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RECENT DISTRIBUTION AND LIFE HISTORY INFORMATION FOR BATS OF EASTERN SOUTH DAKOTA

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ABSTRACT

From May 2000 to August 2002, a study was conducted to document the distribution of bats in South Dakota east of the Missouri River. During the summers of 2000, 2001, and 2002, mist netting and acoustic sampling (Anabat system) were conducted at 35 sites, including state parks, state recreation areas, and national wildlife refuges. Seven species of bat were recorded from this region: *Myotis septentrionalis*, *Myotis lucifugus*, *Myotis ciliolabrum*, *Eptesicus fuscus*, *Lasionycteris noctivagans*, *Lasiurus borealis*, and *Lasiurus cinereus*. Distribution maps and species accounts were compiled for the seven species using data from the summers of 2000, 2001, and 2002 in addition to data from literature records and voucher records.

Key words: Anabat, bat distribution, riparian corridors, South Dakota, species accounts, voucher records

INTRODUCTION

Few studies of bats in South Dakota exist, and those focus primarily on the western region of the state. Since 1861, 24 studies focused on the bats in South Dakota west of the Missouri River; only Findley (1956) and Jones and Genoways (1967) focused on the bats found throughout South Dakota east of the Missouri River. These 30-year-old studies described the distribution of bats within eastern South Dakota from mist netting data and other collection methods at foraging sites. This study provides new data for the South Dakota bat management plan and revises the distributions and life history data (foraging activity, roost sites, diet) for bats of eastern South Dakota.

Thirteen species of bats are currently known from South Dakota: *Myotis evotis*, *M. septentrionalis*, *M. ciliolabrum*, *M. lucifugus* (both *M. l. lucifugus* and *M. l. carissima*), *M. thysanodes*, *M. volans*, *Lasionycteris noctivagans*, *Eptesicus fuscus* (both *E. f. fuscus* and *E. f. pallidus*), *Lasiurus borealis*, *L. cinereus*, *Corynorhinus townsendii* (Choate and Jones 1981), *Nycticeus humeralis* (Lane et al. 2003), and *Tadarida brasiliensis mexicana* (Glass 1982). Five of these taxa (*M. septentrionalis*, *M. lucifugus*, *E. fuscus*, *L. borealis*, and *L. cinereus*) have been captured statewide (Higgins et al. 2000), whereas, *C. townsendii*, *M. evotis*, *M. volans*, and *M. thysanodes* have been

captured primarily in the Black Hills region of western South Dakota (Jones and Genoways 1967; Turner and Jones 1968). *Lasionycteris noctivagans* has been documented in western South Dakota (Jones and Genoways 1967; Mattson 1996), but has only been captured during its migration period (August-November) in eastern South Dakota (Jones and Genoways 1967) and has not been considered a statewide resident. *Myotis ciliolabrum* has been documented mainly in western South Dakota (Jones and Genoways 1967; Tuttle and Heaney 1974; Choate and Anderson 1997). Genoways collected a single specimen (TTU 25695) of this species along the Missouri River in eastern South Dakota. A specimen of *T. brasiliensis mexicana* originally banded in western Oklahoma was recaptured in Menno, Hutchinson County (Glass 1982). Recently, *N. humeralis* was captured in the southeastern corner of eastern South Dakota (Lane et al. 2003).

STUDY AREA

Eastern South Dakota is a mosaic landscape of cropland, wetlands, and pastures and consists primarily of central lowlands. These central lowlands are further divided into eight subregions: the Minnesota River-Red River lowlands (mean elevation, 305 m), the Coteau des Prairies (mean elevation, 549 m), the James River lowland (mean elevation, 411 m), the Lake Dakota plain (mean elevation, 399 m), the James River highlands (mean elevation, 91 m), the Coteau du Missouri (mean elevation, 487 m), the Missouri River trench (mean elevation, 426 m), and the Southern Plateaus (mean elevation, 411 m) (Hogan 1995). Over 31% of eastern South Dakota is composed of agricultural land (row crops, small grains, and bare ground) and only 1.5% of eastern South Dakota is woodland (deciduous or coniferous shelterbelts, woodlands, shrublands, riparian areas, and forests) (Smith et al. 2002).

State parks (SP), state recreation areas (RA), and national wildlife refuges (NWR) throughout eastern South Dakota were chosen as study sites (Fig. 1) because of the prominent expansion of woodland habitat (to facilitate the capture of tree roosting species) and water sources in these areas. Water sources can provide suitable foraging habitat for some species such as *M. lucifugus*. This species has been documented to forage over water, close to water, or to forage over trees in rather open areas (Barbour and Davis 1969).

METHODS

During the summer months (May through August) of 2000-2002, bats were captured using mist nets (Avinet, New York). Captured bats were identified to species, weighed, sexed, checked for reproductive condition and ectoparasites, banded, and then released. Species accounts and distribution maps are based upon mist net capture and acoustic data from the summers of 2000, 2001, and 2002; literature records (Miller 1897; Visher 1914; Over and Churchill 1945; Findley 1956; Jones and Genoways 1967; Lane et al. 2003) and the records of the South Dakota Natural Heritage Program Database, South Dakota Game, Fish and Parks; and voucher specimens at several natural history collections: FHS (Sternberg Museum, Fort Hayes State University), KU (Natural History Museum, University of Kansas), SDADR (South Dakota Animal Disease Research Lab), SDSU (South Dakota State University Natural History Collection, including bats from Department of Health), UNSM (University of Nebraska State Museum), and USNM (National Museum of Natural History) (Jones and Genoways 1967).

Species accounts include captures of mist-netted bats that were subsequently released as "Capture Data", literature records and records of the South Dakota Natural Heritage Program Database as "Additional Records", and voucher records as "Museum Records". Shaded regions on the distribution maps correspond to proposed bat habitat and likely places where this species may be captured. The habitat information is South Dakota land cover data from the USGS GAP Analysis program (http://www.gap.uidaho.edu/ 2005).

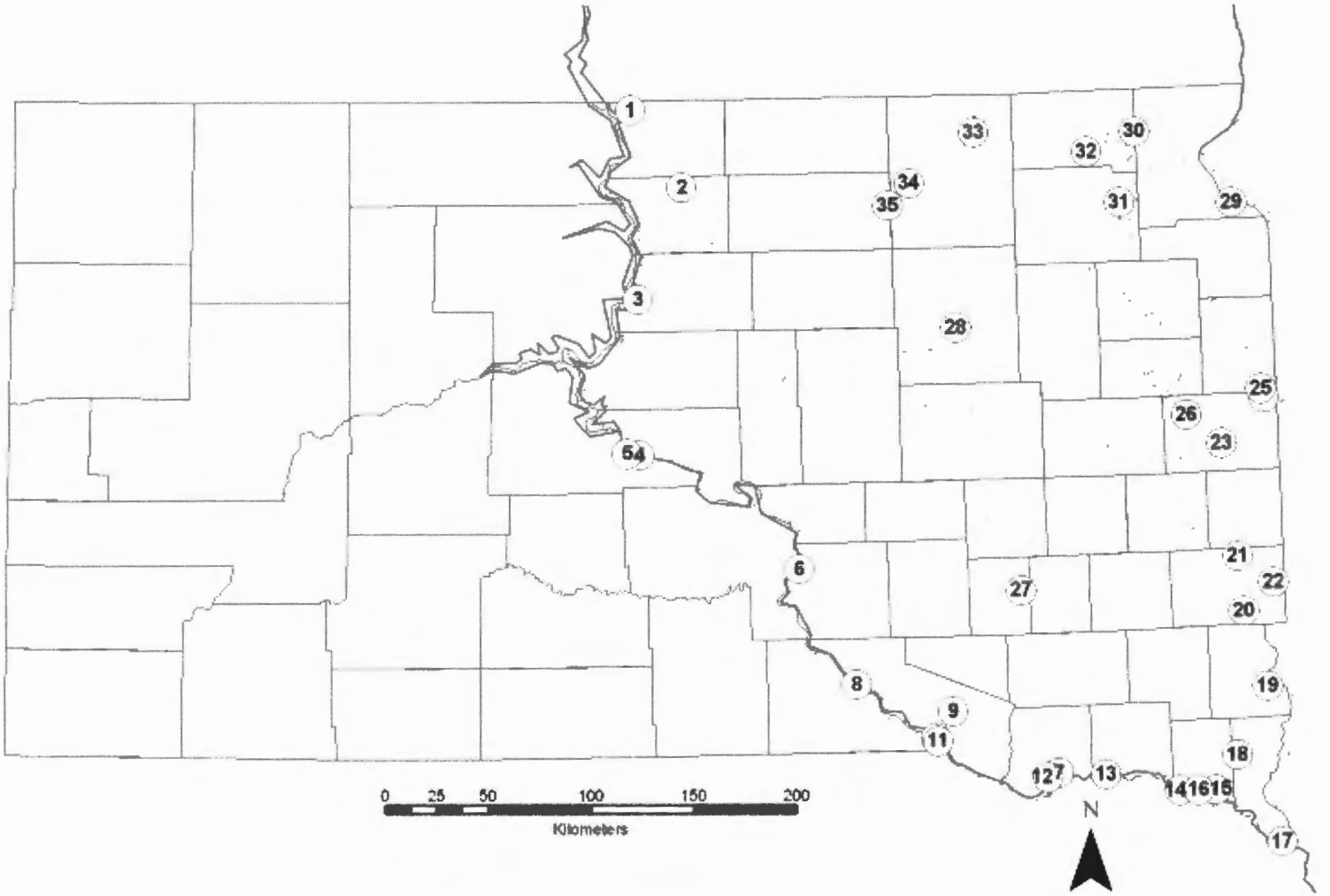

Figure 1.— Study sites in eastern South Dakota: (1) Pollock; (2) Hiddenwood RA; (3) West Whitlocks RA; (4) La Framboise RA; (5) Farm Island RA; (6) American Creek RA; (7) Sand Creek RA; (8) Platte Creek RA; (9) Lake Andes NWR; (10-11) Randall Creek RA and Karl Mundt NWR; (12) Springfield; (13) Lewis and Clark RA; (14) Myron Grove RA; (15) Clay County RA; (16) Vermillion-Cotton Park; (17) Adams Homestead; (18) Union Grove SP; (19) Newton Hills SP; (20) Sioux Falls; (21) Dell Rapids Quarry; (22) Palisades SP; (23) Brookings-McCrory Gardens; (24-25) Oaklake Station and Astoria; (26) Oakwood SP; (27) Mitchell-Hitchcock Park; (28) Fisher Grove RA; (29) Hartford Beach RA; (30) Sica Hollow RA; (31) Waubay NWR; (32) Fort Sisseton RA; (33) Sand Lake NWR; (34) Richmond Lake RA; (35) Mina State RA.

This land cover data originated from the South Dakota Gap Analysis Project, South Dakota Cooperative Fish and Wildlife Research Unit, within the department of Wildlife and Fisheries Sciences at South Dakota State University.

Acoustic sampling has been used effectively to census bats in other regions of the United States (Hayes 1997; Everette et al. 2001; Murray et al. 2001) by recording the echolocation sounds made by bats when they are foraging and commuting. The acoustic device used for species identification in this study was the Anabat system (Titley Electronics, Australia). The Anabat II bat detector records the echolocation calls emitted by the bat via a broadband microphone and reduces the sounds into a frequency that is audible to the human ear and can be recorded using tape for subsequent analysis. This detector system was suitable for this study given the need to use acoustic sampling systems in open habitats with high winds where mist netting would be ineffective, as well as the low cost compared to other acoustic systems.

The Anabat bat detector, delay switch, two 6-volt batteries, and recorder were placed inside a 42x29x15 cm (12 quart) plastic container. The equipment was situated inside the container to protect it from dew and rain and the Anabat microphone was placed through an opening in the lid of the container. In order to maximize the number of bat recordings, the detector was orientated vertically to reduce interference of obstacles, such as trees. The containers were placed above the ground on a metal ladder to reduce the recording of non-target species, such as insects. To accommodate larger sites, up to three Anabat containers were arranged randomly in a study area. In most cases, the detectors remained active at the site from 1900 to 0700 h. However, in areas were vandalization could occur, acoustic censusing was discontinued at closure of mist netting (0100 h). Once the acoustic output from the Anabat detector was transferred to cassette tape, software (Anabat version 6) was used to extract data from the tape via a ZCAIM (zero crossings analysis interface module) (Corben and O'Farrell 1999). Analook software was used to display the data graphically in a frequency (kHz) spectrogram.

The South Dakota bat calls were compared to the call parameters of reference calls by using a discriminant function analysis (DFA) (SAS Institute Inc. 1999). Other studies (Obrist 1995; Vaughan et al. 1997; Parsons and Jones 2000; Fenton et al. 2001; Murray et al. 2001) also have used DFA to identify unknown bat calls using reference calls that differed in the number of call parameters, the quality of the reference calls (unculled versus culled), and the locations where the reference calls were recorded. The reference call library was composed of calls previously recorded from captured bats in New York, Wyoming, New Mexico, Texas, Arizona, and Utah. These prerecorded calls are available from the University of New Mexico bat call library (http://talpa.unm.edu/batcalldatabase 2001).

For this study, different DFA models were created and evaluated for the best combination of factors to identify the South Dakota bat calls. Four different DFA models were tested. The first model used 11 call parameters identified by Corben and O'Farrell (1999): Characteristic Slope-Sc, Maximum Frequency-Fmax, Minimum Frequency-Fmin, Mean Frequency-Fmean, Characteristic Frequency-Fc, Frequency of the Knee-Fk, Duration-Dur, Time from start of call to end of body-Tc, Time from start of call to start of body-Tk, and the time between calls-prev and next. These parameters were used to categorize unculled calls obtained from the reference call library. A stepwise DFA rejected this model because the parameters "prev" and "next" were of no significance ($p = 0.157$ and $p = 0.194$, respectively) in the discrimination among calls.

The second DFA model included nine parameters (Sc, Fmax, Fmin, Fmean, Fc, Fk, dur, Tc and Tk) of culled calls from the reference call library. That is, the quality of the library calls was questionable because there was variation among calls and in the quality of the recordings. To alleviate this problem, the reference bat calls were culled by utilizing the quality (Qual) parameter (Analook software), which removed calls above 0.25 as these calls can be dismissed as "outlier" reference calls or because these calls could have been affected by extraneous noise such as insects. To determine if there were geographic differences in the library reference calls within the second DFA model, parameter means were compared among localities. The

parameters of *M. lucifugus* and *L. noctivagans* calls were most similar among localities, but the *L. cinereus* calls and *M. ciliolabrum* calls differed among localities. The differences in the call parameters meant that the library reference calls from different localities could not be lumped together for each bat species; thus the second DFA model was modified into a third model.

The third DFA model was run to determine if the library reference calls could be categorized correctly into their species/locality sets, while viewing the *L. cinereus* and *M. ciliolabrum* calls as separate entities. The correctly categorized library reference calls would be used to identify bat calls from South Dakota. This model used a limited set of parameters: a slope parameter (Sc), duration (Dur), and two frequency parameters (Fk and Fc). These frequency parameters were chosen over the others (Fmin, Fmean, and Fmax) because most of the identifiable parts of a bat call are in the body of the call. Fk and Fc are both frequency parameters specifically dealing with the call body while Fmin, Fmax, and Fmean are very broad parameters subject to a great deal of variation. The percentage of correctly classified library reference calls was low for some species/locality sets within the third model. The New Mexico calls for *L. noctivagans* were classified incorrectly as *L. cinereus*; while the New Mexico *M. ciliolabrum* and *M. lucifugus* were classified incorrectly as *M. ciliolabrum* Arizona and *M. lucifugus* Arizona. As such, these library reference calls were eliminated from future analyses and the third model was rejected.

Due to inconsistencies in the reference call library (quality of recordings and variation between types of calls) and the likely possibility that some calls were incorrectly identified, only a limited selection of the reference call library was used to analyze calls from South Dakota bats. The final DFA model used four parameters with library reference calls from New Mexico (*E. fuscus*), New York (*L. borealis*, *L. noctivagans*, and *M. septentrionalis*), Wyoming (*M. ciliolabrum*), Arizona (*M. lucifugus*), and Texas (*L. cinereus*). This final model was utilized to classify the calls from South Dakota bats to species based on the library reference call parameters.

RESULTS

In the summer of 2000, the preliminary study began with one county censused for 15 nights. In 2001, 70 nights were spent censusing 34 sites in 19 counties throughout eastern South Dakota. Of 52 bats mist-netted in 2000 and 2001, the percent composition of the total population was *Myotis lucifugus* 35%, *Eptesicus fuscus* 27%, *Lasiurus borealis* 21%, *Myotis septentrionalis* 11%, *Lasiurus cinereus* 4%, and *Lasionycteris noctivagans* 2%. Four specimens were collected and deposited in the South Dakota University Natural History Collection, Brookings, South Dakota. During the summer of 2002, nine sites in five counties along the Missouri River were censused and 52 bats were mist netted. Of these, the percent composition was *M. septentrionalis* 42%, *E. fuscus* 35%, *M. lucifugus* 15%, *L. borealis* 4%, and *L. noctivagans* 4%.

At most sites in 2000 and 2001, capture rates (bats/per net/per night; BNN) were less than 1.0. However, two locations that were within the riparian forests of the Missouri River had greater capture rates: La Framboise RA with 2.3 BNN and Karl Mundt NWR with 1.43 BNN.

In 2002, when censusing efforts were concentrated along the Missouri River, capture rates at many locations were equal to or greater than 1.0 BNN, which was much greater than the capture rates at the non-Missouri River locations. In all non-Missouri River locations, the BNN was less than 0.3, and in half of these, the BNN was zero. Comparatively, the lowest capture rate along the Missouri River was 0.5 BNN (Platte Creek RA), and the capture rates at locations within the riparian forests of the Missouri River (Farm Island RA, Karl Mundt NWR, La Framboise RA, and West Bend RA) were greater than 2.0 BNN. The locality with the highest capture rate (2.6 BNN) and species richness (7 species) was Farm Island RA.

Acoustic data combined with mist netting records noted above provided a better understanding of the distribution of bats in eastern South Dakota. Acoustic data added new species records for *E. fuscus* (7 records), *L. borealis* (10 records), *L. cinereus* (8 records), *L. noctivagans* (5 records), and *M. lucifugus* (4 records) at numerous study sites. Evidently, mist netting data and acoustic data indicate that bats are more abundant in riparian forest areas along the Missouri River than in open habitats of non-Missouri River locations.

Acoustic data identified new bat records in some locations where no capture data, literature, or voucher records existed previously: Brookings County, Oakwood SP (3 species); Brown County, Richmond RA (4 species); Charles Mix County, Platte Creek RA (1 species); Edmunds County, Mina RA (1 species); Minnehaha County, Dell Rapids Quarry (1 species); Roberts County, Hartford Beach RA (2 species) and Sica Hollow SP (3 species); Spink County, Fisher Grove RA (2 species); and Union County, Adams Homestead (4 species) (see Appendix).

Acoustic data supported the voucher records and capture data at several locations. Of the locations with previous capture, literature, or voucher records, 63% of the time these records were matched by acoustic data.

Species Accounts

Myotis septentrionalis (van Zyll de Jong 1979)
Northern Long-eared Myotis

Museum records (6).—BONHOMME COUNTY: Sand Creek park, 3 (KU); Springfield, 1 (KU). HUGHES COUNTY: Farm Island RA, 1 (TTU). STANLEY COUNTY: no specific locality, 1 (USNM).

Capture data (29).—CLAY COUNTY: Myron Grove RA, 5. GREGORY COUNTY: Karl Mundt NWR, 11. HUGHES COUNTY: Farm Island RA, 7, West Bend RA, 3. UNION COUNTY: Union Grove SP, 2. YANKTON COUNTY: Lewis and Clark RA, 1.

Previously, *Myotis septentrionalis* was captured only in counties of eastern South Dakota adjacent to the Missouri River. Jones and Genoways (1967) recorded *M. septentrionalis* in Bonhomme County along the southeastern portion of the Missouri River and museum records exist from counties (Stanley and Hughes) along the central portion of the river. Records are all found within floodplain forests (riparian forests) of the Missouri River that extend from the southwestern corner to the central portion of the state (Fig. 2). Small patches of riparian forest composed mostly of eastern cottonwoods (*Populus deltoides*) are fragmented along the river in Hughes, Gregory, Yankton, and Clay counties, restricting the distribution of *M. septentrionalis* to these areas. Recent capture records from 2001 and 2002 are located within this "riparian forest" zone. In 2001, bats were captured on 23 June and 13 August in Gregory County; 19 August in Hughes County; and 16 June and 29 July in Union County. In 2002, bats were mist netted on 25, 26, 29 May, and 14 July in Gregory County; 16 June in Yankton County; 21 June in Clay County; 26 June in West Bend RA (Hughes County); and 25 July in Farm Island RA (Hughes County). Gravid females were captured on 21 and 26 June 2002, lactating females were captured on 14 July 2002, postlactating females were taken on 14 and 25 July 2002, and young-of-the-year males were captured on 25 July 2002.

Two captures of *M. septentrionalis* in Union County (Union Grove State Park) could indicate that the distribution of this species may be slowly extending northward from the natal area of the Missouri River. This park is a mixture of deciduous trees such as bur oak (*Quercus macrocarpa*) and green ash (*Fraxinus pennsylvanica*) located approximately 32.2 km north of the Missouri River. Genoways et al. (2000) described a similar situation in the range of *Tadarida brasiliensis mexicana*. Individuals of this species were collected directly north of the natal zone in a region called the "pioneering zone," where if conditions were favorable, the species could reproduce. There was no evidence of reproduction of *M. septentrionalis* in Union Grove State Park, but only two male bats were captured at this locality. The bat captured on 16 June 2001 was retained as a voucher specimen (SDSU 2411) in the South Dakota State University Natural History Collection.

Recaptures of bats are very rare, especially in places that have not been extensively mist netted. On 9 September 2004, Alyssa Kiesow (South Dakota Game,

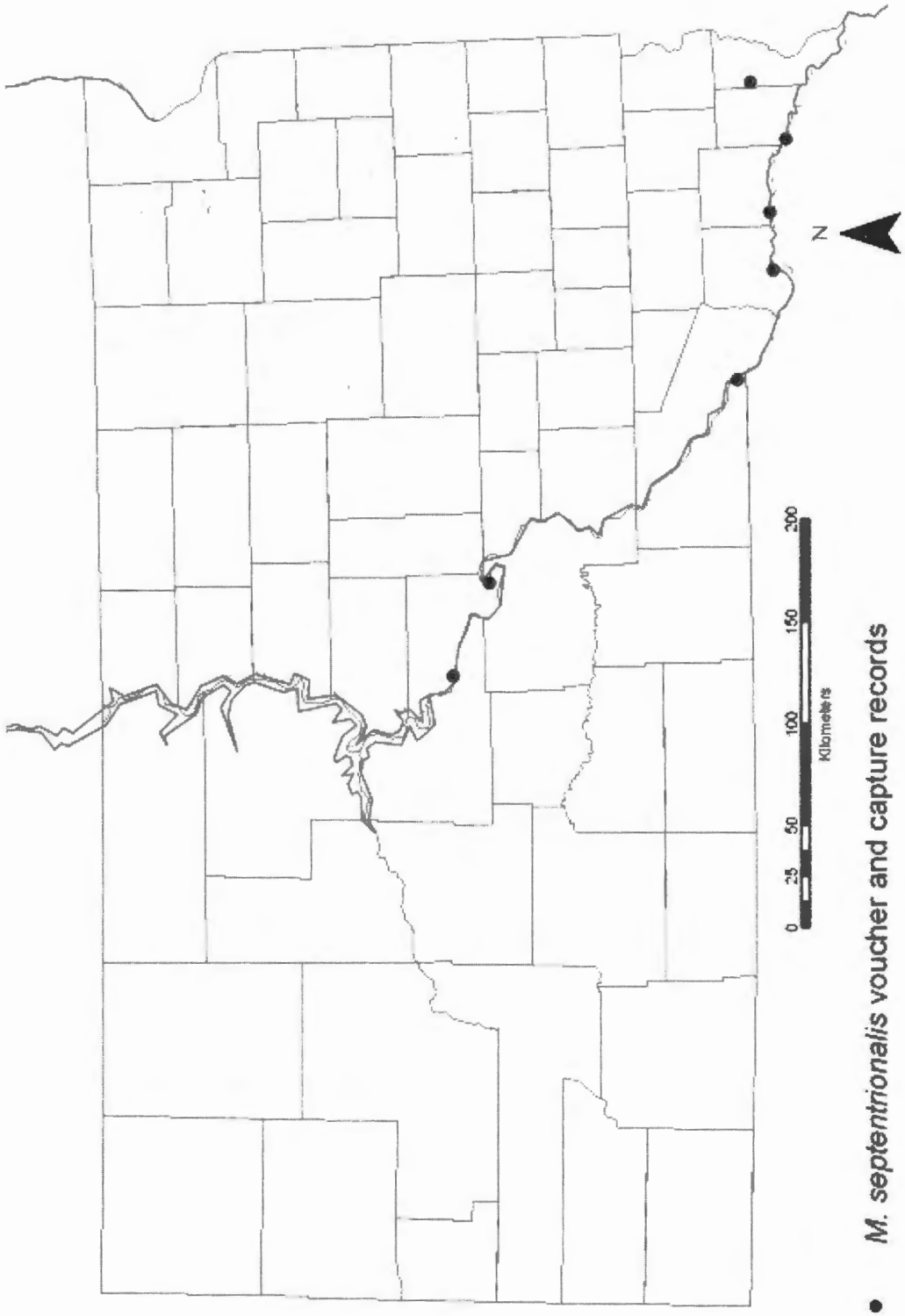

Figure 2.—Distribution of *Myotis septentrionalis* in eastern South Dakota.

Fish and Parks) captured a *M. septentrionalis* that had been previously captured and banded on 25 July 2002 in Farm Island RA near Pierre, South Dakota. The bat was captured in the same locality (the cottonwood floodplain) of Farm Island RA and was reproductively active (post-lactating), indicating the return to this particular locality for reproduction. It appears that this species returns to the cottonwood forests of the Missouri River to reproduce in the summer months.

Of note, previous bat identification keys have relied on pelage coloration and ear length as distinguishing characteristics (Higgins et al. 2000). In this study, however, these characteristics were often misleading, and more specific characteristics such as length and shape of the tragus were more effective in the identification of bats, especially *Myotis* species (Joel Tigner, pers. comm.). *Myotis lucifugus* has a blunt tragus with a rounded end whereas *Myotis septentrionalis* has a narrow tragus with a tapered end.

Myotis lucifugus (Le Conte 1831)
Little Brown Myotis

Museum records (6).—GREGORY COUNTY: Cedar Island, 1 (USNM). MINNEHAHA COUNTY: Sioux Falls, 1 (SDSU). STANLEY COUNTY: Ft. Pierre, 1 (USNM). UNION COUNTY: 6 mi East of Vermillion, 1 (KU). WALWORTH COUNTY: Mobridge, 2 (SDSU).

Capture data (26).—CAMPBELL COUNTY: Pollock, 2. DAY COUNTY: Waubay NWR, 1. GREGORY COUNTY: Karl Mundt NWR, 2. HUGHES COUNTY: Farm Island RA, 2, La Framboise RA, 15. POTTER COUNTY: West Whitlocks RA, 2. WALWORTH COUNTY: Hiddenwood RA, 2.

Anabat recordings.—BROOKINGS COUNTY: Oakwood Lakes SP. BROWN COUNTY: Richmond Lake RA. HUGHES COUNTY: West Bend RA. ROBERTS COUNTY: Hartford Beach RA.

Two subspecies (*M. lucifugus carissima* and *M. lucifugus lucifugus*) of *M. lucifugus* have been reported in the eastern region of South Dakota. *Myotis lucifugus carissima* differs from *M. l. lucifugus* in having slightly larger cranial dimensions and being paler in pelage coloration (Jones and Genoways 1967). The only museum record of *M. l. carissima* comes from Walworth County, central South Dakota. Based on previous museum records, *M. lucifugus* was distributed throughout the southern (Gregory, Minnehaha, and Union counties) and extreme western portions (Stanley County) of eastern South Dakota. Recent capture data from Campbell, Day, and Potter counties and Anabat recordings from Brookings, Brown, and Roberts counties, extend this distribution to include the entire eastern region of South Dakota (Fig. 3).

In 2001, *M. lucifugus* was captured at Farm Island RA (Hughes County) on 11 May and 9 July; Potter County on 23 May; Gregory County on 23 June; La Framboise RA (Hughes County) on 10 July; Campbell County on 14 July; and Walworth County on 16 July. During the summer of 2002, *M. lucifugus* was captured at La Framboise RA on 20 July and West Whitlocks RA (Potter County) on 28 July 2002.

On 2 June 2001, an individual *M. lucifugus* was extracted from a building at Waubay NWR (Day County). A female apparently trapped in the basement was found dehydrated and crawling on the floor. The bat was salvaged as a voucher specimen (SDSU 2410) for the South Dakota State University Natural History Collection. In the summers of 2001 and 2002, *M. lucifugus* were found roosting at a picnic shelter in La Framboise RA where approximately 20-30 bats could be found at any time.

This species was captured in habitats similar to those of *M. septentrionalis* (e.g., floodplain forests of the Missouri River), but also was captured in urban areas such as the city park of Pollock, South Dakota. *Myotis lucifugus* utilizes larger bodies of water for foraging, such as the Missouri River and Hiddenwood Lake, instead of smaller streams like the Vermillion or Big Sioux Rivers, where they were not recorded.

A gravid female was captured on 23 May 2001, and postlactating females were captured on 10 July 2001 and 20 July 2002. A young-of-the-year male was captured on 28 July 2002.

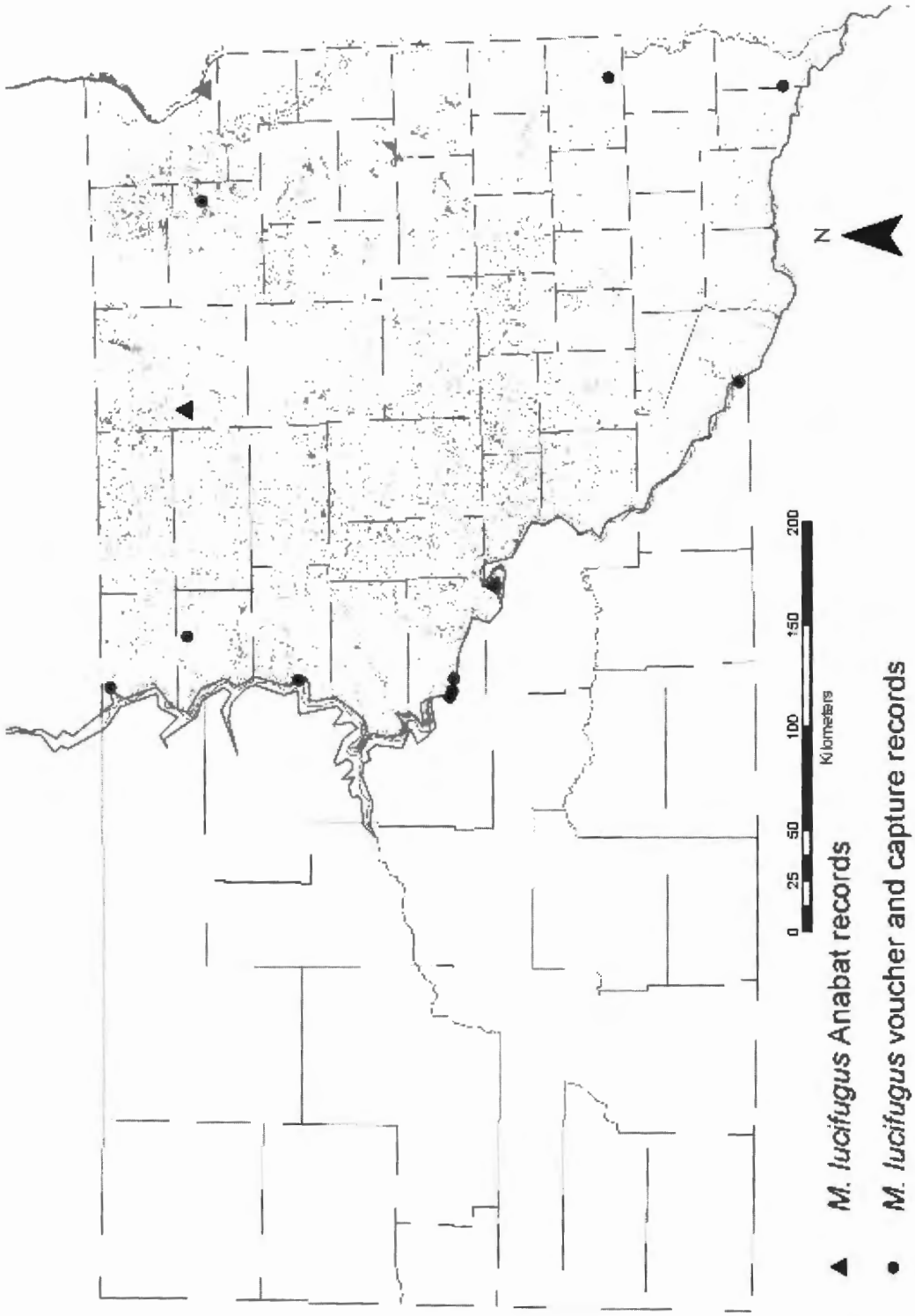

Figure 3.—Distribution of *Myotis lucifugus* in eastern South Dakota.

Myotis ciliolabrum (van Zyll de Jong 1984)
Western Small-footed Myotis

Museum records (1).—HUGHES COUNTY: Farm Island RA, 1 (TTU).

Anabat recordings.—HUGHES COUNTY: Farm Island RA.

Myotis ciliolabrum has been documented mainly in western South Dakota (Jones and Genoways 1967; Tuttle and Heaney 1974; Choate and Anderson 1997). A single *M. ciliolabrum* was collected at Farm Island RA on 2 July 1975 and was deposited in the Texas Tech University Museum (TK 926721). In this study, acoustic records of this species were recorded at Farm Island RA.

Lasionycteris noctivagans (Le Conte 1831)
Silver-haired Bat

Museum records (3).—BROOKINGS COUNTY: Brookings, SD, 1 (SDSU). DAY COUNTY: Waubay NWR, 1 (USNM). KINGSBURY COUNTY: Desmet, 1 (SDSU)

Capture data (3).—HUGHES COUNTY: La Framboise RA, 2. MARSHALL COUNTY: Fort Sisseton SP, 1.

Anabat recordings.—BRULE COUNTY: American Creek RA. CLAY COUNTY: Cotton park in Vermillion. DAY COUNTY: Waubay NWR. GREGORY COUNTY: Karl Mundt NWR. HUGHES COUNTY: West Bend RA and La Framboise RA. MINNEHAHA COUNTY: Sioux Falls. UNION COUNTY: Adams Homestead and Nature Preserve.

Additional records.–CLAY COUNTY: Vermillion (Lane et al. 2003). STANLEY COUNTY: no specific location (South Dakota Natural Heritage Program Database).

Lasionycteris noctivagans is known to be a migratory species that resides in Canada and the northern United States in spring and the southern United States in fall (Izor 1979). In South Dakota, the lack of regional museum and migratory records of *L. noctivagans* obscures an accurate portrayal of its distribution and migration into the eastern portion of the state. Based on the only two records available, the species was thought to occur in the northwestern corner of eastern South Dakota (Jones and Genoways 1967). Current capture records in Marshall and Hughes counties and Anabat recordings in Brule, Day, Clay, Gregory, and Union counties, confirm that the species occurs in the northeastern, southern, and western regions of eastern South Dakota (Fig. 4). Anabat recordings match voucher records from Day County, capture records from Hughes County, and literature records from Clay County.

A male *L. noctivagans* was captured on 18 July 2001 in Marshall County, and a young-of-the-year male and adult female were captured on 20 July 2002 in Hughes County. The male captured from Marshall County in 2001 was retained as a voucher specimen (SDSU 2413) in the South Dakota State University Natural History Collection. These bats may have been migrants, but the fall migration period begins in late August or early September (Banfield 1974). With the capture of a young-of-the-year, this species probably reproduces during the summer months in eastern South Dakota. Recently, a female was found by Scott Pedersen (SDSU Biological Sciences) on 21 April 2004 in Brookings, South Dakota. This would be the earliest record of a *L. noctivagans* in eastern South Dakota and may indicate when this species migrates into the region.

Three bat bugs (*Cimex adjunctus*) were found on a single *L. noctivagans* that was captured in Marshall County. These ectoparasites were feeding on the bat behind its ears, but when disturbed, they began to move about the bat's body. Usinger (1966) has previously reported this ectoparasite from *L. noctivagans*.

Eptesicus fuscus (Palisot de Beauvois 1796)
Big Brown Bat

Museum records (691).—BEADLE COUNTY: Huron, 1 (SDSU). BON HOMME COUNTY: Sand Creek park, 13 (KU); Springfield, 17 (KU). BROOKINGS COUNTY: Brookings, 3 (SDSU); Elkton, 2 (SDSU). BRULE COUNTY: Chamberlain, 1 (SDSU). CHARLES MIX COUNTY: Dante, 1 (SDSU). CLAY COUNTY: Vermillion, 2 (SDSU); Vermillion, 2 (UNSM); Vermillion, 8 (KU). DAVISON COUNTY: Mitchell, 2

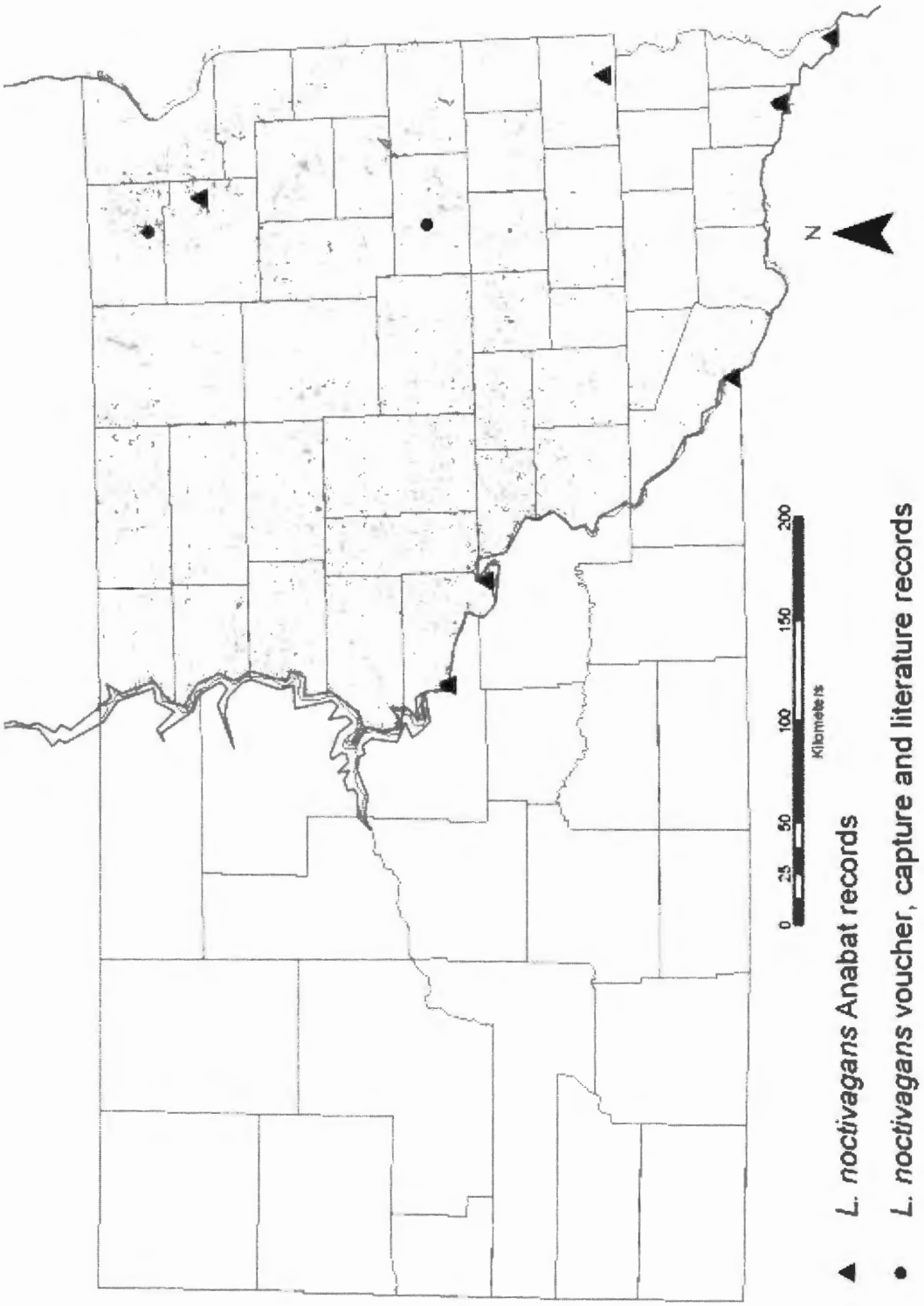

Figure 4.—Distribution of *Lasionycteris noctivagans* in eastern South Dakota.

(SDSU). DUEL COUNTY: Clear Lake, 1 (SDSU). GRANT COUNTY: Milbank, 1 (SDSU). HUGHES COUNTY: Farm Island RA, 8 (TTU); Pierre, 1 (SDSU). HUTCHINSON COUNTY: Freeman, 1 (SDSU). LAKE COUNTY: Madison, 1 (SDSU). LINCOLN COUNTY: Beresford, 4 (SDSU); Canton, 4 (SDSU); Lennox, 1 (SDSU). MINNEHAHA COUNTY: Sioux Falls, 607 (SDSU). MOODY COUNTY: Flandreau, 2 (SDSU); Trent, 1 (SDSU). STANLEY COUNTY: Ft. Pierre, 1 (USNM). TURNER COUNTY: Marion, 1 (SDSU); Viborg, 2 (SDSU). UNION COUNTY: Elkpoint, 1 (SDSU); Union Grove SP, 1 (KU). YANKTON COUNTY: Yankton, 1 (SDSU).

Capture data (32).—BROOKINGS COUNTY: Astoria, 1; Brookings-Pioneer park, 3. CLAY COUNTY: Vermillion-Cotton park, 1. DAVISON COUNTY: Mitchell-Hitchcock park, 1. GREGORY COUNTY: Karl Mundt NWR, 8; Randall Creek RA, 3. HUGHES COUNTY: Farm Island RA, 1; West Bend RA, 7. LINCOLN COUNTY: Newton Hills SP, 1. MINNEHAHA COUNTY: Old Courthouse Museum-Sioux Falls, 1. UNION COUNTY: Union Grove SP, 2. YANKTON COUNTY: Gavins Point Unit of the Lewis and Clark RA, 3.

Anabat recordings.—BROWN COUNTY: Richmond Lake RA. BRULE COUNTY: American Creek RA. CHARLES MIX COUNTY: Platte Creek RA. CLAY COUNTY: Vermillion-Cotton park. DAY COUNTY: Waubay NWR. GREGORY COUNTY: Karl Mundt NWR. HUGHES COUNTY: Farm Island and West Bend. MARSHALL COUNTY: Fort Sisseton RA. MINNEHAHA COUNTY: Dell Rapids Quarry and Sioux Falls. ROBERTS COUNTY: Sica Hollow RA. UNION COUNTY: Adams Homestead and Nature Preserve.

Two subspecies of *E. fuscus* (*E. f. fuscus* and *E. f. pallidus*) have been reported in the eastern region of South Dakota. *Eptesicus f. fuscus* differs from *E. f. pallidus* in having a larger cranium and being darker in pelage coloration (Jones and Genoways 1967). *Eptesicus f. pallidus* was generally considered a western South Dakota species, known only in counties to the west of the Missouri River (Jones and Genoways 1967). Farney and Jones (1980) considered this subspecies as the Rocky Mountain race of the big brown bat. The closest record of this bat to eastern South Dakota was one museum record from Stanley County, along the Missouri River.

The zone of intergradation of the two subspecies has been described as the area between the 98th and 99th meridians, and specimens from Bon Homme County were noted as being intergrades of both subspecies (Jones and Genoways 1967). In this study, many bats were captured throughout the eastern region of the state, but without cranium measurements or genetic data on these animals, the discrimination of subspecies was not possible. Therefore, all specimens were recorded as simply *Eptesicus fuscus*.

New capture records exist for Gregory County at Randall Creek RA (31 May 2002) and Karl Mundt NWR (13 August 2001, 10 July 2002). New county records based upon Anabat recordings exist for Brown, Day, Marshall, and Roberts counties (Fig. 5). Anabat recordings matched voucher records in Brule, Clay, Hughes, and Minnehaha counties and capture data in Clay, Gregory, Hughes, and Minnehaha counties.

In 2000 and 2001, 620 bat carcasses were tested for rabies by the South Dakota Animal Disease Research and Diagnostic Laboratory, Department of Veterinary Science at South Dakota State University. A majority (98%) of the submitted bats were from Minnehaha County. Reproductive data were recorded for each bat that tested negative for rabies in 2000. Nine lactating females were recorded from 19 June to 14 July. Thirty-four juveniles were taken from 23 June to 18 August, and fourteen scrotal males were noted from 8 August to 18 September. Literature records note that a gravid female was captured on 4 June (Jones and Genoways 1967) and a young of the year female was captured on 29 July 2001. Four of the females captured in Hughes County (West Bend RA) on 26 June 2002 were gravid and two of the females were lactating.

Eptesicus fuscus spends its summer reproductive seasons in eastern South Dakota and has been found hibernating in the region from December through March. Department of Health records of *E. fuscus* from throughout the year indicate this species is a year-long resident of eastern South Dakota.

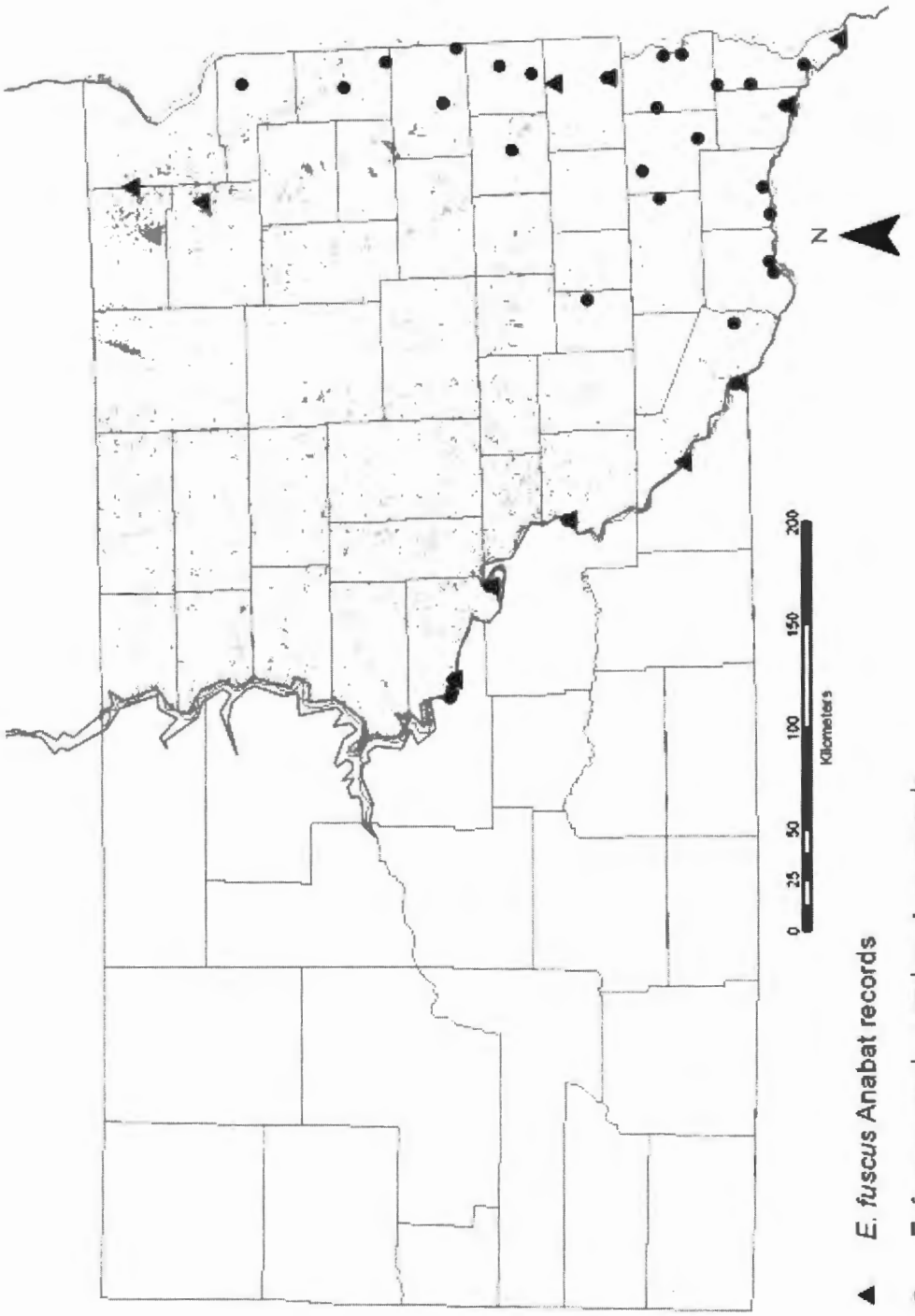

Figure 5.—Distribution of *Eptesicus fuscus* in eastern South Dakota.

Based on acoustic data, mist net capture, and Department of Health data from 2000 and 2001, *E. fuscus* is clearly a commensal species, and seems to be much more abundant in urban areas, or areas with nearby human structures. In 2000 alone, 251 bats were extracted from residences in Sioux Falls; of these, 243 (97%) were *E. fuscus*.

A male *E. fuscus* was captured with six bat ticks (*Ornithodoras kelleyi*) in Davison County on 28 August 2001. This tick has been reported on other individuals captured in Union County (Jones and Genoways 1967).

Lasiurus borealis (Müller 1776)
Red Bat

Museum records (6).—BONHOMME COUNTY: Springfield, 1 (KU). BROOKINGS COUNTY: Brookings, 1 (SDSU). HANSEN COUNTY: Alexandria, 1 (SDSU). HUGHES COUNTY: Farm Island RA, 1 (TTU). MCCOOK COUNTY: Salem, 1 (SDSU). MINNEHAHA COUNTY: Sioux Falls, 1 (SDSU).

Capture data (13).—BROOKINGS COUNTY: Brookings, 3; McCrory Gardens-Brookings, 2; Oak Lake Research Station, 1. GREGORY COUNTY: Karl Mundt NWR, 1. LINCOLN COUNTY: Newton Hills SP, 1. POTTER COUNTY: West Whitlocks RA, 2. UNION COUNTY: Union Grove SP, 3.

Anabat recordings.—BROOKINGS COUNTY: Oakwood Lakes SP. BROWN COUNTY: Richmond Lake RA. BRULE COUNTY: American Creek RA. CLAY COUNTY: Vermillion-Cotton Park. DAY COUNTY: Waubay NWR. EDMUNDS COUNTY: Mina State RA. HUGHES COUNTY: Farm Island and West Bend. MARSHALL COUNTY: Fort Sisseton RA. POTTER COUNTY: West Whitlocks RA. ROBERTS COUNTY: Sica Hollow RA. SPINK COUNTY: Fisher Grove RA. UNION COUNTY: Adams Homestead and Nature Preserve

Additional records.—CLAY COUNTY: no specific locality (Findley 1956). HYDE COUNTY: Highmore (Jones and Genoways 1967). JERAULD COUNTY: Lane (Jones and Genoways 1967).

Historically, *L. borealis* has been documented in a variety of habitats ranging from cottonwood floodplain forests, nonriparian deciduous forested areas, and urban areas. This species' distribution was historically documented in southern counties of eastern South Dakota with the northernmost record in Hyde County. Recent data confirm the southern distribution with new capture data from Union County on 29 July 2001; Lincoln County on 9 August 2001; Gregory County on 13 August 2001; and Potter County on 28 July 2002. Capture data and Anabat recordings now document the occurrence of this bat in Brown, Day, Edmunds, Marshall, Potter, Roberts, and Spink counties, indicating a distribution throughout eastern South Dakota (Fig. 6). Bat calls recorded by Anabat matched capture and museum records from Clay, Hughes, Minnehaha, and Potter counties.

Based on reproductive data from previous studies and capture data from 2000 to 2002, *L. borealis* is gravid in early June with parturition dates in mid-June, while juveniles are volant by the end of August. A gravid *L. borealis* was captured on 7 June 2001 and a lactating bat with two young was captured on 14 June 2000. Volant juveniles were captured on 28 July 2002; 29 July and 9 August 2001; and 23 August 2000.

Lasiurus borealis migrate into eastern South Dakota in April. Findley (1956) recorded *L. borealis* active in the region as early as mid-April. On 10 April 2001, observations were made by Dr. Dave Swanson and Erik Likeness (University of South Dakota) of bats foraging around the streetlights in Vermillion. The latest date when red bats were captured was 26 August in Brookings County (2000-2001). Indeed, *Lasiurus borealis* are thought to migrate south of South Dakota by late August or early September.

Lasiurus cinereus (Palisot de Beauvois 1796)
Hoary Bat

Museum records (14).—BONHOMME COUNTY: Sand Creek park, 3 (KU). BROOKINGS COUNTY: Brookings, 1 (SDSU). BROWN COUNTY: Houghton, 1 (KU). CLAY COUNTY: Vermillion, 1 (SDSU). DAVISON COUNTY: Mitchell, 1 (FHS). HAMLIN COUNTY: Lake Poinsett, 1 (SDSU). HYDE COUNTY: Holabird, 1 (SDSU). LAKE COUNTY: Madison, 1 (SDADR-Rabies positive). MINNEHAHA COUNTY: Sioux Falls, 4 (SDSU).

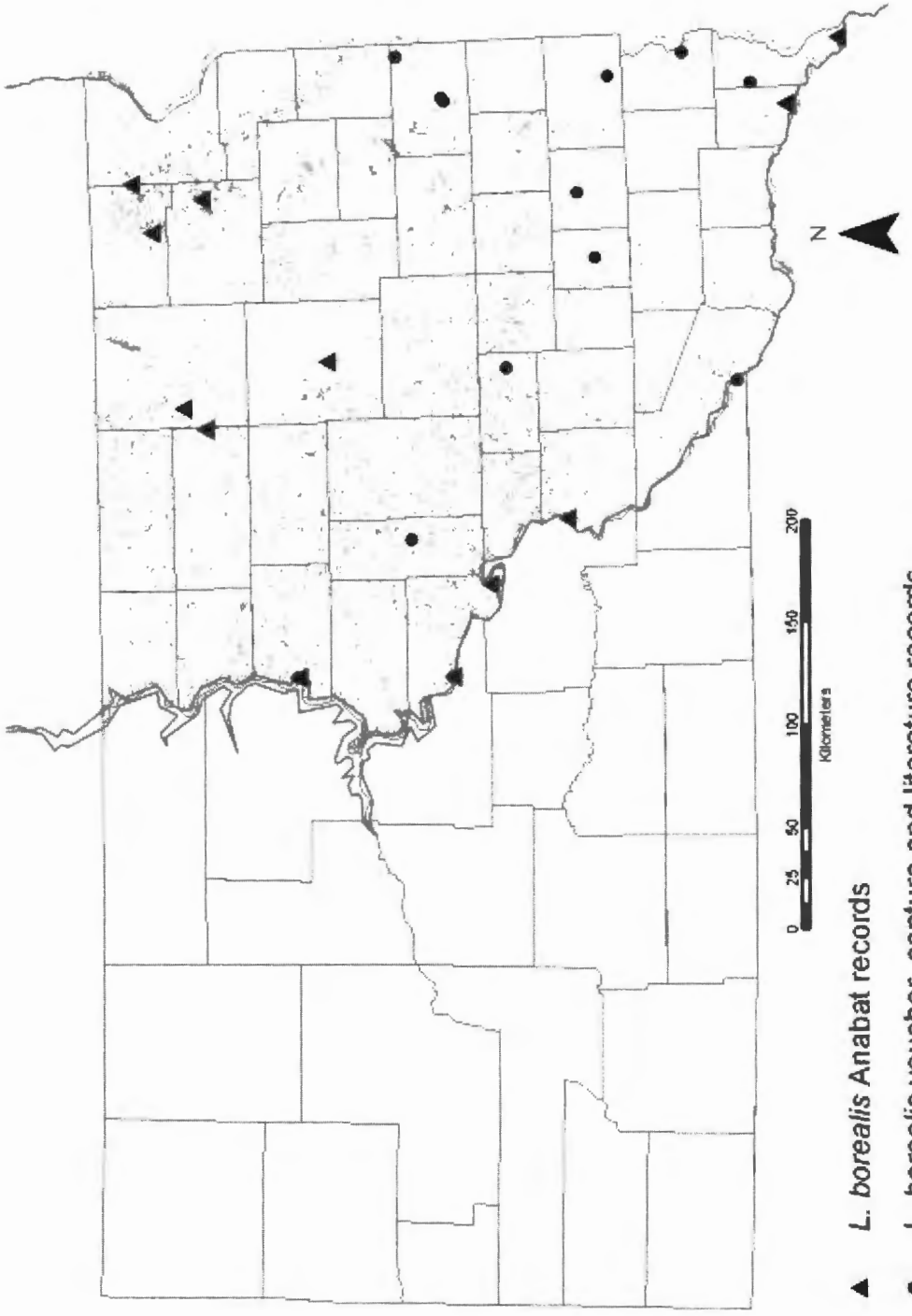

Figure 6.—Distribution of *Lasiurus borealis* in eastern South Dakota.

Capture data (2).—GREGORY COUNTY: Karl Mundt NWR, 1. POTTER COUNTY: West Whitlocks RA, 1.

Anabat recordings.—BROOKINGS COUNTY: Oakwood Lakes SP. BROWN COUNTY: Richmond Lake RA. BRULE COUNTY: American Creek RA. DAY COUNTY: Waubay NWR. HUGHES COUNTY: Farm Island RA and West Bend RA. MARSHALL COUNTY: Fort Sisseton RA. MINNEHAHA COUNTY: Sioux Falls. ROBERTS COUNTY: Sica Hollow RA. SPINK COUNTY: Fisher Grove RA. UNION COUNTY: Adams Homestead and Nature Preserve.

Additional records.—CLAY COUNTY: Vermillion (Findley 1956). HAND COUNTY: St. Lawrence (Jones and Genoways 1967). STANLEY COUNTY: Ft. Pierre (Miller 1897). WALWORTH COUNTY: near Swan Creek (Visher 1914).

Many museum and literature records for *L. cinereus* indicate an occurrence in cottonwood floodplain forests and urban areas throughout eastern South Dakota. Recent capture data has added more capture localities from Gregory County on 23 June 2001 and from Potter County on 16 July 2001; and Anabat recordings from Brule, Day, Hughes, Marshall, Roberts, Spink, and Union counties (Fig. 7). Bat calls recorded by Anabat matched capture and museum records from Minnehaha and Potter counties. The female captured in Potter County was retained as a voucher specimen in the South Dakota State University Natural History Collection (SDSU 2412).

A female *L. cinereus* was found on 1 June 1998 hanging from the steps of a wooden deck of a house in Mitchell (Mullican 1999) with her torpid young. The best estimate for parturition date was mid-May, making this the earliest record of reproduction of *L. cinereus* in the Northern Great Plains.

Other Species Documented in Eastern South Dakota

Records exist for two other species of bat found in eastern South Dakota: *Nycticeius humeralis* (evening bat) and *Tadarida brasiliensis mexicana* (Mexican free-tailed bat). Lane et al. (2003) reported *N. humeralis* from Vermillion, Clay County in 2000. Unfortunately, no specimens were archived in museums. An adult female *T. brasiliensis mexicana*, originally banded in western Oklahoma between 1952 and 1968, was recaptured in Menno, Hutchinson County, three years later during the month of April (Glass 1982). Genoways et al. (2000) classified this species' northward distribution into South Dakota as part of the "exploring zone," where only a few individuals are found, possibly searching for appropriate habitats.

DISCUSSION

Historically, the Great Plains were coined as a "sea of grass" by explorers such as Meriwether Lewis and William Clark. Pre-settlement maps reveal that one-third of the eastern region of South Dakota was composed of tall grasses such as big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*); while the other two-thirds was composed of tallgrass transition such as western wheatgrass (*Agropyron smithii*) and little bluesteam (*Schizachyrium scoparium*) (Gartner and Sieg 1996). Forested areas were few and mainly restricted to areas of permanent water such as riparian streams like the cottonwood groves of the Missouri River. On 7 August 1804, during the Lewis and Clark expedition, Patrick Gass commented "There is no timber in this country, except some cotton wood and willows in the bends of the river. All the high land is a continued prairie."; and on 3 September, "There is no timber in this part of the country; but continued prairie on both sides of the river." (http://www.pbs.org/lewisandclark/archive/index.html 2005).

In those times (early 1800s) before settlement, bats were probably restricted to these riparian areas because of the roosts and foods they provided. Trees along river corridors provide roosting opportunities, an abundance of insect prey, and protection from predators (Carroll et al. 2000; Downs and Racey 2000). The soil of each river's floodplain tends to be rich in nutrients and helps to create a greater diversity in the

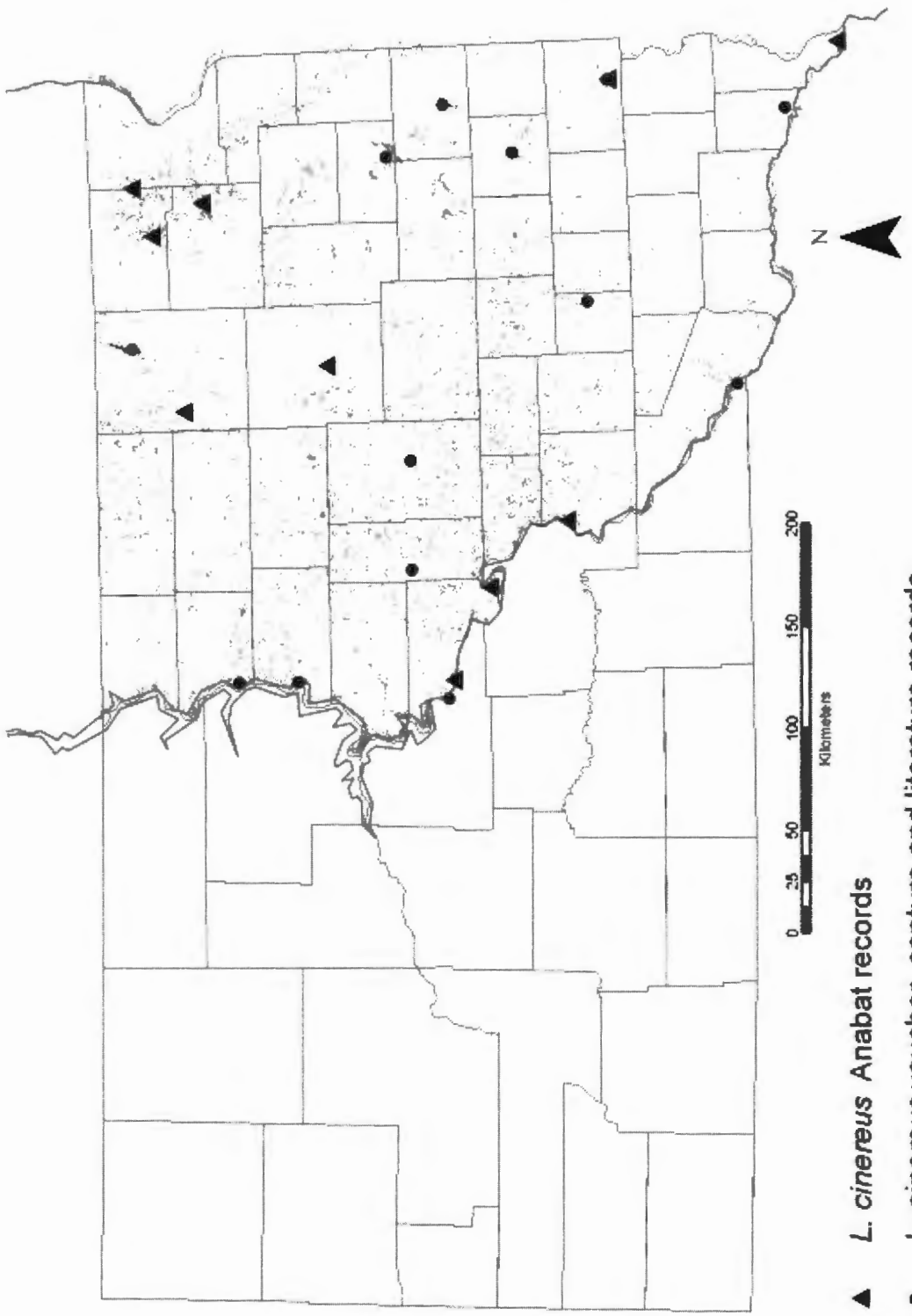

Figure 7.—Distribution of *Lasiurus cinereus* in eastern South Dakota.

structure of plant communities along rivers. Hence, the insect fauna feeding on this vegetation is more diverse and dense (Stauffer and Best 1980), creating a resource for bats. Repeated flooding of the river creates dead and dying trees that bats can use as roosts for resting and predator avoidance. Rivers also provide a water source, so there is an abundance of trees within the floodplain compared to the uplands and grasslands of South Dakota that cannot support many trees.

As the riparian corridors provided roosts and food for bats, this water source also assisted in the human habitation of South Dakota as a source of transportation, food, and electrical energy through dams. As South Dakota became more populated, the uplands and grasslands changed. People began to farm the land, build structures, and plant trees in their cities. These changes contributed to a greater diversity and abundance of bats in non-riparian areas as populations could utilize the human habitations and trees as roost sites.

Currently, thirteen bat species are known to inhabit South Dakota, but only seven of these (*M. septentrionalis*, *M. lucifugus*, *M. ciliolabrum*, *L. noctivagans*, *E. fuscus*, *L. borealis*, and *L. cinereus*) have been documented in eastern South Dakota (Findley 1956; Jones and Genoways 1967; present study). All of the aforementioned species, except *M. septentrionalis* and *M. ciliolabrum*, are currently distributed sporadically throughout eastern South Dakota. *Myotis septentrionalis* was captured only along the Missouri River, where it was common (42% of all captures in 2002). Based on capture data and voucher records, the current distribution of *M. septentrionalis* in eastern South Dakota is limited to the riparian forests of the Missouri River. The current distribution of *M. ciliolabrum* in eastern South Dakota is still unknown as this species has been captured and acoustically documented only in eastern South Dakota at Farm Island RA. The rocky buttes of the Missouri River may provide habitat for *Myotis ciliolabrum* as it is associated with rocky terrain.

This study supports previous studies (Findley 1956; Jones and Genoways 1967; Higgins et al. 2000) that indicated *M. lucifugus*, *M. septentrionalis*, *L. borealis* and *L. cinereus* are summer residents of eastern South Dakota. However, this study challenges the claim that *L. noctivagans* is only a migrant in eastern South Dakota and provides evidence that *L. noctivagans* is a summer resident. *Eptesicus fuscus* has been documented as a yearlong resident of eastern South Dakota using Department of Health records.

A great number of bats are provided each year to the Department of Health. During this 3-year study, 104 bats were captured, while in the same period the Department of Health received more than 600 specimens. Creating a database of life history characteristics (reproductive timing, distribution, and morphological characteristics) from these bats can provide a valuable resource that is not documented by capture, voucher, literature, or acoustic records. Hopefully, when a bat is tested for rabies, these specimens will be archived in a museum with appropriate data (sex, measurements, location, etc). Thereby, our knowledge of this valuable faunal component of South Dakota will increase.

Acoustic devices to census bats also provide critical information about the South Dakota bat population. If the data is not overextended, acoustic devices can effectively census bats in open habitats like those in eastern South Dakota. In open habitats, there is little protection from strong winds; hence mist nets are easier for echolocating bats to detect (Sedlock 2001) and capture rates are reduced. Comparatively, acoustic devices are not influenced as greatly by weather, are relatively easier to set than mist nets, and are able to census bats that are flying nearby without actually capturing the bat.

As acoustic censuses continue as important means of obtaining ecological information on bat populations, biologists and managers should develop a library of bat reference calls from South Dakota bat populations. This would be an important step in future bat research, monitoring, and conservation efforts.

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APPENDIX

Voucher (V), literature (L), capture (C) and acoustic (A) records for bats in eastern South Dakota

County and Locality	*E. fuscus*	*L. borealis*	*L. cinereus*	*L. noctivagans*	*M. ciliolabrum*	*M. lucifugus*	*M. septentrionalis*
Brookings Co.—Brookings	C	C V	V				
Brookings Co.—Oak Lake Station		C					
Brookings Co.—Oakwood Park		A	A			A	
Brown Co.—Richmond RA	A	A	A			A	
Brule Co.—American Creek RA	A V	A	A	A			
Campbell Co.—Pollock				C			
Charles Mix Co.—Platte Creek RA	A						
Clay Co.—Clay Co. Park	A	A		A			
Clay Co.—Cotton Park, Vermillion	A C V	A L	L	L			
Clay Co.—Myron Grove RA							C
Davison Co.—Mitchell	C V		V				
Day Co.—Waubay NWR	A	A	A	A V		C	
Edmunds Co.—Mina State RA		A					
Gregory Co.—Karl Mundt NWR	A C	C	C	A		C	C
Gregory Co.—Randall Creek RA	C						
Hughes Co.—Farm Island RA	A C V	A V	A	A	A V	A C	C V
Hughes Co.—La Framboise RA	V			C		C	
Hughes Co.—West Bend RA	A C	A	A	A		A	C
Lincoln Co.—Newton Hills Park	C	C					
Marshall Co.—Fort Sisseton Park	A	A	A	C			
Minnehaha Co.–Dell Rapids Quarry	A						
Minnehaha Co.—Sioux Falls	A C V	A V	A V	A		V	
Potter Co.—West Whitlocks RA		A C	A C			C	
Roberts Co.—Hartford Beach RA		A				A	
Roberts Co.—Sica Hollow Park	A	A	A				
Spink Co.—Fisher Grove Park		A	A				
Union Co.—Adams Home Park	A	A	A	A			
Union Co.—Union Grove Park	C V	C				V	C V
Walworth Co.—Hiddenwood RA						C	
Yankton Co.—Lewis Clark RA	C V						C

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