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Bats of the Loess Hills Ecoregion of Southeast Nebraska

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ABSTRACT We surveyed bats at 49 sites in the Loess Hills Ecoregion of southeastern Nebraska, along the western edge of the eastern forest biome in eastern Richardson, Nemaha, and Otoe counties. We completed this study shortly before the northern long-eared bat (*Myotis septentrionalis*) was listed by the United States Fish and Wildlife Service under the Endangered Species Act. The expectation of listing, along with potential presence of the endangered Indiana bat (*Myotis sodalis*), motivated the study. We captured 183 bats of five species: eastern red bat (*Lasiurus borealis*) (*n* = 103; 56 %), big brown bat (*Eptesicus fuscus*) (*n* = 47; 26 %), evening bat (*Nycticeius humeralis*) (*n* = 27; 15 %), hoary bat (*Lasiurus cinereus*) (*n* = 4; 2 %), and northern long-eared bat (*n* = 2; 1 %). The mean catch per net site was 3.7 bats (*SD* = 4.8). The Eastern red bat was captured most commonly and at the most sites. We established the first record of this species from Nemaha County, with reproduction documented in all three counties. More reproductive female red bats were captured than adult males. Big brown bat captures consisted of approximately equal proportions adult males, reproductive females, and volant young of year. We established the first records for big brown bat reproduction in Otoe and Nemaha counties. Only reproductive female and juvenile evening bats were captured, with geographic and reproductive records established for all three counties. Captures of the hoary bat, a lactating female at one site and two juveniles at another, represented a Nemaha County geographic and reproductive record. We radio-tagged a non-reproductive female and an adult male northern long-eared bat from Otoe County and tracked them to roosts along the Missouri River, 3.43 and 2.03 km from the net site, respectively. We completed four emergence counts at each roost, with each bat exiting its respective roost on only one evening and neither bat visiting the other roost. We never documented more than three individuals exiting each roost on a given night. Overall, this study documented relatively low abundance, species richness, and species diversity when compared to studies in the eastern United States.

KEY WORDS bats, endangered, Nebraska, northern long-eared bat, threatened

Literature indicates that 8 of 13 species of bats known from Nebraska reside in southeastern Nebraska (Czaplewski et al. 1979, Jones et al. 1983, 1985, Benedict 2004): the northern long-eared bat (*Myotis septentrionalis*), little brown bat (*Myotis lucifugus*), silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), evening bat (*Nycticeius humeralis*), and tri-colored bat (*Perimyotis* [previously *Pipistrellus*] *subflavus*). In addition, the Brazilian free-tailed bat (*Tadarida brasiliensis*) is an uncommon visitor in Nebraska in late summer (Genoways et al. 2000). The Indiana bat (*Myotis sodalis*) is known from short distances to the east in Missouri and Iowa but is not a known resident of Nebraska. Although these eight species occur in eastern forests, information about distribution, abundance, and habitats is lacking in southeastern Nebraska (Benedict 2004). Lack of such basic information is troubling in light of the fungus *Pseudogymnoascus destructans*, the causative agent of white-nose syndrome (WNS), which is responsible for catastrophic population declines in bats that hibernate in caves throughout eastern North America (detailed at https://www.whitenosesyndrome.org/partner/us-fish-wildlife-service). On 4 May 2015, the United States Fish and Wildlife Service (USFWS) listed the northern long-eared bat as threatened under the Endangered Species Act (ESA). This study was completed shortly before the northern long-eared bat was listed by the USFWS but was motivated by the move toward listing, along with potential presence of the endangered Indiana bat.

Eastern Nebraska is at the interface of major biomes: the Dissected Till Plains held the westernmost extent of the eastern deciduous forest, while the Great Plains were characterized by treeless prairie. The eastern half of the state has a humid continental climate, while the western half has a semi-arid climate. Average annual precipitation decreases from about 800 mm in the southeast corner of the state to about 350 mm in the southwestern panhandle. Beyond obvious change in vegetation, the range of many species of animals in the eastern United States (U.S.) ends at this biome divide or their abundance is dramatically altered (Olson et al. 2001). Thus, the Loess Hills of southeastern Nebraska, at the western edge of the eastern forest biome, is an ideal place to compare bat assemblages to more "typical" wooded eastern locations. We compare our data to similar studies in eastern deciduous forests of Indiana, Ohio, Pennsylvania, Virginia, and West Virginia, and with captures in an adjacent portion of Kansas. While such a comparison is important for this reason alone, arrival of WNS has the potential of forever changing this relationship, so pre-WNS data are particularly valuable.

STUDY AREA

We captured bats in the Nebraska/Kansas Loess Hills portion of the Great Plains, Temperate Prairie, Western Corn Belt Plains Ecoregion (Chapman et al. 2001) in eastern Richardson, Nemaha, and Otoe counties in southeastern Nebraska (Fig. 1). The area is glaciated and characterized by deep, rolling loess-covered hills and perennial streams. Loess is underlain by calcareous glacial till on Pennsylvanian shale, sandstone, and limestone. The elevation is 300 - 460 m with local relief of 30 - 90 m. Annual precipitation is 66 - 86 cm, and the area has 150 - 190 frost-free days annually.

Prior to the 1860s, the study area was a transition zone between forest and prairie ecosystems (Kaul and Rolfsmeier 1993). Floodplains along the Missouri River and its tributaries were covered by riparian forests containing bur oak (*Quercus macrocarpa*), basswood (*Tilia americana*), black walnut (*Juglans nigra*), green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and willows (*Salix spp.*). Loess deposits were capped by oak-hickory (*Quercus-Carya*) forests, which gave way to upland prairies containing big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and little bluestem (*Schizachyrium scoparium*). Steeper slopes now support pastures and scattered trees, whereas low-relief areas are dominated by fields of corn, soybeans, small grains, and alfalfa, with few remaining prairies. Roads, towns, and utility corridors are present throughout the region. Benedict et al. (2000) addressed effects of changing landscapes on the distribution of mammals in Nebraska, including bats. As in adjacent portions of Kansas (Sparks and Choate 2000), most trees likely were cut during settlement, but tree cover increased as settlers eliminated the bison, suppressed fire, and planted trees.

METHODS

We netted for bats at 49 mist net sites (Fig. 1; Appendix 1) within and adjacent to upland and riparian woodlands 7 June – 14 August 2014. At each site we placed two net sets across travel corridors such as streams, trails, field margins, and small, infrequently used roads. Each set of nets consisted of one to three nets (6 - 18 m long and 2.6 m high) stacked vertically, to form a wall of netting across the corridor; stacked nets were counted as a single net, regardless of the number of nets staked or their length. We sampled each site on two nights (for a total of four net nights per site) unless rain forced us to stop and repeat that night's effort. As such, we accrued 156 complete and six partial net nights at 49 net sites with 11, 24, and 14 sites in Richardson, Nemaha, and Otoe counties, respectively. Sampling began at dusk and continued for 5 h until about 0200 h. Sampling efforts were based on USFWS guidance (USFWS 2014a). Bats captured were identified to species and the sex, reproductive condition, age, mass, length of right forearm, and time and location/net site of capture were recorded. Capture of volant young or pregnant, lactating, or post-lactating females was considered evidence of reproduction. Handling and care of captured bats followed guidelines for use of mammals in research (Sikes et al. 2011), and we followed the USFWS WNS protocols for summer sampling (current as of 25 January 2011). To locate roosts of the northern long-eared bat and obtain roost counts, we attached 0.25-g radio transmitters (Blackburn Transmitters®; Nacogdoches, Texas) using non-toxic surgical cement (Torbot Group®, Inc.; Cranston, Rhode Island) to an adult male and a non-reproductive female. We released the bats at the net site and tracked them to roosts using 3- and 5-element folding Yagi antennas (Wildlife Materials®; Murphysboro, Illinois) connected to a TRX-2000S PLL Synthesized Tracking Receiver (Wildlife Materials®, Inc.; Murphysboro, Illinois) or a Model R2000 Scanning Receiver (Advanced Telemetry Systems, Inc.; Isanti, Minnesota). We searched for roosts for eight days, and when a tree was located, we mapped the location, identified the species of tree, measured the diameter at breast height (DBH), approximated heights of both tree and roost, and visually estimated the amount of exfoliating bark and level of solar exposure (inverse of canopy cover). We conducted four roost counts per roost during the period 25 – 30 July 2014, counting bats as they left the roost at dusk.

We descriptively compared captures across species and between adult males and reproductive females. We assessed capture success using catch per net night, catch per net site, species per net site, and number of net sites where bats were caught. We calculated site-specific and collective species diversity indices (SDI): $SDI = 1/\sum P_i^2$, where P_i is the proportion of bats belonging to species *i* in each sample (MacArthur 1972). The SDI metric represents the number of equally represented species. We defined species richness as the number of species captured. We compared these metrics to those obtained using similar sampling methods at several study locations in forests of the eastern U.S.

RESULTS AND DISCUSSION

We captured 183 bats representing five species (Table 1). Eastern red bats accounted for 56 % (n = 103) of captures, big brown bats 26 % (n = 47), evening bats 15 % (n = 27), hoary bats 2 % (n = 4), and northern long-eared bats 1 % (n = 2). Species were not evenly represented in the captures, with eastern red bats comprising more than half of the captured sample (Table 1).

The mean rate of capture was 3.7 bats/net site (SD = 4.8) and 0.9 bats/net night (SD = 1.8). No bats were captured at 13 net sites, and only one bat was caught at 8 sites. The greatest number of bats captured at a site was 22 (Site 3), followed by 14 (Sites 25 and 41), 13 (Site 26), and 10 (Sites 4, 27, and 42) individuals. Species richness was greatest at eight sites (4, 22, 25, 26, 41, 42, 43, and 46) where three species were

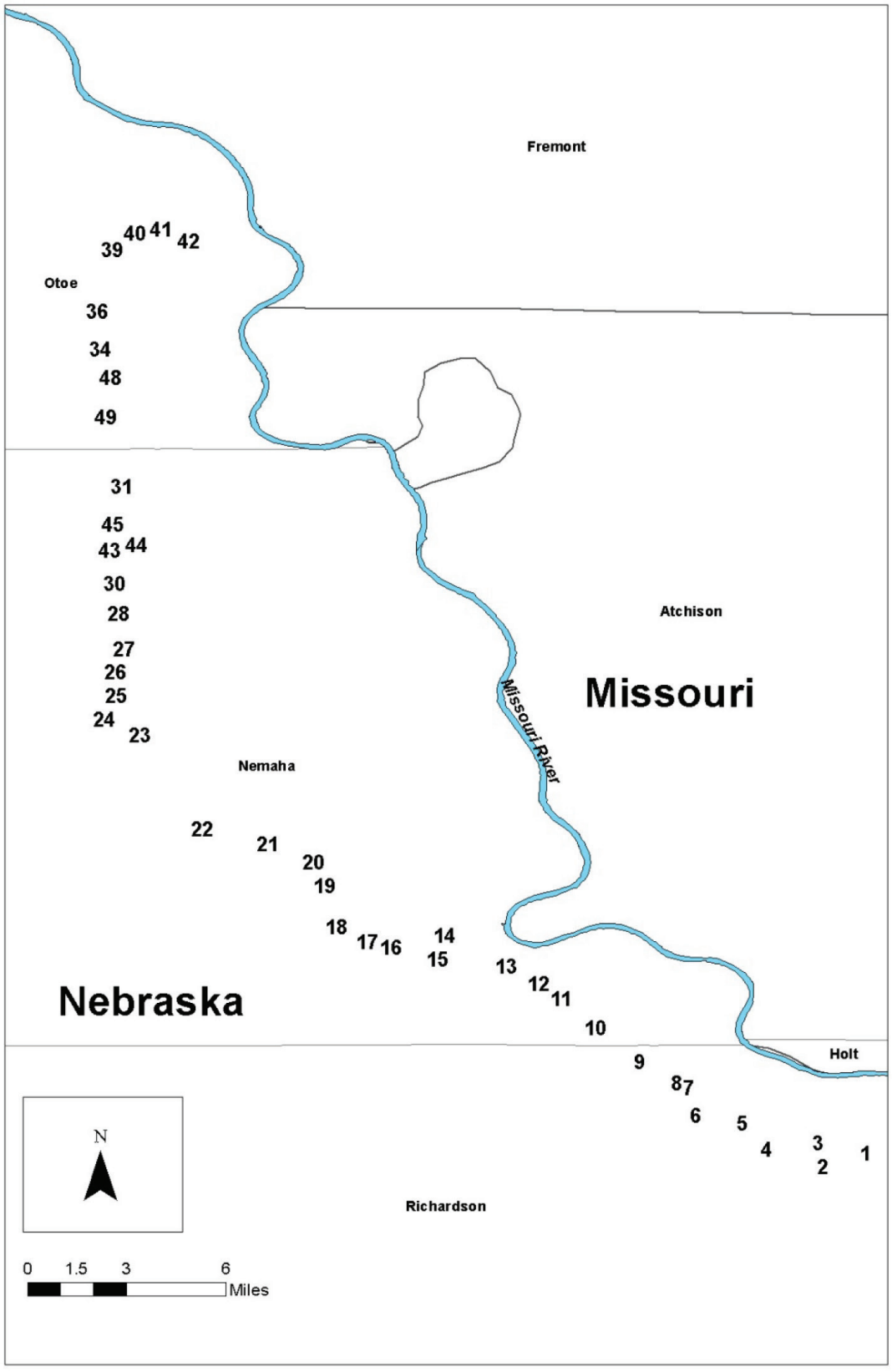

Figure 1. Locations of 49 mist net sites in Richardson, Nemaha, and Otoe counties, Nebraska, 2014.

Table 1. Captures of adult male, pregnant (P), lactating (L), post-lactating (PL), and non-reproductive (NR) adult female, and juvenile (Juv) bats at 49 sites in Richardson, Nemaha, and Otoe counties, Nebraska, 2014. Bats identified to species that escaped before sex and morphometric data were collected are noted (Escape).

Species	Male	P	L	PL	NR	Juv	Escape	Total
Big brown bat	14		6	6	1	17	3	47
Eastern red bat	5	16	12	14	4	44	8	103
Hoary bat			1			2	1	4
Northern long-eared bat	1				1			2
Evening bat			6	5		16		27
Total	20	16	25	25	6	79	12	183

captured. Overall, 1.3 (*SD* = 1.0) species were caught per net site, and the collective SDI was 2.5. Among sites, the SDI ranged from 0 to 2.8 ($\bar{x}$ = 1.5; *SD* = 0.6). Eastern red bats were captured at the most sites (*n* = 30; 61 % of sites), big brown bats were captured at about half as many sites (*n* = 17; 35 %), and other species were captured sporadically. We observed a sex bias between captures of adult male and female eastern red bats and evening bats, but not big brown bats (Table 1). Among adults, female eastern red bats were nearly eight times as common as males, and no adult male evening bats were captured. We obtained evidence of reproduction for all species captured in the study area except the northern long-eared bat.

Eastern Red Bat

The eastern red bat is a common summer resident throughout Nebraska (Czaplewski et al. 1979, Jones et al. 1983, 1985, Benedict 2004, Johnson and Geluso 2017). This was our most abundant species, as it was captured twice as frequently as any other species (Table 1) and at the most net sites. Our study provides a geographic distribution record for Nemaha County, although records exist in surrounding counties (Benedict 2004, Johnson and Geluso 2017). Far more reproductive females than adult males were captured in this study. Differences in sex ratios of red bats have been attributed to migratory patterns (LaVal and LaVal 1979) and to differences in temperature (and/or elevation) during the season of reproduction (Brack et al. 2002, Ford et al. 2001).

Big Brown Bat

The big brown bat is widely distributed across North America and Nebraska, and it was the second most frequently captured species. It is thought to reproduce statewide (Czaplewski et al. 1979, Jones et al. 1983, 1985, Benedict 2004, Geluso et al. 2004b, 2013, Geluso 2006, Serbousek and Geluso 2009, Johnson and Geluso 2017) and is not known to migrate long distances (Jones et al. 1983). Captures of reproductive individuals in Otoe (Sites 36, 37, 41, and 42) and Nemaha counties (Sites 22-26, 28, and 46) provided the first records of reproduction in those counties. Females often form maternity colonies where males are absent or much less common than females (Sparks and Choate 2000). As such, disparate sex ratios often are encountered among specific locations or net sites, although at a larger scale, sexes are often similarly common. In this study, adult males and reproductive females were similarly represented in the catch, similar to Fort Leavenworth, Kansas (Brack et al. 2007), but about a third of the sites that produced this species caught only males, a third produced only reproductive females and/or juveniles, and a third produced both adult males and reproductive females and/or juveniles. The big brown bat uses a variety of vegetation types and roosts (Duchamp et al. 2004), including natural and anthropogenic structures, which may mean the species is more common on the Plains now than pre-settlement (Sparks and Choate 2000).

Evening Bat

In Nebraska, the evening bat is most common in the southern and eastern portions of the state (Benedict 2004, Johnson and Geluso 2017). This species has been expanding its range to the west and north, including Nebraska (Geluso et al. 2008, Johnson and Geluso 2017) and Kansas (Sparks and Choate 2000, Sparks et al. 2011). Our study indicates the species is now common in the Loess Hills, with geographic and reproductive records at Site 4 in Richardson County, Sites 40 and 41 in Otoe County, and Sites 16, 22, 25, 26, 27, 43, 46, and 31 in Nemaha County. Adult males were not captured, which is typical of the northern and western portion of the range; the only nearby record from Kansas is from an upland site at Fort Leavenworth, Kansas (Davis 2005, Davis and Boyles 2005, Brack et al. 2007).

Hoary Bat

Hoary bats occur and reproduce statewide, but records do not indicate that this summer woodland resident is common anywhere in Nebraska (Benedict 2004), or generally elsewhere across its wide geographic distribution. Cryan (2003) indicated that during summer, males are mainly distributed in areas west of Nebraska and females are more common in the East, while Hayes et al. (2015) suggested that the range of female hoary bats might extend farther north and be more restricted to the interior of the continent than males. Captures of a lactating female at Site 13 and two juveniles at Site 16 in southeastern Nemaha County represent geographic and reproductive county records. Barbour and Davis (1969) reported this species frequently flies at heights in excess of 60 m so the species may be poorly sampled by typical mist-netting techniques. Using nets up to 20 m high, Brack (1983) found that 50 % of captures were at heights >8.3 m, but our equipment reached only to 7.8 m. High mortality rates at wind energy facilities (Arnett et al. 2008) suggest the species is more common than indicated from netting.

Northern Long-eared Bat

The northern long-eared bat is considered relatively uncommon throughout the plains states (Czaplewski et al. 1979, Bee et al. 1981, Jones et al. 1983, 1985), but in recent decades, pre-WNS, its abundance and distribution may have been increasing (Sparks and Choate 2000, Geluso et al. 2015). In Nebraska, the species has been found most commonly in the eastern third of the state (Benedict 2004, Geluso et al. 2004b), including a recent acoustic survey on an anthropogenic landscape of southeastern Nebraska (White et al. 2016). The acoustic survey included areas adjacent to our study area, and the survey determined the calls of this species were positively associated with the proportion of forested landscape within 2000 m of sampling stations (White et al. 2016). Stein and White (2016) indicated the species is expected throughout the region.

On 23 July 2014, we captured and radio-tagged an adult male and a non-reproductive adult female at net Site 42 in Otoe County. Both radio-tagged bats were tracked to separate cottonwood trees along the Missouri River. The female was tracked to a heavily wooded levee in Fremont County, Iowa, 3.43 km northeast of the net site, and the male was tracked to the edge of an open, sparsely wooded industrial site in Otoe County, 2.06 km east of the net site (Table 2). The two roost trees were separated by 2.41 km and the Missouri River. Each tagged bat occupied an identified roost only on the first of four nights when emergence counts were completed (Table 2). We did not detect the two tagged bats switching between the two known roosts, indicating the likely presence of additional nearby roosts (Johnson et al 2012). We never documented more than three bats emerging from either roost. Although our roost documentation is consistent with patterns of roost occupation by maternity colonies (Johnson et al 2012) and consistent with determination of a probable maternity colony for ESA regulatory compliance (USFWS 2014b), we do not have direct evidence of reproduction by the northern long-eared bat in the study area.

Northern long-eared bats regularly roost in live and dead trees. Summer maternity colonies are usually under sloughing bark or in hollows of trees, making characteristics of our two roost trees similar to those documented in past studies (Foster and Kurta 1999, Perry and Thill 2007, Johnson et al. 2012). Both roosts were cottonwoods in riparian areas, but they otherwise differed in characteristics. One was a large (DBH = 40 cm), partially dead tree, with only 10 % solar exposure. The other was smaller (DBH = 10 cm), completely dead, and had extensive (75 %) solar exposure. These differences are not surprising given the wide variety of roosts used by northern long-eared bats (Whitaker et al. 2006, Perry and Thill 2007, Timpone et al. 2010, Johnson et al. 2012). A wide variety of deciduous and coniferous tree species are used by maternity colonies, indicating that tree form, not species, is important for roosts (Carter and Feldhamer 2005).

Use of tree-roosts suggests that in the Plains portion of the range, northern long-eared bats should be found most commonly in wooded riparian corridors (Sparks and Choate 2000, Brack et al. 2007). This is in contrast to heavily wooded landscapes in Indiana, Missouri, and West Virginia, where the species is common in both riparian and upland wooded habitats and may be most abundant on non-riparian and upland sites (Brack and Whitaker 2001, Brack et al. 2005).

Species of Possible Occurrence

We did not capture the Indiana bat, which is unknown in Nebraska, but is apparently at the edge of its range a short distances to the east in Missouri and Iowa, or the Brazilian free-tailed bat, which is an uncommon visitor to southeastern

Table 2. Locations, characteristics, and dusk emergence counts of two roost trees used by radio-tagged northern long-eared bats in southeastern Nebraska, 2014.

Roost	Non-reproductive female	Adult male
Location	Extensive levee woodlot along the Missouri River, Freemont Co., IA	Small, disturbed floodplain woodlot, Otoe Co., NE
Distance, direction from capture site	3.4 km east-northeast	2.1 km east
DBH	40 cm	10 cm
Condition	Partially dead; 5 % exfoliating bark	Dead; 15 % exfoliating bark
Canopy Closure	90 %	25 %
Height	5 m	14 m
Four emergence counts	1, 3, 0, 0	3, 3, 0, 0

Nebraska in late summer (Genoways et al. 2000). Likewise, we did not capture silver-haired, little brown, or tri-colored bats that are considered residents of southeastern Nebraska (Czaplewski et al. 1979, Jones et al. 1983, 1985, Benedict 2004).

The silver-haired bat is a spring and autumn migrant in Nebraska, but recent studies (e.g., Geluso et al. 2004a, 2004b, 2013) documented reproduction, including in adjacent counties of Lancaster and Sarpy to the north. Our failure to capture this species during the summer season of reproduction indicates it likely does not occupy the study area in summer. The little brown bat is widely distributed across the U.S., and although abundant in the East, is uncommon or absent in much of its range, including the plains states. The species occupies and reproduces in two geographically separate areas of southeastern and northwestern Nebraska (Webb and Jones 1952, Czaplewski et al. 1979, Benedict 2004, Geluso et al. 2013). There are records in four of eight counties adjacent to the study area in Nebraska (Benedict 2004) and Kansas (Sparks et al. 2011). The species is apparently absent from the study area. The pre-Columbian distribution of the tricolored bat in the Plains States was limited (Sparks and Choate 2000) by its use of woodlands in summer (Veilleux et al. 2003) and underground hibernacula in winter, and both have increased as a result of anthropogenic activities. As a result, the bat's range is expanding (Geluso et al. 2005, Adams et al. 2018) and it is a resident of southeastern Nebraska and eastern Kansas (Czaplewski et al. 1979, Jones et al. 1985, Sparks and Choate 2000). Despite failing to capture the species in the study area, acoustic data from White et al. (2016) predicts the species is a likely summer resident of southeastern Nebraska.

A Comparison to Similar Studies in Eastern Hardwood Forests

For this study, the rate of capture, bats per net night, and bats per net site were lower than at Fort Leavenworth, Kansas (Brack et al. 2007; Table 3), which is also on the western edge of the eastern forest biome. Compared to similar studies in eastern forests, the capture of 0.9 bats per net night was markedly lower, as was 3.7 bats per net site (Table 3). While a variety of factors affect the catch rate, a lower rate of catch may often reflect lower abundance. Because this study and those to which it is compared followed a similar sampling protocol, it is a reasonable inference that bat abundance is relatively low in this study area.

Species richness in southeastern Nebraska was lower than all but one other site to which it is compared (Table 3). Species richness often increases with the level of sampling effort (Caughley 1965) and with habitat quality (Cable et al. 1989), whereas small, isolated habitat patches often do not retain a high species complement (MacArthur and Wilson 1967, Simberloff 1974, Janzen 1983). Finally, sampling more vegetation types is likely to increase the number of

Table 3. Capture success compared to similar studies in woodlands of the eastern and midwestern United States.

Location	Bats/net night	Bats/net site	MacArthur's Diversity Index*	Species richness	Sample sites; area; and timeline	Source
Richardson, Nemaha, and Otoe Co., NE	0.9	3.7	2.5	5	49 sites; long linear; 1 season 2014	Current Study
Ft. Leavenworth, KS	2.9	9.4	1.6	6	21 sites; large area; 3 seasons 1983 -2003	Brack et al. 2007
Crane, IN	1.8	5.6	4.4	8	99 sites; large area; 3 seasons 1987-1998	Brack and Whitaker 2004
Hoosier NF, IN	2.1		4.3	10	72 sites; large area; 5 seasons 1981-1999	Brack et al 2004
Ravenna, OH	2.4	9.7	2.9	6	28 sites; large area; 1 season 2004	Brack and Duffy 2006
Potter and McKean Co., PA & Cattaraugus Co., NY	2.9	12.1	2.3	5	55 sites; long linear; 1 season 2005	Brack 2009
Cumberland Plateau and Ridge & Valley Provinces, VA	1.9	7.8	3.9	11	201 sites; multiple linear in large area; 8 season 2000-2009	Timpone et al. 2011
Camp Dawson, WV	1.4	6.1	4.0	6	15 sites; large area; 1 season 2002	Brack et al. 2005
SE Virginia	2.3	5.6	2.0	6	11 sites; large area; 2 seasons 1995-1996	Hobson (1998)

* $SDI = 1/\Sigma P_i^2$ (MacArthur 1972)

species encountered. However, this study and those to which it is compared, are similar in that most were completed across large study areas, often with a substantial survey effort (11 – 201 sample sites). All surveys sampled woodland habitat, both riparian and upland, and while there are geographic differences in woodlands of Nebraska and more eastern states, that is in part the point of this comparison. Thus, it is a reasonable inference that species richness is relatively low in our study area, equal to that of the northern-most study area in the east (i.e., northern Pennsylvania and southern New York; Table 3).

Species diversity is a measure that combines the importance of abundance and richness. Specifically, the MacArthur (1972) index we used provides a metric representing the number of equally represented species. Our species diversity was greater than Fort Leavenworth, Kansas (Brack et al 2007; Table 3). However, both our study and the one in Kansas had lower diversity indices than six out of seven studies conducted in the eastern U.S. (Table 3). Biomes reflect the distributions of a broad range of fauna and flora, so it might be expected that bat species diversity would be lower at the westernmost extent of the eastern deciduous forest biome.

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Appendix 1. Coordinates for 49 mist net sites in Richardson, Nemaha, and Otoe counties, Nebraska, 2014.

Site No.	Latitude	Longitude
1	N40° 12' 51.181"	W95° 30' 3.117"
2	N40° 12' 43.420"	W95° 31' 10.395"
3	N40° 12' 54.906"	W95° 31' 17.801"
4	N40° 12' 57.110"	W95° 32' 39.206"
5	N40° 13' 38.008"	W95° 33' 18.304"
6	N40° 13' 50.210"	W95° 34' 31.703"
7	N40° 14' 34.109"	W95° 34' 43.117"
8	N40° 14' 41.725"	W95° 35' 1.080"
9	N40° 15' 15.304"	W95° 35' 59.304"
10	N40° 16' 8.610"	W95° 37' 9.002"
11	N40° 16' 54.648"	W95° 38' 6.514"
12	N40° 17' 19.008"	W95° 38' 38.798"
13	N40° 17' 46.509"	W95° 39' 29.601"
14	N40° 18' 21.501"	W95° 41' 6.607"
15	N40° 18' 7.692"	W95° 41' 17.704"
16	N40° 18' 15.445"	W95° 42' 34.128"
17	N40° 18' 25.026"	W95° 43' 7.703"
18	N40° 18' 48.111"	W95° 43' 56.495"
19	N40° 20' 1.715"	W95° 44' 15.414"
20	N40° 20' 30.541"	W95° 44' 33.501"
21	N40° 20' 58.702"	W95° 45' 45.602"
22	N40° 21' 22.499"	W95° 47' 28.503"
23	N40° 23' 50.637"	W95° 49' 7.112"
24	N40° 24' 25.616"	W95° 50' 2.201"
25	N40° 24' 55.111"	W95° 49' 44.092"
26	N40° 25' 41.512"	W95° 49' 45.601"

Site No.	Latitude	Longitude
27	N40° 26' 6.812"	W95° 49' 31.797"
28	N40° 27' 3.425"	W95° 49' 39.982"
29	N40° 27' 25.928"	W95° 49' 37.403"
30	N40° 27' 47.404"	W95° 49' 46.100"
31	N40° 30' 23.121"	W95° 49' 35.806"
32	N40° 31' 24.806"	W95° 49' 48.797"
33	N40° 31' 28.513"	W95° 49' 47.200"
34	N40° 33' 59.133"	W95° 50' 9.108"
35	N40° 34' 34.511"	W95° 50' 6.692"
36	N40° 34' 48.501"	W95° 50' 13.398"
37	N40° 35' 41.513"	W95° 49' 34.800"
38	N40° 35' 46.603"	W95° 49' 36.600"
39	N40° 36' 36.107"	W95° 49' 43.501"
40	N40° 37' 1.904"	W95° 49' 13.799"
41	N40° 37' 8.115"	W95° 48' 32.495"
42	N40° 36' 50.032"	W95° 47' 49.818"
43	N40° 28' 41.436"	W95° 49' 42.780"
44	N40° 28' 50.563"	W95° 49' 30.088"
45	N40° 29' 37.952"	W95° 49' 48.592"
46	N40° 29' 46.533"	W95° 49' 47.026"
47	N40° 32' 36.480"	W95° 49' 55.993"
48	N40° 33' 13.726"	W95° 49' 52.496"
49	N40° 32' 19.305"	W95° 49' 59.799"

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