RARE SPECIES OF SMALL MAMMALS IN NORTHEASTERN KANSAS TALLGRASS PRAIRIE

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Abstract: We sampled small mammals in native tallgrass prairie habitat from autumn 1981 to spring 1998 on Konza Prairie Research Natural Area, Kansas. In 130,560 trap-nights, we captured 14 species of small mammals. In decreasing order of abundance, the relatively common species were the deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), Elliot's short-tailed shrew (*Blarina hylophaga*), white-footed mouse (*P. leucopus*), prairie vole (*Microtus ochrogaster*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), and hispid cotton rat (*Sigmodon hispidus*). Likewise, rare species were the southern bog lemming (*Synaptomys cooperi*), hispid pocket mouse (*Chaetodipus hispidus*), eastern woodrat (*Neotoma floridana*), house mouse (*Mus musculus*), plains harvest mouse (*Reithrodontomys montanus*), least shrew (*Cryptotis parva*), and meadow jumping mouse (*Zapus hudsonius*). Relative abundances of the rare species ranged from 0.002 (individuals/trapline/sampling period) for the meadow jumping mouse to 0.112 for the southern bog lemming. All rare species combined comprised approximately 2% of the small mammal community in grasslands on Konza Prairie. Southern bog lemmings selectively used sites that were left unburned for 2-3 years in contrast to those burned annually and those unburned for ≤ 4 years. Time since fire had no detectable effect on numbers of individuals for the other 6 rare species. In addition, southern bog lemmings, eastern woodrats, and hispid pocket mice were distributed nonrandomly with respect to topography.

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Key words: *Chaetodipus hispidus*, *Cryptotis parva*, eastern woodrat, fire, hispid pocket mouse, house mouse, Konza Prairie Research Natural Area, least shrew, meadow jumping mouse, *Mus musculus*, *Neotoma floridana*, plains harvest mouse, *Reithrodontomys montanus*, southern bog lemming, *Synaptomys cooperi*, topography, *Zapus hudsonius*.

Long-term studies are essential to examine ecological processes that have high annual variability (Franklin 1989). Population and community dynamics of small mammals typically have high inter- and intra-annual variability, especially in temperate regions (e.g. Sexton et al. 1982, Krohne and Burgin 1990). However, most studies of small mammals are short in duration (≤ 3 yrs). Data from short-term studies may be misleading due to slow processes, rare or episodic events (e.g., incidence of disease, wildfire occurrence, and extremes in precipitation, temperature, and production of seeds), or processes with high variability (Franklin 1989, Tilman 1989). In 1981, we initiated a long-term study to assess temporal variability in abundance of small mammals in native tallgrass prairie on the Konza Prairie Research Natural Area in northeastern Kansas. During 17 years of sampling, we captured 14 species of small mammals (Finck et al. 1986, McMillan et al. 1997).

For the purposes of this paper, we consider half of the species (7) to be rare on the site. Herein, we provide information gathered to date, on abundance and habitat selection in native tallgrass prairie for these rare species.

METHODS

Study Site

We studied small mammals in native tallgrass prairie on Konza Prairie Research Natural Area. Konza Prairie is a 3,500-ha field research station, which is composed of flat uplands with shallow soils, terraced by layers of Permian limestone, and lowlands with relatively deep soils. These conditions are typical of the Flint Hills region. Maximum topographic relief is approximately 130 m. Tallgrass species that dominate the site include big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparius*), and switchgrass (*Panicum virgatum*). Common forbs

include heath aster (*Aster ericoides*), western ragweed (*Ambrosia psilostachya*), and fringeleaf ruellia (*Ruellia humilis*). In addition to bur oak (*Quercus macrocarpa*), chinquapin oak (*Q. muhlenbergii*), hackberry (*Celtis occidentalis*), American elm (*Ulmus americanus*), and honey locust (*Gleditsia triacanthos*) in the extreme lowlands, scattered patches of smooth sumac (*Rhus glabra*) and rough-leaved dogwood (*Cornus drummondii*) occur across the site.

Our specific study area encompassed approximately 4 km^2 and included 28 sites from an array of native grazer and fire treatments. Native grazer treatments included 6 sites grazed by bison (*Bison bison*) since 1991. Fire treatments included burning once every year (6 sites), every 2 years (4 sites), every 4 years (10 sites), every 10 years (2 sites), and every 20 years (6 sites). All prescribed burning was conducted during early spring (typically April).

Small Mammal Sampling

We sampled small mammals from autumn 1981 to spring 1998. Although all sites were not sampled during each year, at least 20 sites and up to 28 sites were trapped in each sampling period during 1981-1987 and at least 14 sites and up to 18 sites were trapped each sampling period during 1988-1998. Trapping was conducted during each spring (typically March), summer (typically July), and autumn (typically October) from autumn 1981 to autumn 1987, whereas trapping was conducting only during spring and autumn from spring 1988 to spring 1998.

We established a permanent trapline of 20 stations at each site. Sampling periods consisted of setting 2 large Sherman live-traps (7.6 x 8.9 x 22.9 cm) at each station for 4 consecutive nights. Traps were baited with a mixture of peanut butter and rolled oats (Kaufman et al. 1988). During the summer sampling periods, traps were closed during the day to decrease trap-related mortality. All small mammals were marked to identify individuals at their first capture. At each capture, basic live-trap data including species, sex, and trap station were recorded. Our total study involved 130,560 trap-nights of effort.

Analyses

We used log-likelihood ratios (G -test) to test for intraspecific differences in numbers of individuals related to fire treatments and topographic habitat. We used the relative proportion of stations available each year related to time since fire and topography to calculate our expected values for the G -test. For fire treatment, categories were 1 year (burned), 2-3 years (intermediate unburned), and ≥ 4 years (long-term unburned) since fire. We used the topographic categories of upland, breaks, and lowland for analyses of habitat selectivity. For individuals that were captured more than once in a sampling period, we used data only from the initial capture in our statistical analyses. We made no attempt to assess differences associated with grazing treatments because too few individuals were captured.

RESULTS

The 7 most common mammal species in decreasing order of abundance (Fig. 1) were the deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), Elliot's short-tailed shrew (*Blarina hylophaga*), white-footed mouse (*P. leucopus*), prairie vole (*Microtus ochrogaster*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), and hispid cotton rat (*Sigmodon hispidus*). These were considered "common" small mammals.

The 7 least abundant mammal species (considered "rare" small mammals) were the southern bog lemming (*Synaptomys cooperi*), hispid pocket mouse (*Chaetodipus hispidus*), eastern woodrat (*Neotoma floridana*), house mouse (*Mus musculus*), plains harvest mouse (*Reithrodontomys montanus*), least shrew (*Cryptotis parva*), and meadow jumping mouse (*Zapus hudsonius*). Relative abundances of these species ranged from 0.002 (individuals/trapline/sampling period) for the meadow jumping mouse up to 0.112 for the southern bog lemming. All 7 species combined comprised 2.1% of the community of small mammals from 1981 to 1998 (Table 1).

Mean number (± SE) of the 7 rare species captured during each sampling period (N = 40) was 1.85 ± 0.22. More specifically, mean number of rare species captured was 1.12 ± 0.17, 2.17 ± 0.48, and 2.47 ± 0.40 for spring (N = 17), summer (N = 6), and autumn (N = 17) sampling periods, respectively. Number of the 40 sampling periods each species was captured ranged from 2 for the meadow jumping mouse to 20 for the southern bog lemming (Table 1). Only 2 meadow jumping mice were captured during the entire study, and therefore are not included in further analyses.

Although rare, southern bog lemmings, hispid pocket mice, eastern woodrats, house mice, plains harvest mice, and least shrews all were caught on each day of our 4-day sampling period. Further, 4 or possibly 5 of the 6 species exhibited a reduction in the number of new individuals captured toward the end

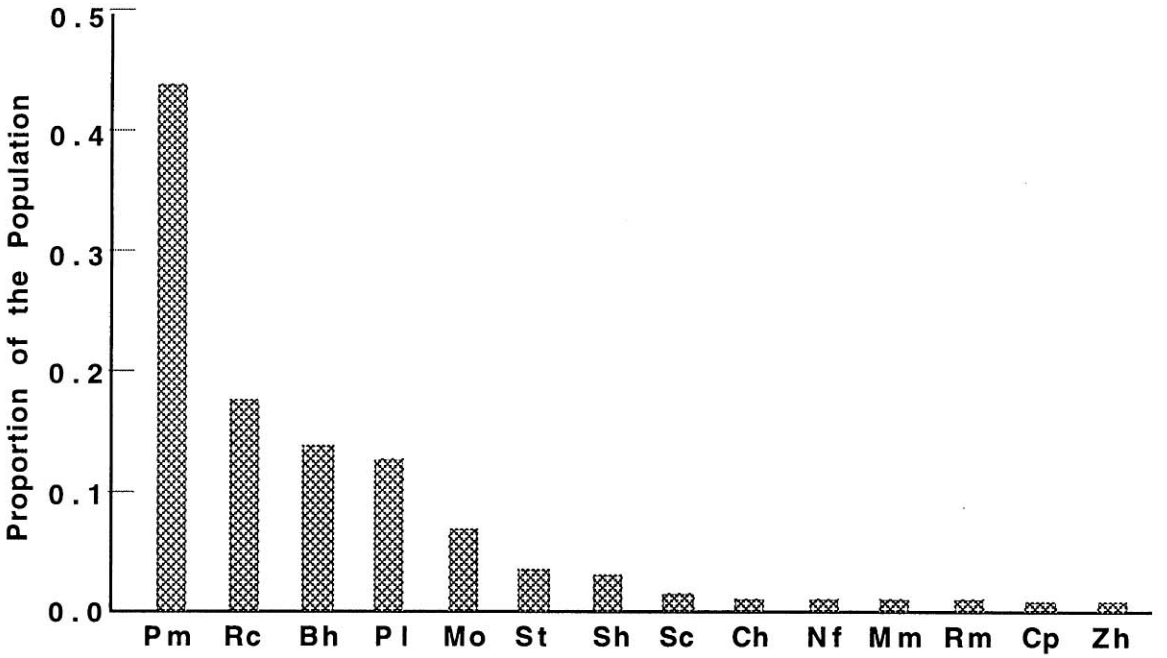

Fig. 1. The proportion of the small mammal community made up of each of the fourteen species captured in native tallgrass prairie. The species captured were Peromyscus maniculatus (Pm), Reithrodontomys megalotis (Re), Blarina hylophaga (Bh), P. leucopus (Pl), Microtus ochrogaster (Mo), Spermophilus tridecemlineatus (St), Sigmodon hispidus (Sh), Synaptomys cooperi (Sc), Chaetodipus hispidus (Ch), Neotoma floridana (Nf), Mus musculus (Mm), R. montanus (Rm), Cryptotis parva (Cp), and Zapus hudsonius (Zh). Sampling was conducted on Konza Prairie Research Natural Area during autumn 1981-spring 1998.

of our sampling periods (Fig. 2). Only the eastern woodrat did not show a decreasing rate of capture by day 4.

Both fire treatment and topography significantly influenced habitat selection by the rare species. Southern bog lemmings selectively used sites that were 2-3 years since fire and underused annually burned areas ($G = 22.0$, d.f. = 2, $P < 0.001$).

However, number of years since the last fire had no detectable effect on number of individuals captured for the other rare species. Two species, the eastern woodrat and hispid pocket mouse, selectively used breaks habitat ($G = 4.24$, d.f. = 2, $P < 0.1$ and $G = 38.35$, d.f. = 2, $P < 0.001$, respectively) over uplands and lowlands, whereas the southern bog lemming preferred lowland habitat ($G = 5.31$,

Table 1. The percent of the small mammal community, number of individuals captured, and mean number per trapline (relative abundance) for each of the seven rare species of small mammals. Also given, are the number of sampling periods (SPs) out of 17 springs, 6 summers, and 17 autumns that each species was captured (# of springs, # of summers, # of autumns). Sampling was conducted in native tallgrass prairie habitat on Konza Prairie Research Natural Area during 1981-1998.

Species	Percent	Number	Number/trapline	SPs
southern bog lemming	1.09	91	0.112	9,3,8
hispid pocket mouse	0.29	24	0.029	3,4,8
eastern woodrat	0.24	20	0.025	3,3,6
house mouse	0.20	17	0.021	0,2,8
plains harvest mouse	0.19	16	0.020	3,0,5
least shrew	0.12	10	0.012	1,0,6
meadow jumping mouse	0.02	2	0.002	0,1,1

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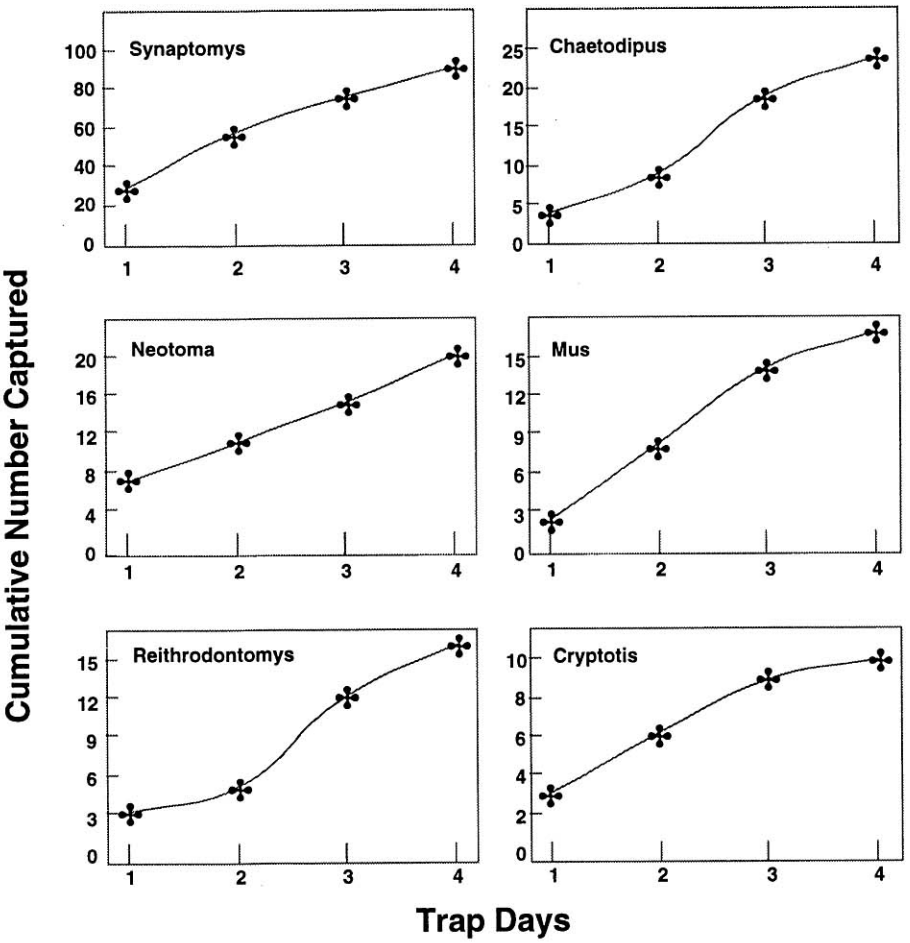

Fig. 2. Cumulative number of new individuals captured during each day 1 of the four-day sampling periods for each of the rare species (except Z. hudsonius) of small mammals captured in native tallgrass prairie. Sampling was conducted on Konza Prairie Research Natural Area during autumn 1981-spring 1998.

d.f. = 2, $P < 0.1$) over the other habitat types. Too few individuals were captured to perform statistical analyses for the remaining 4 species. However, greater than expected captures of the house mouse in lowland and breaks, plains harvest mouse in breaks, and least shrew in uplands suggest patterns of differential habitat use if these trends continue with additional captures (Fig. 3).

DISCUSSION

During our 17-year study, we captured all species of terrestrial small mammals thought to occur in prairie habitats on Konza Prairie (Finck et al. 1986, McMillan et al. 1997). Seven of the 14 species of small mammals captured in native tallgrass prairie on Konza Prairie we defined as rare (≤ 0.1 individuals/trapline). Of the 7 species, we expected the eastern woodrat, house mouse, hispid pocket mouse, and meadow jumping mouse to be uncommon or rare in our grassland habitats. The eastern woodrat typically is associated with woody vegetation (Wiley 1980, Bee et al. 1981, Jones et al. 1985, McMillan and Kaufman 1994). Consistent with this habitat association, eastern woodrats occur throughout woody habitats on Konza Prairie (Finck et al. 1986, McMillan and Kaufman 1994, McMillan et al. 1997). Likewise, house mice generally have a commensal relationship with humans, and rarely use native grasslands (Jones et al. 1985, Kaufman and Kaufman, 1990). For the other 2 species, Konza Prairie is located at the edge of their ranges: eastern edge for the hispid pocket mouse and western edge for the meadow jumping mouse (Jones et al. 1985). Therefore, Konza Prairie may represent marginal habitat for these 2 species. In contrast, the southern bog lemming, plains harvest mouse, and least shrew are grassland species and were surprisingly rare on Konza Prairie.

It is possible that these rare species are actually common on the site, but our methods did not accurately or effectively sample the "rare" species. Three possibilities exist: (1) we did not sample the appropriate habitats, (2) Sherman live-traps do not effectively sample all species, and (3) these species do not enter the traps in the first few days of a trapping session.

In the first case, our study sites spanned 4 km^2, and at each site we sampled a transect across habitats representative of the site. However, it is possible that some localized populations associated with specific habitat types were not sampled. For example, least shrews were relatively common on a study area during 1 year of a multi-year investigation conducted during 1983-1987 on Konza Prairie (Clark et al. 1995).

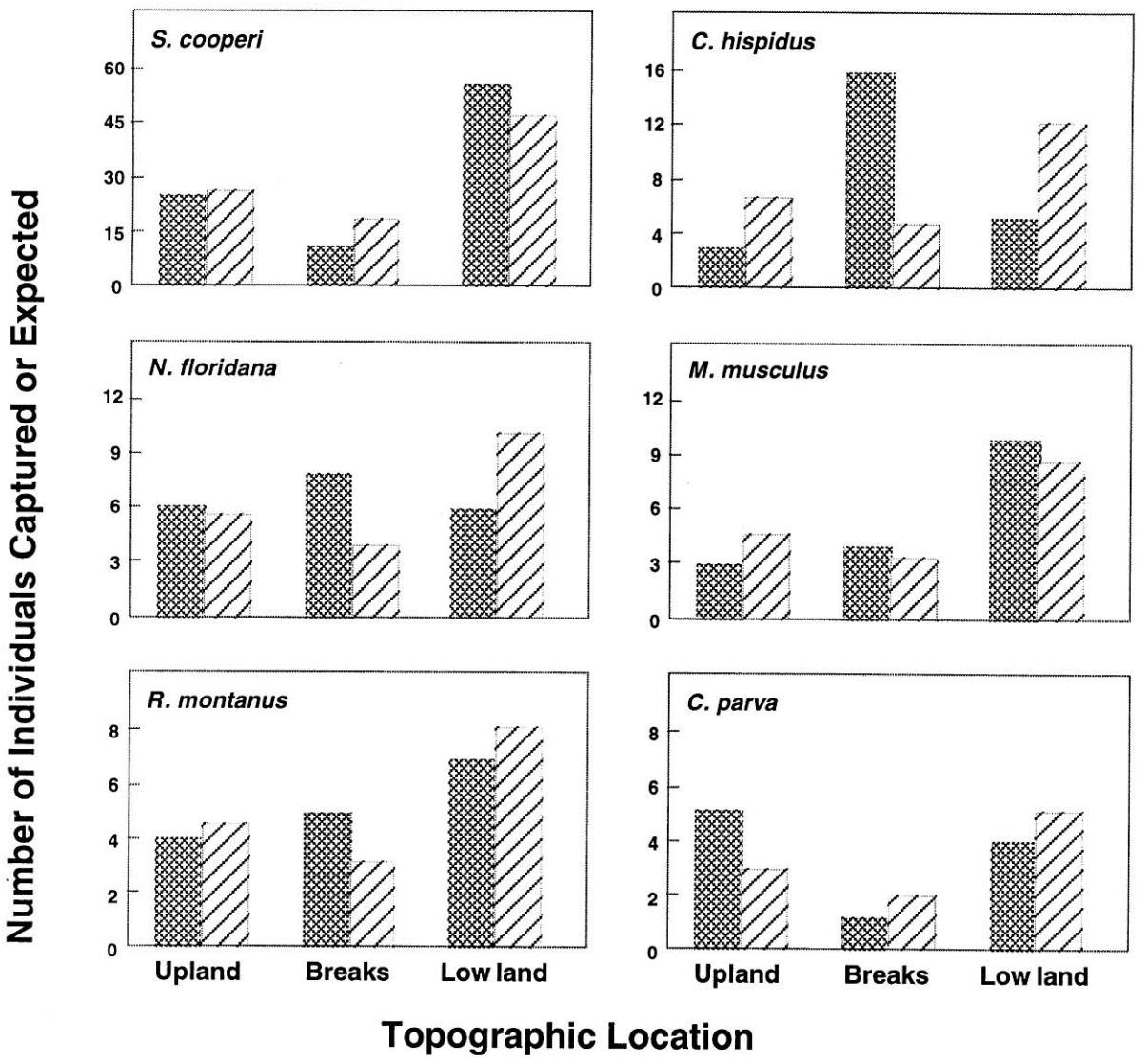

Fig. 3. Number of individuals captured in upland, breaks, and lowland habitats for each of the rare species (except Z. hudsonius) of small mammals captured in native tallgrass prairie. Hatched bars are observed individuals and lined bars are expected number of individuals calculated from the availability of each habitat type. Sampling was conducted on Konza Prairie Research Natural Area during autumn 1981-spring 1998. S. cooperi , C. hispidus , and N. floridana exhibited significantly nonrandom use of available habitats at the $P < 0.001$, $P < 0.1$, and $P < 0.1$ levels, respectively.

Secondly, it is likely that all small mammals on the site are differentially susceptible to capture by Sherman live-traps. However, Sherman live-traps have been used to effectively sample each of the species we consider rare (Clark et al. 1995, Kaufman and Kaufman 1990, McMillan and Kaufman 1994, Zwank et al. 1997), except possibly least shrews, and likely did so in this study.

To determine whether we were effectively sampling the rare species with our trapping methodology, we examined the day of capture for individuals of each species. If our sampling was effective, we would expect captures on the first day of sampling and a decreased number of new individuals toward the end of our 4-day sampling periods. We observed this pattern for 4 and possibly 5 of the

grassland species. On average, we captured < 2 and never more than 5 of the 7 rare species of small mammals within a sampling period. Most ecological studies of mammals are typically only 1 to a few (3 or 4) years in duration (Weatherhead 1986). Short-term studies likely undersample species richness of small mammals and biodiversity in general. Because our study has spanned 17 years, we have captured all 14 of the expected species and have accumulated sufficient data to examine patterns for the rare species.

Southern bog lemmings selectively used intermediate unburned sites (2-3 years without fire), which agrees with the findings of Bee et al. (1981) that they prefer areas with a dense litter layer. However, we expected even greater selectivity of use for long-term unburned sites (≥ 4 years without fire), but found no relationship. This pattern of use suggests that habitat conditions for southern bog lemmings are better at intermediate lengths of time after fire than conditions found in sites recently burned or left unburned for long periods of time. As predicted (Kaufman et al. 1995), southern bog lemmings selectively used lowland habitat. Preferential use of lowland habitat agreed with the affinity of bog lemmings for mesic areas with thick vegetation (Bee et al. 1981, Linzey 1983, Jones et al. 1985). Surprisingly, southern bog lemmings were caught more frequently in uplands than seemed likely from known habitat affinity. This pattern suggests that bog lemmings are not as dependent on wet areas as previously thought (Jones et al. 1985), but this needs further investigation.

The eastern woodrat was associated positively with breaks habitat, but not lowland prairie. This finding was somewhat unexpected. However, shrubs and large rocks, which are important habitat features for woodrats (Wiley 1980, Bee et al. 1981, Jones et al. 1985, McMillan and Kaufman 1994), are both associated with limestone outcrops in breaks habitat on Konza Prairie. The distance between wooded ravines and most traplines probably made it unlikely that woodrats would be caught in lowland regions of our prairie lines. However, some of the trap-lines were relatively close to woody ravines, and therefore these data also suggest that woodrats rarely venture into the prairie from areas with woody vegetation.

The hispid pocket mouse selectively used breaks habitat over upland and lowland habitats, which is consistant with an earlier study (Kaufman et al. 1995). This pattern of use was consistent with the association of pocket mice with open, arid grassland areas in rocky, loamy or sandy soils (Kaufman and Fleharty 1974, Bee et al. 1981, Jones et al. 1985, McMillan and Kaufman 1994). Interestingly, pocket mice on Konza Prairie were captured repeatedly at the same station within the same site, although captures of different individuals were separated by multiple years (e.g. 7 of the 24 pocket mice were captured at 3 stations on the same site during 1981, 1983, 1984, 1985, 1990, and 1995). This observation suggests that few locations may be suitable for use by these granivorous mice on the eastern edge of their range (Jones et al. 1985). The rarity of these mice on our traplines was consistent with their preference for annual grasses associated with old-field habitat over native tallgrass prairie at a local site on Konza Prairie (McMillan and Kaufman 1994).

Although we captured too few individuals of the other rare species to perform statistical analyses, the preliminary patterns we found suggest predictions that can be tested with additional captures of these species. House mice appeared to choose lowland and breaks habitat over upland. Use of lowland and breaks over upland habitat by house mice is a pattern that is consistent with a use of farmsteads and agricultural fields and occasional dispersal to native habitats (Bee et al. 1981, Kaufman and Kaufman 1990).

Plains harvest mice appeared to choose breaks habitat over lowland or upland. Selective use of breaks habitat by plains harvest mice agrees with a preference for rocky and dry areas with sparse vegetation (Kaufman and Fleharty 1974, Bee et al. 1981), but is not consistent with preferential use of prairie uplands (Bee et al. 1981).

Least shrews appeared to choose upland over lowland or breaks. Use of more xeric upland habitat by least shrews agrees with earlier reports for this species (Jones et al. 1985, Clark et al. 1995).

We considered about 50% of the native grassland small mammal species to be rare in tallgrass prairie habitats on Konza Prairie. Because they are rare, ecological processes associated with these species are difficult to examine. Because this investigation has been going on for 17 years, we are able to begin to look at ecological characteristics of these rare species. For our investigation into small mammal population and community dynamics in tallgrass prairie (and likely most small mammal studies), a short-term approach would have led to inaccurate or at least incomplete conclusions for these relatively uncommon species.

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