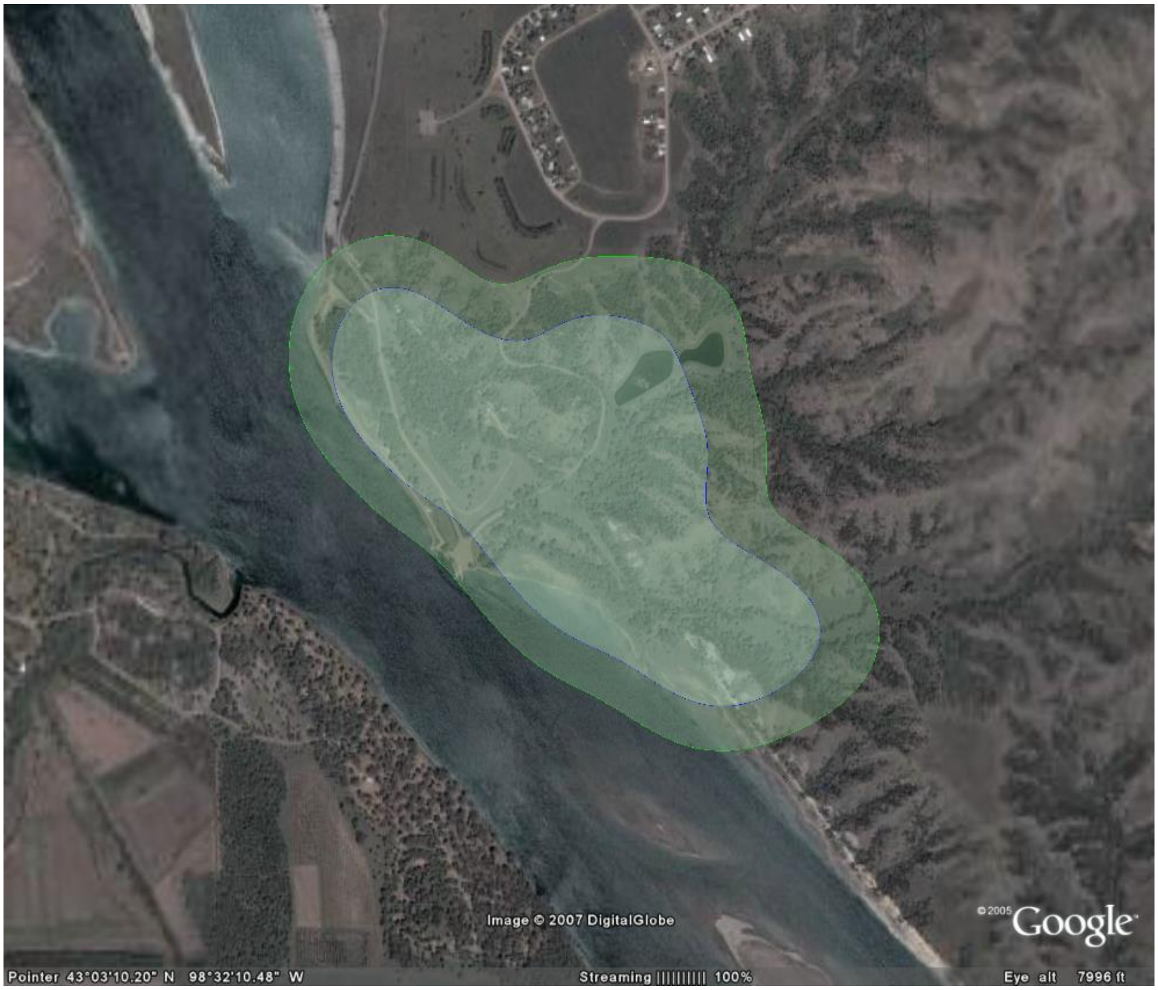


Figure 4.7. BIOTAS® produced 95% (green) and 75% (blue) adaptive kernel home-range for 102999 at Fort Randall Dam Spillway, overlaid onto Google™ Earth satellite imagery.

102974 an adult female *Myotis septentrionalis*

Figure 4.8. BIOTAS® produced 95% (yellow) and 75% (green) adaptive kernel home-range for 102974 at Byre Game Production Area, overlaid onto Google™ Earth satellite imagery.

102991 an adult female *Myotis septentrionalis*

Figure 4.9. BIOTAS® produced 95% (green) and 75% (blue) adaptive kernel home-range for 102991 at Arikara Game Production Area, overlaid onto Google™ Earth satellite imagery.

102972 an adult female *Myotis septentrionalis*

Figure 4.10. BIOTAS® produced 95% (green) and 75% (orange) adaptive kernel home-range for 102972 at Oahe Downstream Recreation Area, overlaid onto Google™ Earth satellite imagery.

103007 a subadult female *Myotis septentrionalis*

Figure 4.11. BIOTAS® produced 95% (green) and 75% (purple) adaptive kernel home-range for 103007 at Byre Game Production Area, overlaid onto Google™ Earth satellite imagery.

103021 an adult male *Myotis septentrionalis*

Figure 4.12. BIOTAS® produced 95% (blue) and 75% (green) adaptive kernel home-range for 103021 at Fort Randall Dam Spillway, overlaid onto Google™ Earth satellite imagery.

103023 an adult female *Eptesicus fuscus*

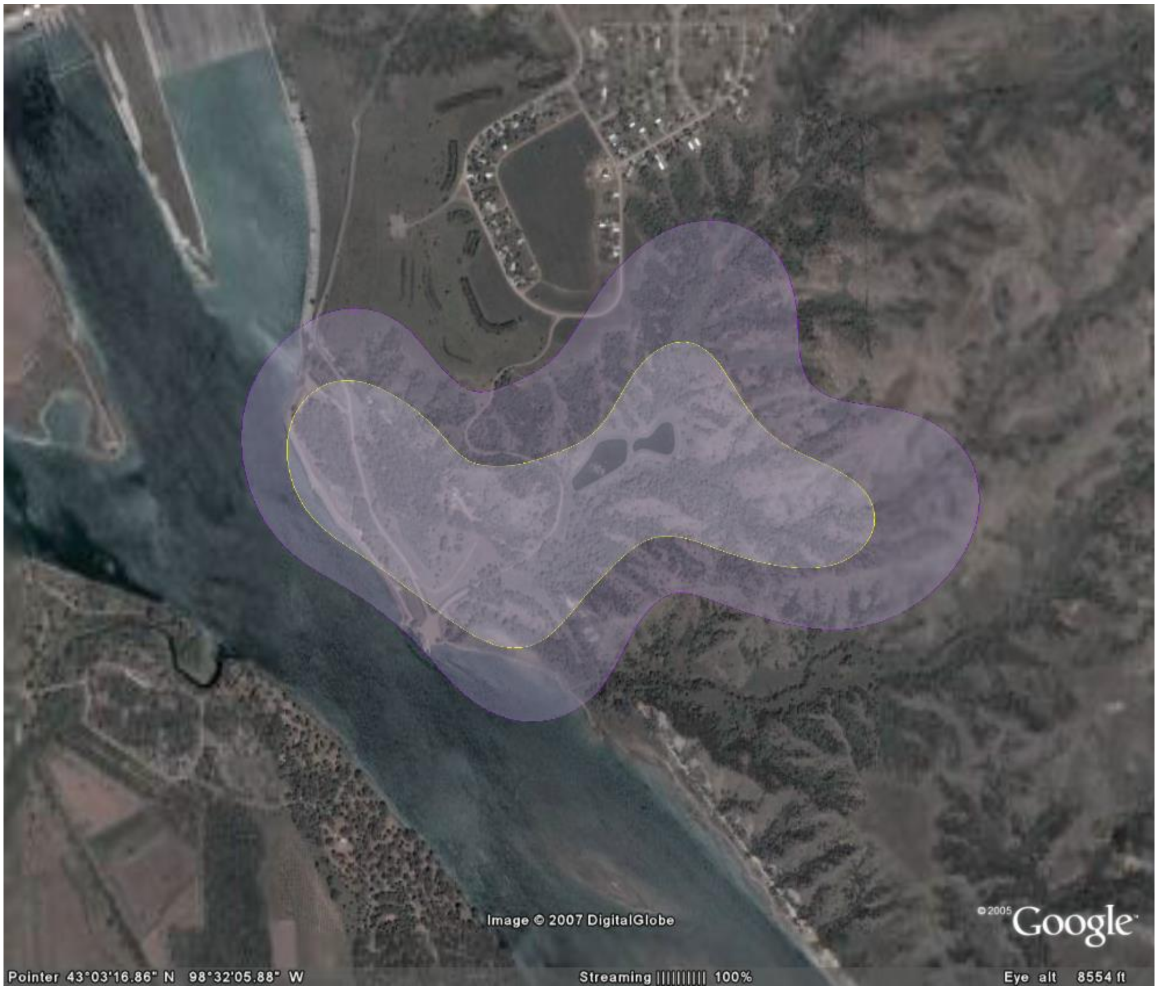


Figure 4.13. BIOTAS® produced 95% (purple) and 75% (yellow) adaptive kernel home-range for 103023 at Fort Randall Dam Spillway, overlaid onto Google™ Earth satellite imagery.

103025 an adult male *Eptesicus fuscus*

Figure 4.14. BIOTAS® produced 95% (blue) and 75% (yellow) adaptive kernel home-range for 103025 at Fort Randall Dam Spillway, overlaid onto Google™ Earth satellite imagery.

102973 an adult female *Eptesicus fuscus*

Figure 4.15. BIOTAS® produced 95% (green) and 75% (purple) adaptive kernel home-range for 102973 at Byre Game Production Area, overlaid onto Google™ Earth satellite imagery.

102996 an adult female *Eptesicus fuscus*

Figure 4.16. BIOTAS® produced 95% (yellow) and 75% (orange) adaptive kernel home-range for 102996 at Byre Game Production Area, overlaid onto Google™ Earth satellite imagery.

Table 4.3. Habitat selection analysis of 102990 an adult female *Myotis septentrionalis* at Arikara Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland	13	0.14528	5	0.05396	0.2563
Deciduous Trees + Deciduous Woodland + High Cover Grassland	6	0.1776	6	0.03045	0.1446
Idle Grassland + Low Cover Grassland + Medium Cover Grassland + Pastureland	12	0.31984	11	0.10966	0.52085
Permanent Wetland + Semipermanent Wetland	4	0.14414	5	0.01647	0.07824
Water	0	0.21313	7	0	0

Observed Chi Squared Value = 25.1464
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.4. Habitat selection analysis of 102985 an adult male *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland	1	0.1961	9	0.00446	0.02288
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	5	0.16146	7	0.01835	0.09421
High Cover Grassland + Medium Cover Grassland	6	0.22705	10	0.03096	0.15898
Idle Grassland + Low Cover Grassland	31	0.19294	8	0.13594	0.69798
Permanent Wetland + Semipermanent Wetland + Water + Temporary Wetland	1	0.22244	10	0.00506	0.02596

Observed Chi Squared Value = 65.4876
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.5. Habitat selection analysis of 103002 a subadult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland + Pastureland	0	0.2059	8	0	0
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	3	0.19483	8	0.01426	0.05343
Deciduous Trees + Deciduous Woodland + High Cover Grassland	5	0.15857	7	0.01934	0.07248
Low Cover Grassland + Idle Grassland + Medium Cover Grassland	31	0.29932	12	0.22631	0.84824
Permanent Wetland + Water + Temporary Wetland	2	0.14138	6	0.0069	0.02585

Observed Chi Squared Value = 45.1988
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.6. Habitat selection analysis of 103004 a subadult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland + Pastureland + Idle Grassland	1	0.43469	15	0.01279	0.07118
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	5	0.25006	9	0.03677	0.20475
Deciduous Trees + Deciduous Woodland + High Cover Grassland + Medium Cover Grassland + Low Cover Grassland	27	0.15794	5	0.12542	0.69831
Permanent Wetland + Water + Semipermanent Wetland + Temporary Wetland	1	0.15731	5	0.00463	0.02576

Observed Chi Squared Value = 76.5527
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.7. Habitat selection analysis of 103003 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland + Pastureland + Idle Grassland	2	0.41856	14	0.02462	0.11829
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	3	0.19126	7	0.01688	0.08108
Deciduous Trees + Deciduous Woodland + High Cover Grassland + Medium Cover Grassland + Low Cover Grassland	27	0.19542	7	0.15518	0.74558
Permanent Wetland + Temporary Wetland + Water	2	0.19476	7	0.01146	0.05504

Observed Chi Squared Value = 55.0176
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.8. Habitat selection analysis of 102987 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland + Hayland + Idle Grassland	1	0.31255	11	0.00919	0.04071
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	1	0.24297	8	0.00715	0.03165
Deciduous Trees + High Cover Grassland + Deciduous Woodland + Low Cover Grassland + Medium Cover Grassland	32	0.22256	8	0.20947	0.92764
Permanent Wetland + Water + Temporary Wetland	0	0.22192	8	0	0

Observed Chi Squared Value = 79.7682
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.9. Habitat selection analysis of 102999 an adult female *Myotis septentrionalis* at Fort Randall Dam Spillway using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland + Idle Grassland	37	0.33703	12	0.33703	1
Deciduous Woodland + High Cover Grassland + Low Cover Grassland	0	0.29199	11	0	0
Permanent Wetland + Water	0	0.15077	6	0	0
Riverine Wetland + Seasonal Wetland	0	0.22021	8	0	0

Observed Chi Squared Value = 83.3248
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.10. Habitat selection analysis of 102974 an adult female *Myotis septentrionalis* at Byre Game Production Area using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	1	0.3639	13	0.01011	0.05372
Creeping Juniper Dwarf-shrubland + Xeric Shrubland + Barren + Unvegetated Badlands + Vegetated Badlands	3	0.13835	5	0.01153	0.06127
Low Cover Grassland + High Cover Grassland + Medium Cover Grassland	28	0.16685	6	0.12978	0.68964
Water	4	0.33089	12	0.03677	0.19538

Observed Chi Squared Value = 69.2812
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.11. Habitat selection analysis of 102991 an adult female *Myotis septentrionalis* at Arikara Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland	22	0.14192	5	0.08216	0.54011
Deciduous Woodland + Deciduous Trees + High Cover Grassland	8	0.14363	5	0.03024	0.19877
Idle Grassland + Low Cover Grassland + Pastureland	6	0.18656	7	0.02946	0.19364
Medium Cover Grassland	0	0.14161	5	0	0
Permanent Wetland + Semipermanent Wetland	2	0.19506	7	0.01027	0.06749
Temporary Wetland + Seasonal Wetland	0	0.19123	7	0	0

Observed Chi Squared Value = 65.8498
Chi Squared Cumlative Value (df: 5, alpha: 0.05) = 11.0705
Probability (p) observed use differs from expected use = 0.0001

Table 4.12. Habitat selection analysis of 102972 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland + Pastureland + Idle Grassland	0	0.42365	16	0	0
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	14	0.17486	6	0.06616	0.44385
Deciduous Trees + Deciduous Woodland + High Cover Grassland	0	0.13919	5	0	0
Low Cover Grassland + Medium Cover Grassland	15	0.13842	5	0.05612	0.37646
Permanent Wetland + Semipermanent Wetland + Water + Temporary Wetland	8	0.12388	5	0.02679	0.17969

Observed Chi Squared Value = 64.2028
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.13. Habitat selection analysis of 103007 a subadult female *Myotis septentrionalis* at Byre Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	1	0.16632	5	0.0052	0.02048
High Cover Grassland + Medium Cover Grassland	28	0.21817	7	0.1909	0.75216
Low Cover Grassland	3	0.6155	20	0.0577	0.22736

Observed Chi Squared Value = 63.0309
Chi Squared Cumlative Value (df: 2, alpha: 0.05) = 5.9915
Probability (p) observed use differs from expected use = 0.0001

Table 4.14. Habitat selection analysis of 103021 an adult male *Myotis septentrionalis* at Fort Randall Dam Spillway using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland + Idle Grassland	34	0.17191	6	0.17191	1
Deciduous Woodland + High Cover Grassland + Low Cover Grassland	0	0.36809	13	0	0
Riverine Wetland + Permanent Wetland + Seasonal Wetland	0	0.1702	6	0	0
Water	0	0.2898	10	0	0

Observed Chi Squared Value = 117.9529
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.15. Habitat selection analysis of 103023 an adult female *Eptesicus fuscus* at Fort Randall Dam Spillway using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland	29	0.20981	8	0.15602	0.81736
Deciduous Woodland + High Cover Grassland	2	0.19637	8	0.01007	0.05276
Eastern Red Cedar Shrubland + Idle Grassland + Low Cover Grassland	8	0.12086	5	0.02479	0.12988
Permanent Wetland + Water + Seasonal Wetland	0	0.2224	9	0	0
Riverine Wetland	0	0.25055	10	0	0

Observed Chi Squared Value = 76.6704
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.16. Habitat selection analysis of 103025 an adult male *Eptesicus fuscus* at Fort Randall Dam Spillway using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland + Idle Grassland	35	0.39764	14	0.38659	0.98101
Deciduous Woodland + High Cover Grassland + Low Cover Grassland	1	0.26937	10	0.00748	0.01899
Permanent Wetland + Water	0	0.1405	5	0	0
Riverine Wetland + Seasonal Wetland	0	0.19249	7	0	0

Observed Chi Squared Value = 59.5352
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.17. Habitat selection analysis of 102973 an adult male *Eptesicus fuscus* at Byre Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	2	0.21301	7	0.01331	0.05957
High Cover Grassland + Medium Cover Grassland	29	0.21211	7	0.19222	0.86005
Low Cover Grassland	1	0.57488	18	0.01796	0.08038

Observed Chi Squared Value = 71.6486
Chi Squared Cumlative Value (df: 2, alpha: 0.05) = 5.9915
Probability (p) observed use differs from expected use = 0.0001

Table 4.18. Habitat selection analysis of 102996 an adult female *Eptesicus fuscus* at Byre Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	5	0.22679	8	0.03065	0.06002
High Cover Grassland	31	0.56615	21	0.47434	0.92902
Low Cover Grassland + Medium Cover Grassland	1	0.20705	8	0.0056	0.01096

Observed Chi Squared Value = 15.2879
Chi Squared Cumlative Value (df: 2, alpha: 0.05) = 5.9915
Probability (p) observed use differs from expected use = 0.0005

Table 4.19. Habitat selection analysis of *Myotis septentrionalis* (n = 2) at Arikara Game Production Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Hayland	35	0.11395	8	0.05463	0.44003
Deciduous Trees + Deciduous Woodland + High Cover Grassland	13	0.13993	10	0.02492	0.2007
Medium Cover Grassland + Low Cover Grassland + Pastureland + Idle Grassland	18	0.13844	10	0.03414	0.27494
Permanent Wetland	7	0.10919	8	0.01047	0.08433
Seasonal Wetland + Temporary Wetland	0	0.14296	10	0	0
Semipermanent Wetland	0	0.16794	12	0	0
Water	0	0.18759	14	0	0

Observed Chi Squared Value = 129.4258
Chi Squared Cumlative Value (df: 6, alpha: 0.05) = 12.5916
Probability (p) observed use differs from expected use = 0.0001

Table 4.20. Habitat selection analysis of *Myotis septentrionalis* (n = 2) at Byre Game Production Area using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	4	0.16964	11	0.01013	0.05258
Barren + Unvegetated Badlands + Vegetated Badlands + Creeping Juniper Dwarf-shrubland + Xeric Shrubland	4	0.07576	5	0.00452	0.02348
High Cover Grassland + Medium Cover Grassland	56	0.18226	12	0.15233	0.79088
Low Cover Grassland	3	0.57234	38	0.02563	0.13305

Observed Chi Squared Value = 147.4180
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.21. Habitat selection analysis of *Myotis septentrionalis* (n = 2) at Fort Randall Dam Spillway using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland	53	0.18524	13	0.13828	0.82246
Deciduous Woodland + High Cover Grassland + Low Cover Grassland	1	0.21393	15	0.00301	0.01792
Eastern Red Cedar Shrubland + Idle Grassland	17	0.11208	8	0.02684	0.15962
Permanent Wetland + Water	0	0.19935	14	0	0
Riverine Wetland + Seasonal Wetland	0	0.28939	21	0	0

Observed Chi Squared Value = 169.1785
Chi Squared Cumlative Value (df: 4, alpha: 0.05) = 9.4877
Probability (p) observed use differs from expected use = 0.0001

Table 4.22. Habitat selection analysis of *Myotis septentrionalis* (n = 6) at Oahe Downstream Recreation Area using Neu's method (Neu *et al.,* 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	2	0.11192	25	0.001	0.01155
Barren + Shale Barren Slope Sparse Vegetation + Vegetated Badlands	29	0.02071	5	0.00268	0.03099
Deciduous Trees + Deciduous Woodland	0	0.02178	5	0	0
Hayland	0	0.02098	5	0	0
High Cover Grassland	27	0.15248	34	0.01838	0.2124
Idle Grassland	0	0.11033	25	0	0
Low Cover Grassland	142	0.07446	17	0.0472	0.54554
Medium Cover Grassland	10	0.2648	59	0.01182	0.13662
Pastureland	0	0.13546	30	0	0
Permanent Wetland + Semipermanent Wetland + Temporary Wetland + Water	14	0.08708	20	0.00544	0.0629

Observed Chi Squared Value = 636.7409
Chi Squared Cumlative Value (df: 9, alpha: 0.05) = 16.9190
Probability (p) observed use differs from expected use = 0.0001

Table 4.23. Habitat selection analysis of *Eptesicus fuscus* (n = 2) at Byre Game Production Area using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture	8	0.20287	15	0.02254	0.1196
Barren + Unvegetated Badlands + Xeric Shrubland + Vegetated Badlands + Creeping Juniper Dwarf-shrubland	4	0.07223	5	0.00401	0.02129
High Cover Grassland + Medium Cover Grassland	58	0.18229	13	0.14684	0.77913
Low Cover Grassland	2	0.54261	39	0.01507	0.07997

Observed Chi Squared Value = 149.7527
Chi Squared Cumlative Value (df: 3, alpha: 0.05) = 7.8147
Probability (p) observed use differs from expected use = 0.0001

Table 4.24. Habitat selection analysis of *Eptesicus fuscus* (n = 2) at Fort Randall Dam Spillway using Neu's method (Neu *et al.*, 1974).

Habitat	Observed Count	Habitat Proportion	Expected Use	Selection Ratio	Standardized Ratio
Agriculture + Pastureland	55	0.1361	10	0.10115	0.80319
Deciduous Woodland + High Cover Grassland	4	0.1416	10	0.00765	0.06078
Eastern Red Cedar Shrubland + Low Cover Grassland + Idle Grassland	15	0.08452	6	0.01713	0.13604
Permanent Wetland	0	0.14607	11	0	0
Riverine Wetland + Seasonal Wetland	0	0.18372	14	0	0
Water	0	0.30799	23	0	0

Observed Chi Squared Value = 207.6807
Chi Squared Cumlative Value (df: 5, alpha: 0.05) = 11.0705
Probability (p) observed use differs from expected use = 0.0001

Table 4.25. A simplified habitat selection analysis of 102990 an adult female *Myotis septentrionalis* at Arikara Game Production Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Seasonal Wetland	Semipermanent Wetland	Temporary Wetland	Water	Rank
Agriculture		+	-	-	+	+	+	+	-	+	+	+	+	+	4
Deciduous Trees	-		-	-	+	-	+	+	-	-	+	+	-	+	8
Deciduous Woodland	+	+		+	+	+	+	+	+	+	+	+	+	+	1
Hayland	+	+	-		+	+	+	+	+	+	+	+	+	+	2
High Cover Grassland	-	-	-	-		-	+	-	-	-	-	+	-	+	11
Idle Grassland	-	+	-	-	+		+	+	-	+	+	+	+	+	5
Low Cover Grassland	-	-	-	-	-	-		-	-	-	+	-	-	-	13.5
Medium Cover Grassland	-	-	-	-	+	-	+		-	-	-	+	-	+	10
Pastureland	+	+	-	-	+	+	+	+		+	+	+	+	+	3
Permanent Wetland	-	+	-	-	+	-	+	+	-		+	+	+	+	6
Seasonal Wetland	-	-	-	-	+	-	+	+	-	-		+	-	+	9
Semipermanent Wetland	-	-	-	-	-	-	+	-	-	-	-		-	+	12
Temporary Wetland	-	+	-	-	+	-	+	+	-	-	+	+		+	7
Water	-	-	-	-	-	-	+	-	-	-	-	-	-		13.5
Lamba (Λ)	0.53	0.92	0.23	0.30	0.68	0.59	0.16	0.71	0.51	0.77	0.91	0.62	0.98	0.27	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.26. A simplified habitat selection analysis of 102985 an adult male *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Semipermanent Wetland	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		-	+	+	+	+	-	+	-	-	+	+	+	-	-	+	+	+	+	7
Barren	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1
Creeping Juniper Dwarf-shrubland	-	-		+	+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	12
Deciduous Trees	-	-	-		+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	13
Deciduous Woodland	-	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	-	-	15
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	-	-	18
High Cover Grassland	+	-	+	+	+	+		+	-	+	+	+	+	+	-	+	+	-	+	4.5
Idle Grassland	-	-	-	-	-	+	-		-	-	+	+	-	-	-	-	-	-	-	16
Low Cover Grassland	+	-	+	+	+	+	+	+		+	+	+	+	+	-	+	+	+	+	3
Medium Cover Grassland	+	-	+	+	+	+	-	+	-		+	+	+	+	-	+	+	+	+	4.5
Pastureland	-	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	-	-	17
Permanent Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	19
Ponderosa Pine Forest	-	-	+	+	+	+	-	+	-	-	+	+		-	-	+	+	+	+	8
Semipermanent Wetland	+	-	+	+	+	+	-	+	-	-	+	+	+		-	+	+	+	+	6
Shale Barren Slope Sparse Vegetation	+	-	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	2
Temporary Wetland	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-		+	+	-	10
Towns	-	-	-	-	+	+	-	+	-	-	+	+	-	-	-	-		-	-	14
Vegetated Badlands	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-	-	+		-	11
Water	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-	+	+	+		9
Lamba (Λ)	0.8	0.17	0.99	0.97	0.42	0.24	0.62	0.31	0.38	0.66	0.28	0.24	0.89	0.68	0.37	0.97	0.94	1	0.93	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.27. A simplified habitat selection analysis of 103002 a subadult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	16
Barren	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1
Creeping Juniper Dwarf-shrubland	+	-		+	+	+	-	+	-	-	+	+	-	-	-	+	-	-	10
Deciduous Trees	+	-	-		+	+	-	+	-	-	+	+	-	-	-	+	-	-	11
Deciduous Woodland	+	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	-	13
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	-	17
High Cover Grassland	+	-	+	+	+	+		+	-	+	+	+	+	+	+	+	-	+	3.5
Idle Grassland	+	-	-	-	-	+	-		-	-	+	+	-	-	-	-	-	-	14
Low Cover Grassland	+	-	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	2
Medium Cover Grassland	+	-	+	+	+	+	-	+	-		+	+	+	-	+	+	+	+	5
Pastureland	+	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	-	15
Permanent Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	18
Ponderosa Pine Forest	+	-	+	+	+	+	-	+	-	-	+	+		-	+	+	+	-	7
Shale Barren Slope Sparse Vegetation	+	-	+	+	+	+	-	+	-	+	+	+	+		+	+	+	+	3.5
Temporary Wetland	+	-	+	+	+	+	-	+	-	-	+	+	-	-		+	+	-	8
Towns	+	-	-	-	+	+	-	+	-	-	+	+	-	-	-		-	-	12
Vegetated Badlands	+	-	+	+	+	+	-	+	-	-	+	+	-	-	-	+		-	9
Water	+	-	+	+	+	+	-	+	-	-	+	+	+	-	+	+	+		6
Lamba (Λ)	0.34	0.16	1.00	1.00	0.52	0.32	0.45	0.40	0.36	0.66	0.35	0.29	0.81	0.47	0.91	0.99	0.98	0.73	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.28. A simplified habitat selection analysis of 103004 a subadult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Semipermanent Wetland	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		-	+	+	+	+	-	+	-	-	+	+	+	-	-	+	+	+	+	7
Barren	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1
Creeping Juniper Dwarf-shrubland	-	-		+	+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	12
Deciduous Trees	-	-	-		+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	13
Deciduous Woodland	-	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	-	-	15
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	-	-	18
High Cover Grassland	+	-	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	3.5
Idle Grassland	-	-	-	-	-	+	-		-	-	+	+	-	-	-	-	-	-	-	16
Low Cover Grassland	+	-	+	+	+	+	+	+		+	+	+	+	+	-	+	+	+	+	3.5
Medium Cover Grassland	+	-	+	+	+	+	-	+	-		+	+	+	-	-	+	+	+	+	6
Pastureland	-	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	-	-	17
Permanent Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	19
Ponderosa Pine Forest	-	-	+	+	+	+	-	+	-	-	+	+		-	-	+	+	+	+	8
Semipermanent Wetland	+	-	+	+	+	+	-	+	-	+	+	+	+		-	+	+	+	+	5
Shale Barren Slope Sparse Vegetation	+	-	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	2
Temporary Wetland	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-		+	+	-	10
Towns	-	-	-	-	+	+	-	+	-	-	+	+	-	-	-	-		-	-	14
Vegetated Badlands	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-	-	+		-	11
Water	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-	+	+	+		9
Lamba (Λ)	0.80	0.20	1.00	0.97	0.42	0.24	0.54	0.31	0.44	0.72	0.27	0.23	0.87	0.66	0.32	0.96	0.95	1.00	0.93	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.29. A simplified habitat selection analysis of 103003 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		+	+	+	+	+	-	+	-	+	+	+	+	-	+	+	+	+	4
Barren	-		-	-	+	+	-	+	-	-	+	+	-	-	-	+	-	-	12
Creeping Juniper Dwarf-shrubland	-	+		+	+	+	-	+	-	-	+	+	-	-	-	+	-	-	10
Deciduous Trees	-	+	-		+	+	-	+	-	-	+	+	-	-	-	+	-	-	11
Deciduous Woodland	-	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	-	14.5
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	-	17
High Cover Grassland	+	+	+	+	+	+		+	-	+	+	+	+	-	+	+	+	+	3
Idle Grassland	-	-	-	-	-	+	-	+	-	-	+	+	-	-	-	-	-	-	14.5
Low Cover Grassland	+	+	+	+	+	+	+	+		+	+	+	+	-	+	+	+	+	1.5
Medium Cover Grassland	-	+	+	+	+	+	-	+	-		+	+	+	-	+	+	+	+	5
Pastureland	-	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	-	16
Permanent Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	18
Ponderosa Pine Forest	-	+	+	+	+	+	-	+	-	-	+	+		-	+	+	+	-	7
Shale Barren Slope Sparse Vegetation	-	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	1.5
Temporary Wetland	-	+	+	+	+	+	-	+	-	-	+	+	-	-		+	+	-	8
Towns	-	-	-	-	+	+	-	+	-	-	+	+	-	-	-		-	-	13
Vegetated Badlands	-	+	+	+	+	+	-	+	-	-	+	+	-	-	-	+		-	9
Water	-	+	+	+	+	+	-	+	-	-	+	+	+	-	+	+	+		6
Lamba (Λ)	0.51	0.98	1	1	0.43	0.25	0.38	0.32	0.33	0.59	0.28	0.22	0.78	0.27	0.9	0.98	0.95	0.68	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.30. A simplified habitat selection analysis of 102987 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		+	+	+	+	+	-	+	-	-	+	+	+	-	+	+	+	+	5
Barren	-		-	-	+	+	-	+	-	-	+	+	-	-	-	+	-	+	11
Creeping Juniper Dwarf-shrubland	-	+		+	+	+	-	+	-	-	+	+	-	-	-	+	-	+	9
Deciduous Trees	-	+	-		+	+	-	+	-	-	+	+	-	-	-	+	-	+	10
Deciduous Woodland	-	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	+	13
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	+	16
High Cover Grassland	+	+	+	+	+	+		+	-	+	+	+	+	+	+	+	+	+	2
Idle Grassland	-	-	-	-	-	+	-		-	-	+	+	-	-	-	-	-	+	14
Low Cover Grassland	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	1
Medium Cover Grassland	+	+	+	+	+	+	-	+	-		+	+	+	-	+	+	+	+	4
Pastureland	-	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	+	15
Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	17
Ponderosa Pine Forest	-	+	+	+	+	+	-	+	-	-	+	+		-	+	+	+	+	6.5
Shale Barren Slope Sparse	+	+	+	+	+	+	-	+	-	+	+	+	+		+	+	+	+	3
Wetland	-	+	+	+	+	+	-	+	-	-	+	+	-	-		+	+	+	6.5
Towns	-	-	-	-	+	+	-	+	-	-	+	+	-	-	-		-	+	12
Vegetated Badlands	-	+	+	+	+	+	-	+	-	-	+	+	-	-	-	+		+	8
Water	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		18
Lamba (Λ)	0.59	1.00	0.96	0.99	0.54	0.30	0.33	0.39	0.28	0.46	0.35	0.29	0.68	0.35	0.81	1.00	0.91	0.26	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.31. A simplified habitat selection analysis of 102999 an adult female *Myotis septentrionalis* at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		+	+	+	+	+	+	+	+	+	+	+	+	1
Deciduous Woodland	-		+	+	-	-	+	-	-	+	+	-	+	7
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	+	+	-	-	9
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11.5
High Density Development	-	+	+	+		-	+	+	-	+	+	-	+	5
Idle Grassland	-	+	+	+	+		+	+	+	+	+	+	+	2
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	-	+	+	+	-	-	+		-	+	+	-	+	6
Pastureland	-	+	+	+	+	-	+	+		+	+	+	+	3
Permanent Wetland	-	-	-	+	-	-	+	-	-		+	-	-	10
Riverine Wetland	-	-	-	-	-	-	+	-	-	-	+	-	-	11.5
Seasonal Wetland	-	+	+	+	+	-	+	+	-	+	+		+	4
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.2	0.7	0.61	0.54	0.87	0.21	0.43	0.97	0.23	0.58	0.52	0.77	0.68	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.32. A simplified habitat selection analysis of 102974 an adult female *Myotis septentrionalis* at Byre Game Production Area using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		-	-	-	-	+	+	-	+	-	-	8
Barren	+		-	-	+	+	+	-	+	-	+	5
Creeping Juniper Dwarf-shrubland	+	+		-	+	+	+	-	+	-	+	4
High Cover Grassland	+	+	+		+	+	+	-	+	-	+	2.5
Low Cover Grassland	+	-	-	-		+	+	-	+	-	-	7
Medium Cover Grassland	-	-	-	-	-		-	-	-	-	-	11
Ponderosa Pine Forest	-	-	-	-	-	+		-	+	-	-	9.5
Unvegetated Badlands	-	+	+	+	+	+	+		+	-	+	2.5
Vegetated Badlands	-	-	-	-	-	+	-	-	+	-	-	9.5
Water	+	+	+	+	+	+	+	+	+		+	1
Xeric Shrubland	+	-	-	-	+	+	+	-	+	-		6
Lamba (Λ)	0.99	0.68	0.64	0.59	1	0.08	0.51	0.57	0.39	0.31	0.97	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.33. A simplified habitat selection analysis of 102991 an adult female *Myotis septentrionalis* at Arikara Game Production Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Seasonal Wetland	Semipermanent Wetland	Temporary Wetland	Water	Rank
Agriculture		+	-	-	+	+	+	+	+	+	+	+	+	+	2.5
Deciduous Trees	+		-	-	+	-	+	+	-	-	+	+	-	+	7.5
Deciduous Woodland	+	+		+	+	+	+	+	+	+	+	+	+	+	1
Hayland	-	+	-		+	+	+	+	+	+	+	+	+	+	2.5
High Cover Grassland	-	-	-	-		-	+	+	-	-	-	+	-	+	10
Idle Grassland	-	+	-	-	+		+	+	-	+	+	+	+	+	5
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	-	14
Medium Cover Grassland	-	-	-	-	-	-	+		-	-	-	+	-	+	11
Pastureland	-	+	-	-	+	+	+	+		+	+	+	+	+	4
Permanent Wetland	-	+	-	-	+	-	+	+	-		+	+	+	+	6
Seasonal Wetland	-	-	-	-	+	-	+	+	-	-		+	-	+	9
Semipermanent Wetland	-	-	-	-	-	-	+	-	-	-	-		-	+	12
Temporary Wetland	-	+	-	-	+	-	+	+	-	-	+	+		+	7.5
Water	-	-	-	-	-	-	+	-	-	-	-	-	-		13
Lamba (Λ)	0.29	0.91	0.21	0.29	0.77	0.81	0.18	0.73	0.63	0.92	0.9	0.61	0.96	0.28	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.34. A simplified habitat selection analysis of 102972 an adult female *Myotis septentrionalis* at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Semipermanent Wetland	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	16
Barren	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1
Creeping Juniper Dwarf-shrubland	+	-		+	+	+	+	+	-	+	+	+	-	-	-	-	+	-	-	9
Deciduous Trees	+	-	-		+	+	+	+	-	+	+	+	-	-	-	-	+	-	-	10
Deciduous Woodland	+	-	-	-		+	+	+	-	+	+	+	-	-	-	-	-	-	-	12
Hayland	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	19
High Cover Grassland	-	-	-	-	-	+		-	-	+	-	-	-	-	-	-	-	-	-	17.5
Idle Grassland	+	-	-	-	-	+	+		-	+	-	-	-	-	-	-	-	-	-	15
Low Cover Grassland	+	-	+	+	+	+	-	+		+	+	+	+	+	-	+	+	+	-	4.5
Medium Cover Grassland	-	-	-	-	-	+	+	-	-		-	-	-	-	-	-	-	-	-	17.5
Pastureland	+	-	-	-	-	+	+	+	-	+		+	-	-	-	-	-	-	-	13
Permanent Wetland	+	-	-	-	-	+	+	+	-	+	-		-	-	-	-	-	-	-	14
Ponderosa Pine Forest	+	-	+	+	+	+	+	+	-	+	+	+		+	-	+	+	+	-	4.5
Semipermanent Wetland	+	-	+	+	+	+	+	+	-	+	+	+	-		-	+	+	+	-	6
Shale Barren Slope Sparse Vegetation	+	-	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	2
Temporary Wetland	+	-	+	+	+	+	+	+	-	+	+	+	-	-	-		+	+	-	7
Towns	+	-	-	-	+	+	+	+	-	+	+	+	-	-	-	-		-	-	11
Vegetated Badlands	+	-	+	+	+	+	+	+	-	+	+	+	-	-	-	-	+		-	8
Water	+	-	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	+		3
Lamba (Λ)	0.43	0.14	0.95	0.99	0.70	0.39	0.42	0.46	0.41	0.40	0.50	0.48	0.74	0.77	0.23	0.85	1.00	0.94	0.40	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.35. A simplified habitat selection analysis of 103007 a subadult female *Myotis septentrionalis* at Byre Game Production Area using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		+	+	-	-	+	+	-	+	-	-	6
Barren	-		-	-	-	+	-	-	-	-	-	10.5
Creeping Juniper Dwarf-shrubland	-	+		-	-	+	-	-	-	-	-	9
High Cover Grassland	+	+	+		+	+	+	-	+	-	+	3
Low Cover Grassland	+	+	+	-		+	+	-	+	-	+	4
Medium Cover Grassland	-	-	+	-	-		-	-	-	-	-	10.5
Ponderosa Pine Forest	-	+	+	-	-	+		-	+	-	-	7
Unvegetated Badlands	+	+	+	+	+	+	+		+	-	+	2
Vegetated Badlands	-	+	+	-	-	+	-	-		-	-	8
Water	+	+	+	+	+	+	+	+	+		+	1
Xeric Shrubland	+	+	+	-	-	+	+	-	+	-		5
Lamba (Λ)	0.92	0.26	0.27	0.47	0.67	0.24	1	0.46	0.84	0.28	0.81	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.36. A simplified habitat selection analysis of 103021 an adult male *Myotis septentrionalis* at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		+	+	+	+	+	+	+	+	+	+	+	+	1
Deciduous Woodland	-		+	+	-	-	+	-	-	+	+	-	+	7
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	+	+	-	-	9
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11
High Density Development	-	+	+	+		-	+	+	-	+	+	-	+	4.5
Idle Grassland	-	+	+	+	+		+	+	-	+	+	+	+	3
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	-	+	+	+	-	-	+		-	+	+	-	+	6
Pastureland	-	+	+	+	+	+	+	+		+	+	+	+	2
Permanent Wetland	-	-	-	+	-	-	+	-	-		+	-	-	10
Riverine Wetland	-	-	-	-	-	-	+	-	-	-		-	-	12
Seasonal Wetland	-	+	+	+	+	-	+	-	-	+	+		+	4.5
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.2	0.7	0.62	0.53	0.87	0.24	0.42	0.97	0.21	0.6	0.51	0.76	0.68	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.37. A simplified habitat selection analysis of 103023 an adult female *Eptesicus fuscus* at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		+	+	+	+	+	+	+	+	+	+	+	+	1
Deciduous Woodland	-		+	+	+	-	+	+	-	+	+	+	+	4
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	+	+	-	-	9
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11
High Density Development	-	-	+	+		-	+	+	-	+	+	-	+	5.5
Idle Grassland	-	+	+	+	+		+	+	-	+	+	+	+	3
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	-	-	+	+	-	-	+		-	+	+	-	+	7
Pastureland	-	+	+	+	+	+	+	+		+	+	+	+	2
Permanent Wetland	-	-	-	+	-	-	+	-	-		+	-	-	10
Riverine Wetland	-	-	-	-	-	-	+	-	-	-		-	-	12
Seasonal Wetland	-	-	+	+	+	-	+	-	-	+	+		+	5.5
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.28	0.33	0.5	0.49	0.95	0.31	0.39	0.91	0.29	0.5	0.47	0.87	0.59	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.38. A simplified habitat selection analysis of 103025 an adult male *Eptesicus fuscus* at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		+	+	+	+	-	+	+	-	+	+	+	+	3
Deciduous Woodland	-		+	+	+	-	+	+	-	+	+	+	+	4
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	-	+	-	-	10
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11
High Density Development	-	-	+	+		-	+	+	-	+	+	-	+	6
Idle Grassland	+	+	+	+	+		+	+	-	+	+	+	+	2
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	-	-	+	+	-	-	+		-	+	+	-	+	7
Pastureland	+	+	+	+	+	+	+	+		+	+	+	+	1
Permanent Wetland	-	-	+	+	-	-	+	-	-		+	-	-	9
Riverine Wetland	-	-	-	-	-	-	+	-	-	-		-	-	12
Seasonal Wetland	-	-	+	+	+	-	+	+	-	+	+		+	5
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.3	0.38	0.51	0.47	0.94	0.3	0.38	0.92	0.26	0.52	0.46	0.85	0.6	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.39. A simplified habitat selection analysis of 102973 an adult male *Eptesicus fuscus* at Byre Game Production Area using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		+	+	-	+	+	+	+	+	-	-	4
Barren	-		-	-	-	+	-	-	-	-	-	10
Creeping Juniper Dwarf-shrubland	-	+		-	-	+	-	-	-	-	-	9
High Cover Grassland	+	+	+		+	+	+	+	+	-	-	3
Low Cover Grassland	-	+	+	-		+	+	+	+	-	-	5
Medium Cover Grassland	-	-	-	-	-		-	-	-	-	-	11
Ponderosa Pine Forest	-	+	+	-	-	+		+	+	-	-	6
Unvegetated Badlands	-	+	+	-	-	+	-		-	-	-	8
Vegetated Badlands	-	+	+	-	-	+	-	+		-	-	7
Water	+	+	+	+	+	+	+	+	+		-	2
Xeric Shrubland	+	+	+	+	+	+	+	+	+	+		1
Lamba (Λ)	0.85	0.46	0.47	0.55	0.91	0.43	0.91	0.5	0.77	0.48	0.08	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.40. A simplified habitat selection analysis of 102996 an adult female *Eptesicus fuscus* at Byre Game Production Area using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		-	+	-	+	+	+	-	+	-	+	5
Barren	+		+	-	+	+	+	-	+	-	+	4
Creeping Juniper Dwarf-shrubland	-	-		-	-	+	-	-	-	-	-	10
High Cover Grassland	+	+	+		+	+	+	+	+	-	+	2
Low Cover Grassland	-	-	+	-		+	+	-	+	-	-	7
Medium Cover Grassland	-	-	-	-	-		-	-	-	-	-	11
Ponderosa Pine Forest	-	-	+	-	-	+		-	+	-	-	8
Unvegetated Badlands	+	+	+	-	+	+	+		+	-	+	3
Vegetated Badlands	-	-	+	-	-	+	-	-		-	-	9
Water	+	+	+	+	+	+	+	+	+		+	1
Xeric Shrubland	-	-	+	-	+	+	+	-	+	-		6
Lamba (Λ)	0.7	0.56	0.21	0.49	0.97	0.18	0.66	0.51	0.47	0.4	0.83	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.41. A simplified habitat selection analysis of *Myotis septentrionalis* (n = 2) at Arikara Game Production Area using compositional analysis (Aebischer *et al.*, 1993).

	Agriculture	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Seasonal Wetland	Semipermanent Wetland	Temporary Wetland	Water	Rank
Agriculture		+	-	-	+	+	+	+	+	+	+	+	+	+	3
Deciduous Trees	-		-	-	+	-	+	+	-	-	+	+	-	+	8
Deciduous Woodland	+	+		+	+	+	+	+	+	+	+	+	+	+	1
Hayland	+	+	-		+	+	+	+	+	+	+	+	+	+	2
High Cover Grassland	-	-	-	-		-	+	-	-	-	-	+	-	+	11
Idle Grassland	-	+	-	-	+		+	+	-	+	+	+	+	+	5
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	-	14
Medium Cover Grassland	-	-	-	-	+	-	+		-	-	-	+	-	+	10
Pastureland	-	+	-	-	+	+	+	+		+	+	+	+	+	4
Permanent Wetland	-	+	-	-	+	-	+	+	-		+	+	+	+	6
Seasonal Wetland	-	-	-	-	+	-	+	+	-	-		+	-	+	9
Semipermanent Wetland	-	-	-	-	-	-	+	-	-	-	-		-	+	12
Temporary Wetland	-	+	-	-	+	-	+	+	-	-	+	+		+	7
Water	-	-	-	-	-	-	+	-	-	-	-	-	-		13
Lamba (Λ)	0.37	0.88	0.24	0.3	0.66	0.65	0.18	0.69	0.55	0.76	0.88	0.61	0.95	0.29	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.42. A simplified habitat selection analysis of *Myotis septentrionalis* (n = 2) at Byre Game Production Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		-	-	-	+	+	+	-	+	-	+	6
Barren	+		-	-	+	+	+	-	+	-	+	5
Creeping Juniper Dwarf-shrubland	+	+		-	+	+	+	-	+	-	+	4
High Cover Grassland	+	+	+		+	+	+	-	+	-	+	3
Low Cover Grassland	-	-	-	-		+	+	-	+	-	+	7
Medium Cover Grassland	-	-	-	-	-		-	-	-	-	-	11
Ponderosa Pine Forest	-	-	-	-	-	+		-	+	-	-	9
Unvegetated Badlands	+	+	+	+	+	+	+		+	-	+	2
Vegetated Badlands	-	-	-	-	-	+	-	-		-	-	10
Water	+	+	+	+	+	+	+	+	+		+	1
Xeric Shrubland	-	-	-	-	-	+	+	-	+	-		8
Lamba (Λ)	0.91	0.81	0.77	0.54	0.95	0.08	0.46	0.53	0.36	0.34	1	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.43. A simplified habitat selection analysis of *Myotis septentrionalis* (n = 2) at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		+	+	+	+	+	+	+	+	+	+	+	+	1
Deciduous Woodland	-		+	+	+	-	+	+	-	+	+	+	+	4
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	+	+	-	-	9
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11
High Density Development	-	-	+	+		-	+	+	-	+	+	-	+	5.5
Idle Grassland	-	+	+	+	+		+	+	+	+	+	+	+	2
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	-	-	+	+	-	-	+		-	+	+	-	+	7
Pastureland	-	+	+	+	+	-	+	+		+	+	+	+	3
Permanent Wetland	-	-	-	+	-	-	+	-	-		+	-	-	10
Riverine Wetland	-	-	-	-	-	-	+	-	-	-		-	-	12
Seasonal Wetland	-	-	+	+	+	-	+	-	-	+	+		+	5.5
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.25	0.45	0.53	0.48	0.96	0.27	0.39	0.9	0.27	0.51	0.48	0.9	0.59	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.44. A simplified habitat selection analysis of *Myotis septentrionalis* (n = 6) at Oahe Downstream Recreation Area using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	Deciduous Trees	Deciduous Woodland	Hayland	High Cover Grassland	Idle Grassland	Low Cover Grassland	Medium Cover Grassland	Pastureland	Permanent Wetland	Ponderosa Pine Forest	Semipermanent Wetland	Shale Barren Slope Sparse Vegetation	Temporary Wetland	Towns	Vegetated Badlands	Water	Rank
Agriculture		-	+	+	+	+	-	+	-	-	+	+	+	+	-	+	+	+	-	6.5
Barren	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1
Creeping Juniper Dwarf-shrubland	-	-		+	+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	12
Deciduous Trees	-	-	-		+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	13.5
Deciduous Woodland	-	-	-	-		+	-	+	-	-	+	+	-	-	-	-	-	-	-	15
Hayland	-	-	-	-	-		-	-	-	-	-	+	-	-	-	-	-	-	-	18
High Cover Grassland	+	-	+	+	+	+		+	-	+	+	+	+	+	-	+	+	+	+	4
Idle Grassland	-	-	-	-	-	+	-		-	-	+	+	-	-	-	-	-	-	-	16
Low Cover Grassland	+	-	+	+	+	+	+	+		+	+	+	+	+	-	+	+	+	+	3
Medium Cover Grassland	+	-	+	+	+	+	-	+	-		+	+	+	+	-	+	+	+	+	5
Pastureland	-	-	-	-	-	+	-	-	-	-		+	-	-	-	-	-	-	-	17
Permanent Wetland	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	19
Ponderosa Pine Forest	-	-	+	+	+	+	-	+	-	-	+	+		+	-	+	+	+	-	8
Semipermanent Wetland	-	-	+	+	+	+	-	+	-	-	+	+	-		-	+	+	+	-	9
Shale Barren Slope Sparse Vegetation	+	-	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	2
Temporary Wetland	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-		+	+	-	10
Towns	-	-	-	-	+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	13.5
Vegetated Badlands	-	-	+	+	+	+	-	+	-	-	+	+	-	-	-	-	+		-	11
Water	+	-	+	+	+	+	-	+	-	-	+	+	+	-	-	+	+	+		6.5
Lamba (Λ)	0.86	0.18	0.97	0.93	0.45	0.26	0.46	0.32	0.37	0.63	0.30	0.26	0.96	0.98	0.31	1.00	0.91	0.98	0.63	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.45. A simplified habitat selection analysis of *Eptesicus fuscus* (n = 2) at Byre Game Production Area (Aebischer *et al.,* 1993).

	Agriculture	Barren	Creeping Juniper Dwarf-shrubland	High Cover Grassland	Low Cover Grassland	Medium Cover Grassland	Ponderosa Pine Forest	Unvegetated Badlands	Vegetated Badlands	Water	Xeric Shrubland	Rank
Agriculture		-	+	-	+	+	+	-	+	-	-	6
Barren	+		+	-	+	+	+	+	+	-	-	4
Creeping Juniper Dwarf-shrubland	-	-		-	-	+	-	-	-	-	-	10
High Cover Grassland	+	+	+		+	+	+	+	+	-	-	3
Low Cover Grassland	-	-	+	-		+	+	-	+	-	-	7
Medium Cover Grassland	-	-	-	-	-		-	-	-	-	-	11
Ponderosa Pine Forest	-	-	+	-	-	+		-	+	-	-	8
Unvegetated Badlands	+	-	+	-	+	+	+		+	-	-	5
Vegetated Badlands	-	-	+	-	-	+	-	-		-	-	9
Water	+	+	+	+	+	+	+	+	+		-	2
Xeric Shrubland	+	+	+	+	+	+	+	+	+	+		1
Lamba (Λ)	0.88	0.75	0.26	0.7	1	0.23	0.62	0.83	0.47	0.61	0.14	

Observed use differs from expected use in all permutations, $p < 0.05$

Table 4.46. A simplified habitat selection analysis of *Eptesicus fuscus* (n = 2) at Fort Randall Dam Spillway using compositional analysis (Aebischer *et al.,* 1993).

	Agriculture	Deciduous Woodland	Eastern Red Cedar Shrubland	High Cover Grassland	High Density Development	Idle Grassland	Low Cover Grassland	Low Density Development	Pastuerland	Permanent Wetland	Riverine Wetland	Seasonal Wetland	Water	Rank
Agriculture		-	+	+	+	-	+	-	-	+	+	+	+	5
Deciduous Woodland	+		+	+	+	-	+	-	-	+	+	+	+	4
Eastern Red Cedar Shrubland	-	-		+	-	-	+	-	-	-	+	-	-	10
High Cover Grassland	-	-	-		-	-	+	-	-	-	+	-	-	11
High Density Development	-	-	+	+		-	+	-	-	+	+	-	+	7
Idle Grassland	+	+	+	+	+		+	-	-	+	+	+	+	3
Low Cover Grassland	-	-	-	-	-	-		-	-	-	-	-	-	13
Low Density Development	+	+	+	+	+	+	+		-	+	+	+	+	2
Pastureland	+	+	+	+	+	+	+	+		+	+	+	+	1
Permanent Wetland	-	-	+	+	-	-	+	-	-		+	-	-	9
Riverine Wetland	-	-	-	-	-	-	+	-	-	-		-	-	12
Seasonal Wetland	-	-	+	+	+	-	+	-	-	+	+		+	6
Water	-	-	+	+	-	-	+	-	-	+	+	-		8
Lamba (Λ)	0.4	0.4	0.46	0.45	1	0.38	0.37	0.35	0.34	0.47	0.44	0.97	0.55	

Observed use differs from expected use in all permutations, $p < 0.05$

DISCUSSION

The previous study by Swier (2003) investigated roost habitat of bat species in Eastern and Central South Dakota through the use of radio-telemetry and found that the selectivity of different roost characteristics varied among bat species but that the dominate tree species selected was the Plains Cottonwood (*Populus deltoides monilifera*). The findings of this study, with a substantially larger sample size, are consistent with Swier (2003). This is not surprising as they are the most common tree in the riparian habitats of Eastern and Central South Dakota and the dominance of this species in some cases may limit roost options and selection. However, Plains Cottonwood trees have many potentially favorable attributes: rapid growth, deeply furrowed bark, large branches, readily exfoliating bark, and the ease in which cavities are formed. Thus, Plains Cottonwood trees are an integral part of bat habitat and bat management in this region.

Insufficient roost data was collected during the present study on *Myotis lucifugus* (n = 1) and *Myotis ciliolabrum* (n = 1) for analysis. However, the roosting behavior of the *M. lucifugus* radio-tracked in this study was similar to the findings of Swier (2003) wherein these bats selected trees of a small circumference and in advanced stages of decay in locations with little or no canopy cover (Table 4.1). This may reflect the selection of warmer roosts with greater potential for radiant heating due to increased solar exposure and decreased thermal inertia which allow rapid day time heating. The energetic savings of these warmer roosts have been well documented in *M. lucifugus,* and related to rapid gestation (Racey, 1973; Fenton, 1970) and development of young, and exogenous heat for daily arousal (Fenton, 1970).

The capture of *Myotis ciliolabrum* is significant and represents the first live capture of this species along the Missouri River in South Dakota – an in-depth description of radio-tracking can be found in Chapter 2: Section 2. This bat roosted under the bark of a large Plains Cottonwood, which is not surprising given the wide variety of roosts utilized by this species. Potential roost sites for *M. ciliolabrum* include but are not limited to: rock crevices (Tuttle and Heaney, 1974), abandoned swallow nest (Merriam, 1886), buildings (Jones, 1964), and under loose bark (Jones, 1964), all of which are readily available along the lower Missouri River and its tributaries. *Myotis ciliolabrum* may be present along portions of the Missouri River in South Dakota and along eastward-flowing rivers in western South Dakota that provide adequate habitat, as was hypothesized by Jones and Genoways (1967) and Bales (2007, *In press*). The distribution and roosting habits of *M. ciliolabrum* in this region should be investigated further, and in the interim *M. ciliolabrum* should be considered for status as a species of concern in the central region of the state, and future studies of this species should become a conservation priority.

On average *Myotis septentrionalis* (n = 29) changed roosts every 2.6 days with an average distance moved of 182 m (Table 4.1). This was similar to what Forster and Kurta (1999) found in a Michigan population of *M. septentrionalis* that changed roosts approximately every two days, and may be typical of many tree-roosting bats (Lewis, 1995). The average distance moved by the Michigan *M. septentrionalis* was similar to that observed in South Dakota *M. septentrionalis,* albeit, the South Dakota bats exhibited a greater amount of variation. This may be due to larger sample size or to habitat differences in these different locations.

Roost trees used by *Myotis septentrionalis* had a larger circumference than surrounding trees (Table 4.1), matching the findings of Foster and Kurta (1999), and Swier (2003). Foster and Kurta (1999) documented the use of both cavity and bark roosts, however *M. septentrionalis* in Eastern and Central South Dakota showed selectivity for roosting under the bark of Plains Cottonwood trees, most likely due to their readily exfoliating bark. This roost choice maybe because of either the warmer roost conditions due to radiant heating of a dark surface (the bark of Plains Cottonwoods is significantly darker than the light wood of a debarked tree) or merely an artifact of tree availability. Roosts were mostly located under bark on main tree limbs and no selection was shown for either canopy cover category (Table 4.1). These bats showed selectivity for trees in the second stage of decay and did not utilize trees in stages one, five, six or seven (Table 4.1). This confirms the suggestion of Forster and Kurta (1999) who speculated that the choice of live roost trees may be common in this species, much more so than in North American bat species (e.g., *Myotis sodalis, M. lucifugus*) with similar roosting habits. Given the status of *Myotis septentrionalis* as a species of concern in South Dakota (SDNHP, 2004), its roost habits, and its reputation as a forest interior species (Carroll *et al.,* 2002) – the protection and promotion of tracts of riverine gallery forest, and the recruitment and protection of larger older aged trees (in particular Plains Cottonwood) should be a future conservation priority.

On average, *Eptesicus fuscus* changed roosts every 3.1 days with an average distance moved of 136 meters. *Eptesicus fuscus* selectively utilized Plains Cottonwood trees and roosted in tree cavities (Table 4.1). However, the use of a variety of other roost types by this species is well documented (reviewed by Agosta, 2002). Roosts were located on and within tree trunks or main limbs but there was no selection between the two locations. No selectivity was shown for either living or dead trees, nor to the degree of canopy cover, however, roost trees did have larger circumference than surrounding trees (Table 4.1). These observations are similar to those of Swier (2003) and Cryan *et al.* (2001) wherein *E. fuscus* selected trees in the second and third stages of decay and did not utilize trees in stages one, five, six or seven (Table 4.1). The avoidance of roost trees categorized in stages of decay five and six may be due to sample size and/or snag availability in the areas covered in this study. *Eptesicus fuscus* is a very common bat species in South Dakota (Swier, 2003 and 2006; data presented herein) due to its ability to exploit anthroprogenic structures, but the conservation of this species and the roost habitats it utilizes may also benefit other bat species (Agosta, 2002).

On average, *Lasiurus cinereus* changed roosts every 1.5 days with an average distance moved of 835.8 meters. *Lasiurus cinereus* roosted in several species of tree: Elms (*Ulmus* sp.), Plains Cottonwoods, and an American Basswood (*Tilia americana*). These bats selectively used foliage roosts in tree stands with 50-100% canopy cover category. These results are similar to those of other studies of the roosting habits of *L. cinereus* and other *Lasiurines* (Mager and Nelson, 2001; Menzel *et al.,* 1998; Campbell *et al.,* 1996; Constantine, 1966). Trees with larger circumferences were not selected for over smaller trees, though this may be the result of a relatively small sample size (seven roosts). However, roosts were typically located in groups of trees and may reflect the selection of roost trees that offered increased protection from the ever present wind in South Dakota. The roosting habits of *L. cinereus* may reflect the selection of roosts based on the microclimate as suggested by Willis and Brigham (2005) wherein *L. cinereus* selected roosts with lower forest density and lower wind speeds, presumably providing flight and energetic benefits. *Lasiurus cinereus* selected for trees in the first and second stages of decay; there was no difference in selection between the two – trees in stages three, four, five, six or seven were not utilized (Table 4.1). The use of roost trees in the second stage of decay likely indicated the selection of larger older aged trees (Table 4.1), which may be used as navigation markers (Campbell *et al.,* 1996). Together, these data indicate that this species may benefit from the recruitment and conservation of large stand of older aged trees.

On average, *Lasiurus borealis* changed roosts every 1.2 days with an average distance moved of 388.6 meters. *Lasiurus borealis* showed no selectivity for any particular tree species as a roost compared to that expected based on availability. However, 66.7% of roosts were Plains Cottonwood trees likely due to the dominance of this tree in the area. *Lasiurus borealis* selected foliage roost in living trees with 50-100% canopy cover (Table 4.1). This was not surprising as *L. borealis* is well documented as being a tree-foliage roost specialist (Mager and Nelson, 2001; Menzel *et al.,* 1998). Roost trees were not significantly larger than surrounding trees, which may indicate the selection for groups of trees. These results are similar to what Mager and Nelson (2001), and Menzel *et al.* (1998) found for this species, wherein *L. borealis* utilized foliage roosts in trees with a high degree of canopy cover and frequently changed roosts showing fidelity to an area but not a particular tree. *Lasiurus borealis* selected for trees in the first and second stages of decay, with slightly more roosts in stage two; trees in stages three, four, five, six or seven were not utilized (Table 4.1). As a foliage roosting forest edge (ecotone) species (Carroll *et al.,* 2002), *L. borealis* is likely to benefit from the conservation of riverine gallery forest. The promotion of large old aged trees is likely to benefit *L. borealis* through the creation of canopy gaps, generating a habitat mosaic with horizontal and vertical edges (Edwards *et al.,* 2000).

The mean home-range size for *Myotis septentrionalis* (n = 12) in Eastern and Central South Dakota was 91.34 ha (95% AKM) and 45.16 ha (75% AKM; Table 4.2). This was larger than the home-range of 65 ha calculated for *M. septentrionalis* in Allegheny Mountains of West Virginia (95% AKM; Owen *et al.,* 2003). The home-range of *M. septentrionalis* in Eastern and Central South Dakota is likely larger than those in West Virginia, due to the differences in the quality and/or spatial distribution of suitable habitat. There was no significant difference between male and female *Myotis septentrionalis* in terms of their home-range sizes (both 95% and 75% AKM) but this may be due to the limited sample size of male (n = 2) *M. septentrionalis* in this study. However, Owen *et al.* (2003) did not find a difference in the home-range of pregnant and lactating females in this species but a difference in the home-ranges size of reproductively active males and females is likely, and has been shown in many other bat species (Kunz and Fenton, 2003).

The mean home range size for *Eptesicus fuscus* (n = 4) was 187.54 ha (95% AKM) and 73.14 ha (75% AKM) in Central and Eastern South Dakota (Table 4.2). The home-range of *E. fuscus* in this study was much smaller than Duchamp *et al.* (2004) found for non-reproductively active females of 1900 ha and slightly smaller than the 270 ha for reproductively active females of this species in Indiana. This may be the result of having insufficient locations in the present study (37.50 locations per bat) in contrast to Duchamp *et al.* (2004) who reported an average of 86.45 locations per bat for *E. fuscus*. In fact, this may be the case as Menzel *et al.* (2001) calculated an average home-range size of 2906 ha for reproductively active female *E. fuscus* in North Carolina. The *Eptesicus fuscus* in this study have home-ranges smaller than those documented by Duchamp *et al.* (2004) and Menzel *et al.* (2001), and this may be due to less anthroprogenic disturbance at the South Dakota locations as compared to the urban-rural interfaces examined in those studies. The actual home-ranges of *E. fuscus* in Eastern and Central South Dakota are likely larger than those documented herein, and even larger still for reproductively active *E. fuscus*. A large number of locations per bat may be needed to determine the home-range of *E. fuscus* in the region, reflecting the spatial distribution of the limited suitable habitat(s).

Using both Neu's method (Neu *et al.,* 1974)and compositional analysis (Aebischer *et al.,* 1993) of habitat selection for the radio-tracked *Myotis septentrionalis* and *Eptesicus fuscus* (only those with sufficient locations) showed that observed habitat use was significantly different than expected based on habitat availability for all individuals and species at all locations (Tables 4.3 – 4.46). This was to be expected as it has been repeatedly documented that bats are selective in their use of habitats (e.g., Owen *et al.,* 2003, Duchamp *et al.,* 2004). Neu's method and compositional analysis returned differing results likely due the grouping of structurally similar habitats in Neu's method to avoid low (≤ 5) expected use based on availability. This is likely due to the size of habitats assumed to be available (95% AKM with 2 km buffer) and the number of different habitats indicated therein. Therefore, compositional analysis of habitat selection is more likely to accurately reflect bat habitat utilization and selection. Species habitat selection analyses frequently differed from individual analyses likely due to differing contributions of each individual; however individuals of the same species at the same locations frequently differed in their habitat use thereby suggesting interspecific competition.

The selection of agricultural and grassland habitats by *Myotis septentrionalis* likely points towards commuting behavior between spatially diffuse resources because *M. septentrionalis* primarily feeds by gleaning insects from vegetation, typically associated with forest and woodlands and has little use for habitats dominated by tall grass and forbs (Tables 4.19, 4.20, 4.21, 4.41, 4.42, 4.43, 4.44; Caceres and Barclay, 2000). The inclusion of habitats unlikely to be actually utilized by *M. septentrionalis* as foraging or roosting habitats as selected habitats, such as unvegetated badlands, creeping juniper dwarf-shrubland, barren ground, or shale barren slope with sparse vegetation (e.g., Table 4.42 and Table 4.44) is probably due to misclassifications of habitats by the South Dakota GAP project within the area defined as available. The use and importance of riverine gallery forest to *M. septentrionalis* is probably underestimated by both Neu's method

(Neu *et al.,* 1974) and compositional analysis (Aebischer *et al.,* 1993) of habitat selection due to misclassification, as it is not adequately indicated at these locations by data from the South Dakota GAP project, but is indeed present and prevalent, combined with the roosts utilized by this species in Eastern and Central South Dakota (Swier, 2003; data presented herein), and that throughout much of the range of *M. septentrionalis*, the species is considered a forest interior species (e.g., Carroll *et al.,* 2002; Owen *et al.,* 2003) that utilizes forest understory as foraging habitat (Brack and Whitaker, 2001).

Eptesicus fuscus readily utilizes open areas above agriculture and grassland habitats for foraging (e.g., Table 4.23, 4.45; Duchamp *et al.,* 2004, Menzel *et al.,* 2001). This likely reflects the propensity of *E. fuscus* to use aerial hawking foraging behavior (Kurta and Baker, 1990). The use of xeric shrubland appears to reflect the use of wooded guts (draws) that come up off the flood plain, which may serve as protected corridors for movement or foraging (e.g., Table 4.45). Given the type of roosts utilized by *E. fuscus* along the Missouri River and its tributaries (Swier, 2003; data presented herein) and that this species is considered a forest edge (ecotone) species (Carroll *et al.,* 2002), the use and importance of Plains Cottonwoods dominated riverine gallery forest is probably underestimated.

Riverine gallery forest is an important habitat for bats in Eastern and Central South Dakota, yet it makes up only 1.5% of the total land coverage in the region (Smith *et al.,* unpublished). Of the twelve species of bats known to inhabit South Dakota (SDNHP, 2004; Choate and Jones, 1981; Lane *et al.,* 2003), eight (*Eptesicus fuscus, Nycticeius humeralis, M.ciliolabrum, M. septentrionalis, M. lucifugus, Lasionycteris* *noctivagans, Lasiurus cinereus,* and *Lasiurus borealis*) have been documented in Eastern and Central South Dakota along the Lower Missouri River drainage and select tributaries (Jones and Genoways, 1967; Findley, 1956; Swier, 2003 and 2006; Lane *et al.,* 2003; data presented herein). This comparatively high bat species richness is likely due to an abundance of trees in the floodplain, corridor effect (Stauffer and Best, 1980), available water sources, periodic flooding and fires, and rich soils', thus, making this an ecologically rich area. This combination of factors creates foraging and roosting habitats that meet the diverse requirements of the bat species present in the region. Periodic ecological disturbance and the death of aging trees may create gaps in the canopy thereby creating vertical and horizontal edge habitats that could benefit ecotone specialist bats (Edwards *et al.,* 2000; Kalcounis *et al.,* 1999). Aging trees and periodic disturbances may create snags which could be used as references for orientation and navigation (Campbell *et al.,* 1996), and critical roosting habitat. The riverine gallery forest in Eastern and Central South Dakota along the Missouri River and its tributaries should be protected and conserved, even more than they are presently under the stewardship of South Dakota Game, Fish and Parks, various tribal agencies and federal agencies. With a goal of preserving and restoring these woodland habitats, recruiting and promoting large old aged trees, snags, and a diverse habitat mosaic, given the roosting habits and habitat utilization of bat species.

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Appendix 1

Capture Records from 2005 and 2006 Field Seasons Along the Lower Missouri River in South Dakota. Recaptures indicated in red.

Date	Location	Species	Age	Sex	Reproductive Condition	Forearm (mm)	Mass (g)	Band No.
6/3/2005	Arikara GPA	*M.sept*	A	F	Non	35	7	SDGFP 05301
6/3/2005	Arikara GPA	*M.sept*	A	F	Non	36	7	SDGFP 05302
6/8/2005	Farm Island RA	*M.luc*	subA	M	Non	34.5	7.5	SDGFP 05303
6/8/2005	Farm Island RA	*E.fus*	A	F	Non	46	16.8	SDGFP 05304
6/9/2005	Farm Island RA	*M.sept*	subA	M	Non	36	6	SDGFP 05305
6/9/2005	Oahe Downstream RA	*M.sept*	A	F	Preg	32	7.5	SDGFP 05306
6/10/2005	Oahe Downstream RA	*M.sept*	A	M	Non	36	7	SDGFP 05307
6/10/2005	Oahe Downstream RA	*L.noc*	A	F	Preg	42	17.5	SDGFP 05308
6/10/2005	Oahe Downstream RA	*M.sept*	A	M	Non	33.5	6	SDGFP 05309
6/10/2005	Oahe Downstream RA	*M.sept*	A	F	Preg	37	9.5	SDGFP 05310
6/10/2005	Oahe Downstream RA	*M.luc*	subA	M	Non	36	5.8	SDGFP 05311
6/11/2005	Oahe Downstream RA	*M.sept*	A	M	Non	33	5.5	SDGFP 05312
6/12/2005	SDSU	*L.bor*	A	F	Preg	40	17.5	SDGFP 05313
6/29/2005	Byre GPA	*M.sept*	A	F	Non	36	8	201P
7/1/2005	Byre GPA	*M.sept*	A	F	Lac	36	6.75	202P
7/1/2005	Byre GPA	*M.sept*	A	F	Lac	34	6.7	203P
7/1/2005	Byre GPA	*M.sept*	A	F	Lac	35.5	7.5	204P
7/2/2005	Byre GPA	*M.sept*	A	F	Lac	35	7.25	205P
7/2/2005	Byre GPA	*M.sept*	A	F	Lac	36	7.5	206P
7/3/2005	Byre GPA	*M.sept*	A	F	Lac	36	7	202P
7/3/2005	Byre GPA	*L.bor*	A	M	Non	39	13.1	207P
7/5/2005	Byre GPA	*L.noc*	A	M	Non	40	12.5	208P
7/6/2005	SDSU	*E.fus*	A	M	Non	42	14.2	SDGFP 05314
7/9/2005	West Bend RA	*L.bor*	J	M	Non	38	9	SDGFP 05315
7/9/2005	West Bend RA	*E.fus*	J	F	Non	44	13.1	SDGFP 05316
7/10/2005	West Bend RA	*E.fus*	J	M	Non	43	13	SDGFP 05317
7/10/2005	West Bend RA	*L.cin*	A	F	r.Lac	56	32	SDGFP 05318
7/11/2005	West Bend RA	*E.fus*	J	M	Non	45	16	SDGFP 05319
7/15/2005	Fort Randall Spillway	*M.sept*	A	M	Non	34	6	209P
7/16/2005	Fort Randall Spillway	*M.sept*	A	F	Non	35	7	210P
7/16/2005	Fort Randall Spillway	*E.fus*	A	M	Non	44	20	211P
7/16/2005	Fort Randall Spillway	*M.sept*	A	M	Non	35	7	212P
7/16/2005	Fort Randall Spillway	*E.fus*	A	M	Non	43	17	213P
7/16/2005	Fort Randall Spillway	*M.sept*	A	M	Non	35	7	214P
7/16/2005	Fort Randall Spillway	*M.sept*	A	M	Non	36	6	215P
7/17/2005	Fort Randall Spillway	*L.bor*	J	M	Non	38	8	216P
7/18/2005	L&C Boy Scout Camp	*M.sept*	A	M	Non	34	6.9	217P
7/18/2005	L&C Boy Scout Camp	*M.sept*	A	M	Non	37	7	218P
7/19/2005	L&C Boy Scout Camp	*L.cin*	J	F	Non	55	23.5	219P
7/19/2005	L&C Boy Scout Camp	*M.sept*	A	M	Non	36	8	220P

7/20/2005	L&C Boy Scout Camp	*E.fus*	J	M	Non	49	16.5	232P
7/20/2005	L&C Boy Scout Camp	*E.fus*	J	F	Non	46	17	233P
7/26/2005	L&C Boy Scout Camp	*E.fus*	A	M	Scrt	46.5	19.75	234P
7/27/2005	L&C Boy Scout Camp	*E.fus*	A	M	Scrt	43.5	15.75	236P
7/27/2005	L&C Boy Scout Camp	*E.fus*	A	F	p.Lac	46	23	235P
7/28/2005	L&C Boy Scout Camp	*M.sept*	A	F	p.Lac	37	7.75	237P
7/28/2005	L&C Boy Scout Camp	*L.cin*	A	F	Non	56	23.5	238P
8/2/2005	Karl Mundt NWR	*M.sept*	A	F	Non	35.5	6.5	239P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	45.5	20	240P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	46	19	271P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	45	13.75	272P
8/2/2005	Karl Mundt NWR	*E.fus*	A	F	p.Lac	47.5	20	273P
8/2/2005	Karl Mundt NWR	*M.sept*	A	F	Non	36	8.25	274P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	47	17.75	275P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	41.5	16.75	277P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	43	16.25	278P
8/2/2005	Karl Mundt NWR	*E.fus*	J	M	Non	45.5	17.25	279P
8/2/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	42.5	12.75	280P
8/3/2005	Karl Mundt NWR	*M.sept*	A	F	Non	37.5	6.75	261P
8/3/2005	Karl Mundt NWR	*M.sept*	A	M	Scrt	35	6	262P
8/3/2005	Karl Mundt NWR	*M.sept*	A	F	Non	35	6	263P
8/3/2005	Karl Mundt NWR	*M.sept*	A	F	Non	34	6.5	264P
8/3/2005	Karl Mundt NWR	*E.fus*	A	M	Scrt	46.5	18.5	264P
8/20/2005	Farm Island RA	*L.bor*	A	M	Scrt	39	13.2	SDGFP 05320
8/20/2005	Farm Island RA	*M.sept*	A	M	Scrt	35	9	SDGFP 05321
8/21/2005	Arikara GPA	*M.sept*	J	F	Non	36	7	SDGFP 05322
8/21/2005	Arikara GPA	*L.bor*	J	F	Non	38	9	SDGFP 05323
8/21/2005	Arikara GPA	*E.fus*	J	M	Scrt	44	16	SDGFP 05324
8/21/2005	Arikara GPA	*M.sept*	A	M	Scrt	36	9	SDGFP 05325
8/21/2005	Arikara GPA	*M.sept*	A	F	Non	35	7	SDGFP 05326
9/2/2005	Byre GPA	*M.sept*	J	F	Non	37	7	267P
9/2/2005	Byre GPA	*M.sept*	A	F	Non	36	8.5	268P
9/2/2005	Byre GPA	*M.sept*	A	F	Non	35	10	269P
9/3/2005	Byre GPA	*M.sept*	A	F	Non	37	7.5	270P
9/3/2005	Byre GPA	*L.bor*	A	M	Scrt	38	10	291P
9/3/2005	Byre GPA	*M.sept*	A	F	Non	36	7	292P
9/3/2005	Byre GPA	*E.fus*	J	M	Scrt	45.5	19	293P
9/4/2005	Byre GPA	*M.sept*	A	F	Non	35	6.5	294P
9/6/2005	SDSU	*L.bor*	A	F	Non	41	21.5	SDGFP 05327
9/7/2005	Byre GPA	*M.luc*	J	F	Non	35	6.2	295P
9/7/2005	Byre GPA	*M.sept*	J	M	Non	35	6	296P
9/9/2005	Oahe Downstream RA	*M.sept*	J	F	Non	35	7	SDGFP 05328
9/9/2005	Oahe Downstream RA	*L.bor*	J	M	Scrt	37	9.8	SDGFP 05329
9/9/2005	Oahe Downstream RA	*M.sept*	J	F	Non	36	6.5	SDGFP 05330
9/9/2005	Oahe Downstream RA	*M.luc*	J	F	Non	35	7.5	SDGFP 05331
9/9/2005	Oahe Downstream RA	*M.sept*	A	F	Non	35	7.8	SDGFP 05332
9/10/2005	Oahe Downstream RA	*M.luc*	A	M	Non	36	7.7	SDGFP 05311
9/10/2005	Oahe Downstream RA	*M.sept*	A	F	Non	37	9.5	SDGFP 05333
9/30/2005	Byre GPA	*E.fus*	A	F	Non	45	19	241P
9/30/2005	Byre GPA	*M.luc*	A	F	Non	35	9	242P
10/1/2005	Byre GPA	*L.bor*	A	M	Non	40	13	243P

5/4/2006	Fort Randall Spillway	*E.fus*	A	F	Non	46	16.5	297P
5/4/2006	Fort Randall Spillway	*E.fus*	A	M	Non	46	17	298P
5/12/2006	Oahe Downstream RA	*M.sept*	A	M	Non	35	7.1	sdgfp 05335
5/12/2006	Oahe Downstream RA	*M.sept*	subA	F	Non	36.5	7	sdgfp 05336
5/12/2006	Oahe Downstream RA	*M.sept*	subA	F	Non	35.5	6.5	sdgfp 05337
5/12/2006	Oahe Downstream RA	*M.sept*	A	F	Non	35	7	sdgfp 05338
5/12/2006	Oahe Downstream RA	*M.sept*	A	F	Non	36	7	sdgfp 05339
5/12/2006	Oahe Downstream RA	*M.sept*	A	F	Non	36.5	6	sdgfp 05334
5/13/2006	Oahe Downstream RA	*M.sept*	A	M	Non	35	6	SDGFP 05341
5/13/2006	Oahe Downstream RA	*M.sept*	A	M	Non	35	5.9	SDGFP 05342
5/13/2006	Oahe Downstream RA	*M.sept*	A	F	Non	36.5	8	SDGFP 05343
5/24/2006	Byre GPA	*E.fus*	A	M	Non	46	17.5	345P
5/24/2006	Byre GPA	*M.sept*	A	F	Non	35.7	6.8	347P
6/3/2006	Fort Randall Spillway	*M.sept*	A	F	Non	36	6.3	299P
6/3/2006	Fort Randall Spillway	*L.bor*	A	F	Preg	42	13	300P
6/3/2006	Fort Randall Spillway	*M.sept*	A	M	Non	34	7	348P
6/3/2006	Fort Randall Spillway	*E.fus*	A	M	Non	46	17	349P
6/15/2006	Byre GPA	*M.sept*	A	F	Preg	36	8	221P
6/15/2006	Byre GPA	*M.sept*	A	F	Lac	36	7.7	222P
6/15/2006	Byre GPA	*E.fus*	A	F	Non	42	21.8	223P
6/15/2006	Byre GPA	*L.bor*	A	F	Non	42.5	14	224P
6/15/2006	Byre GPA	*L.cin*	A	F	Non	56	28	225P
6/15/2006	Byre GPA	*M.sept*	A	M	Non	35	6.1	226P
7/11/2006	Arikara GPA	*M.sept*	A	F	r.Lac	36	6.7	SDGFP 05386
7/11/2006	Arikara GPA	*M.sept*	A	F	Non	35.5	7.2	SDGFP 05387
7/12/2006	Arikara GPA	*E.fus*	A	F	Non	46	18	SDGFP 05388
7/12/2006	Arikara GPA	*M.sept*	A	M	Non	36	7.8	SDGFP 05389
7/20/2006	Oahe Downstream RA	*L.bor*	J	F	Non	41	16	SDGFP 05390
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	34	6	SDGFP 05391
7/20/2006	Oahe Downstream RA	*M.sept*	A	M	Non	34	7	SDGFP 05392
7/20/2006	Oahe Downstream RA	*M.sept*	A	M	Non	34	8	SDGFP 05312
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	36	6.5	SDGFP 05393
7/20/2006	Oahe Downstream RA	*M.sept*	J	M	Non	35	8	SDGFP 05394
7/20/2006	Oahe Downstream RA	*M.sept*	A	F	p.Lac	36	9	SDGFP 05395
7/20/2006	Oahe Downstream RA	*M.sept*	A	M	Non	36	9	SDGFP 05396
7/20/2006	Oahe Downstream RA	*E.fus*	A	F	p.Lac	48	22	SDGFP 05397
7/20/2006	Oahe Downstream RA	*M.luc*	J	F	Non	35	9	SDGFP 05398
7/20/2006	Oahe Downstream RA	*M.sept*	J	M	Non	34	6	SDGFP 05399
7/20/2006	Oahe Downstream RA	*M.sept*	A	M	Non	35	7	SDGFP 05400
7/20/2006	Oahe Downstream RA	*M.sept*	A	F	p.Lac	35	8	SDGFP 05361
7/20/2006	Oahe Downstream RA	*M.sept*	J	M	Non	34	5	SDGFP 05362
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	35	6.5	SDGFP 05363
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	35	6	SDGFP 05364
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	34	6	SDGFP 05365
7/20/2006	Oahe Downstream RA	*M.sept*	J	F	Non	36	6	SDGFP 05366
7/20/2006	Oahe Downstream RA	*M.sept*	A	F	p.Lac	36	7	SDGFP 05367
7/20/2006	Oahe Downstream RA	*M.sept*	A	F	p.Lac	36	7.2	SDGFP 05368
7/20/2006	Oahe Downstream RA	*M.sept*	A	F	Non	36	7	SDGFP 05343
7/20/2006	Oahe Downstream RA	*M.cil*	A	M	Non	34	5.6	SDGFP 05369
8/15/2006	Byre GPA	*M.sept*	subA	F	Non	36	7.5	227P
8/15/2006	Byre GPA	*E.fus*	A	F	Non	46	20	228P

8/28/2006	Arikara GPA	*E.fus*	J	F	Non	45	15	SDGFP 05344
8/28/2006	Arikara GPA	*M.sept*	J	F	Non	34	6.5	SDGFP 05347
8/28/2006	Arikara GPA	*M.sept*	J	M	Non	34.5	6	SDGFP 05348
8/28/2006	Arikara GPA	*M.luc*	J	M	Non	38	7.5	SDGFP 05345
8/30/2006	SDSU	*E.fus*	A	M	Scrt	46	14	SDGFP 05355
8/31/2006	Fort Randall Spillway	*M.sept*	A	M	Scrt	34	7.5	255P
8/31/2006	Fort Randall Spillway	*M.sept*	J	F	Non	36	6.5	254P
8/31/2006	Fort Randall Spillway	*M.sept*	J	F	Non	35	6.5	257P
8/31/2006	Fort Randall Spillway	*M.sept*	A	M	Scrt	34.5	6.7	258P
8/31/2006	Fort Randall Spillway	*E.fus*	J	M	Non	43	16	256P
8/31/2006	Fort Randall Spillway	*M.sept*	A	M	Scrt	36	7	256P
8/31/2006	Fort Randall Spillway	*E.fus*	A	M	Scrt	46	20	260P
8/31/2006	Fort Randall Spillway	*E.fus*	A	F	Par	45	18	352P
8/31/2006	Fort Randall Spillway	*E.fus*	A	M	Scrt	42	15	353P
8/31/2006	Fort Randall Spillway	*E.fus*	A	M	Scrt	44	16	354P
8/31/2006	Fort Randall Spillway	*L.bor*	A	F	Non	42	15	350P
9/17/2006	Byre GPA	*L.bor*	A	F	Non	41	13	355P
9/17/2006	Byre GPA	*E.fus*	J	F	Non	44	16	356P
9/17/2006	Byre GPA	*M.luc*	A	F	Non	36	9	358P
9/17/2006	Byre GPA	*M.sept*	J	F	Non	35	6	357P
9/17/2006	Byre GPA	*E.fus*	A	F	Non	46	18	360P
9/17/2006	Byre GPA	*L.noc*	J	M	Non	41	10	359P
9/24/2006	Arikara GPA	*L.bor*	A	F	Non	42	14	SDGFP 05384
9/24/2006	Arikara GPA	*M.sept*	A	M	Scrt	36	7.2	SDGFP 05382
9/24/2006	Arikara GPA	*E.fus*	A	F	Non	45	19	SDGFP 05383
9/26/2006	Byre GPA	*M.sept*	A	M	Non	35.5	6.5	244P
9/26/2006	Byre GPA	*M.sept*	A	M	Scrt	36	7	245P
9/26/2006	Byre GPA	*M.luc*	A	M	Non	38	8	246P
11/2/2006	SDSU	*E.fus*	A	F	Non	46	20	SDGFP 05346