Species Diversity of Small Mammals in the Tallgrass Prairie Preserve, Osage County, Oklahoma

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A total of 714 small mammals representing 15 species was captured, identified and released (11,000 trap nights at 110 different trap sites in six different habitat types) at the Tallgrass Prairie Preserve, Osage Co., Oklahoma. More species of small mammals were trapped in the prairie-grass habitat (13 species) than in disturbed areas (9 species), grassy streamsides (7 species), wooded streamsides (6 species), rock outcrops (6 species), or upland woods (6 species) habitats. Species diversity and evenness indices (Shannon's Index) of small mammals were determined for six habitat types. Mean species diversity values ranged from a high value in the prairie-grass habitat, to low values in the upland woods and wooded streamsides habitats. High community similarity (Horn's Index) was found in upland woods and wooded streamsides habitats. Community similarity also was high among prairie-grass, rock outcrops, grassy streamsides, and disturbed habitats.

INTRODUCTION

The tallgrass prairie once extended north and south from southern Manitoba to mid-Texas and was the eastern edge of North American grasslands (*1*). It is bordered on the east by deciduous forest and on the west by mixed-grass prairie. Of all grassland associations, tallgrass prairie receives the most rainfall and has the greatest north-south diversity (*1*).

The tallgrass prairie was a natural system controlled by climate, fire, and bison. The extent of tallgrass prairie has declined with disappearance of bison (*Bison bison*) and the increase in fire prevention practices. Favorable climate and soil conditions have resulted in the cultivation of much of the tallgrass prairie, eliminating the original vegetation (*2*). Of the original 57 million ha of tallgrass prairie, about 10% remains (*3*). Much of what remains exists as fragments around highways, railways, cemeteries, and such. Although many of these fragments have never been disturbed and are inhabited by tallgrass-prairie biota, they probably are not comparable to the tallgrass prairie of the past in terms of composition of small mammals. Today, the tallgrass prairie is the rarest of all of North America's major biomes (*3*).

In 1989, The Nature Conservancy purchased a 12,146 ha ranch in the Osage Hills of Oklahoma and established the Tallgrass Prairie Preserve (*3*). This land had been grazed but never cultivated and was to form the foundation for restoring a tallgrass-prairie ecosystem. The Nature Conservancy's intent is to recreate the original conditions by adding bison and controlled burning. Their ultimate goal is to protect biological diversity by maintaining examples of otherwise scarce ecosystems (*4*).

Our objective was to inventory the small mammals in the Tallgrass Prairie Preserve and compare species diversities of small mammals in different habitats. The data will serve as a baseline of the composition of small mammals prior to the introduction of bison and controlled burns. Future studies using similar methods can be compared with results of our study to determine what impact bison and fire actually have on the composition of small mammals.

METHODS

Our study was conducted within the Tallgrass Prairie Preserve, 13.4 km north of Pawhuska in Osage County, Oklahoma. The 12,146 ha Tallgrass Prairie Preserve lies within the Osage Hills of the Tallgrass Prairie Rolling Hills physiognomic region (*5*) of Oklahoma. The preserve contains gently rolling hills dissected by spring-fed streams that converge to form three main creek systems: Sand Creek and Wild Hog Creek through the central part of the preserve, and Bird

Creek along the western edge just outside the preserve. These drainage systems support deciduous, riparian forests. The rolling prairies, which dominate the topography, are covered with prairie grasses including tallgrass species. Uplands are covered with deciduous forests, and hillsides are often eroded, exposing limestone outcrops. Mean temperature and total precipitation were 15.8°C and 106 cm, respectively, for the study period (Oklahoma Climatological Survey, Norman, Oklahoma).

Species diversity and evenness of small mammals were determined for six habitat types in the preserve: prairie-grass, rock outcrops, wooded streamsides, grassy streamsides, upland woods and disturbed areas habitats. Physiognomic descriptions of each habitat type were prepared. These included a list of major vegetation forms present and their general topographic features. Trap sites were selected relative to the proportion of each of the six habitats in the preserve. Estimates of the percentage of each habitat type were calculated using an area-line meter (Planix 5000) on topographical maps. Because the amount of rock outcrop area was not obtainable from topographical maps, it was conservatively determined to be one-half of that estimated for disturbed areas. Areas of rock outcrops, wooded streamsides, grassy streamsides, upland woods, and disturbed habitats were subtracted from total preserve area, resulting in the area of prairie-grass habitat. Specific sites were different for each collecting night in order to sample the vast area of the preserve.

The live-trap survey of small mammals was made at least two nights a month for 1 y beginning in June 1991 and continuing through May 1992. Sherman live-traps (23.5 × 7.7 × 9.0 cm) baited with rolled oats, were used to capture small mammals and were placed in trap lines of varying lengths (dependent upon the amount of habitat present) in each habitat type. A trap-line consisted of a series of trap stations (two traps per station) about 4 m apart. Trap-lines for the grassy streamsides were placed within 3 m of the stream edge and for the upland woods approximately 20 m away from the ecotone of forest and grassland. Representative museum voucher specimens of each species captured were prepared and deposited in the University of Central Oklahoma Collection of Vertebrates.

The Shannon index (*6*) was used to determine a species diversity value for each sample period for all six habitats. Evenness values (*6*) also were calculated for each sample period. Mean species diversity and evenness values were calculated for each habitat for the 1 y period. Kruskal-Wallis nonparametric one-way ANOVA (*6*) was used to test for significant differences among the mean ranks of species diversity or evenness values among habitats. Dunn's multiple comparison test (*6*) was used to ascertain which of the mean ranks for species diversity or evenness were different if a statistically significant ANOVA resulted. Horn's index for community similarity (*7*) was calculated to determine degree of community overlap.

RESULTS and DISCUSSION

Composition of the Tallgrass Prairie Preserve was estimated to be: 92.3% prairie grasses, 4.0% upland woods, 2.5% wooded streamsides, 0.6% grassy streamsides, 0.4% disturbed areas, and 0.2% rock outcrops. Prairie-grass habitat was composed of open, rolling, prairie fields containing such grass species as *Andropogon gerardi* (big bluestem), *A. scoparius* (little bluestem), *Sorghastrum nutans* (Indian grass), *Panicum virgatum* (switchgrass), *Tripsacum dactyloides* (eastern gama grass), *Elymus canadensis* (Canada wild rye), *E. virginicus* (Virginia wild rye), and *Sporobolus asper* (tall dropseed). A variety of forbs, such as *Achillea millefolium* var. *lanulosa* (yarrow), *Asclepias* spp. (milkweeds), *Gaura* sp. (gaura), and *Smilax* sp. (green briar) were also present. Soil was moderately to well drained, shallow (25.4-152.4 cm) and composed of dark, silty, clay loam on a sandstone and limestone bedrock (*8*).

Rock outcrops were found on the edges of hills and in areas of heavy erosion. Outcrops varied from steep and bluff-like to flat, eroded hillsides. Typical grasses of the area were little Bluestem, *Elymus* sp. (wild rye), *Lepidium virginicum* (peppergrass), and *Aristida* sp. (three-awn). Other vegetation present included *Rubus* sp. (blackberry), and *Ambrosia* spp. (ragweed). In some areas, small trees, *Quercus stellata* (post oak), *Q. marilandica* (blackjack oak), and *Celtis* sp. (hackberry) were established among the rocks. Soil was stony, well drained, shallow (10.2-101.6 cm), and composed of dark brown, silty loam on a bedrock of shale, sandstone, or limestone (*8*).

Wooded streamside habitat occurred adjacent to Sand, Wild Hog, and Bird creeks. These

lowland creeks supported riparian forest vegetation, including *Ulmus rubra* (slippery elm), *Bumelia lanuginosa* (chittamwood), *Carya cordiformis* (hickory), *Staphylea trifolia* (American bladdernut), *Celtis occidentalis* (sugarberry), *Quercus macrocarpa* (bur oak), dwarf *Q. prinoides* (chinquapin oak), shumard oak (*Q. shumardii*), eastern redbud (*Cercis canadensis*), willow (*Salix nigra*), *Fraxinus pennsylvanica* (ash), *Platanus occidentalis* (sycamore), *Cornus drummondii* (roughleaf dogwood), *Maclura pomifera* (Osage orange), *Viburnum rufidulum* (blackhaw), *Symphoricarpos orbiculatus* (coral berry), *Parthenocissus quinquefolia* (Virginia creeper), *Cephalanthus occidentalis* (buttonbush), and *Toxicodendron radicans* (poison ivy). Soil was a deep, moderately drained, dark brown, silty loam extending to a depth of 152.4 cm (*8*).

Grassy streamside habitat bordered springfed streams that coursed through the open prairie toward major creeks. Typical tallgrass species were present, although more densely than in the prairie-grass habitat, and less bluestem was present. Other vegetation included *Melilotus alba* (white sweet clover), *M. officinalis* (yellow sweet clover), *Solidago* sp. (goldenrod), and *Juncus* sp (rush). This habitat was sometimes very wet from stream overflow. Soil was dark, silty loam on shale and sandstone bedrock, poorly drained and ranged from moderately deep to deep (25.4-152.4 cm) (*8*).

Upland woods habitat occurred on top of many of the larger hills. Dominant trees were post oak and blackjack oak. Understory and ground cover was mostly coral berry, Virginia creeper, dwarf chinquapin, eastern redbud, and poison ivy. Soil in the upland woods was a dark, grayish brown, sandy or silty loam on bedrock of shale and sandstone, shallow to moderately deep (25.4-101.6 cm) (*8*).

Disturbed areas occurred where non-natural structures, including ranch houses, corrals, oil production sites, and roads existed. These areas were numerous enough to include as a general habitat type. Vegetation of this area consisted primarily of little bluestem, *Gutierrezia dracunculoides* (broomweed), goldenrod, *Chenopodium album* (lamb's quarter), *Solanum* spp. (nightshades), ragweed, gaura, white sweet clover, and yellow sweet clover. Soils of these areas were variable.

The total number of sites trapped on the preserve was 110. All site locations and descriptions were compiled in a journal deposited in the University of Central Oklahoma Collection of Vertebrates. Total number of trap nights was 11,000, 61.3% of which were placed in the prairie-grass habitat, 7.0% in rock outcrops, 9.2% in wooded streamsides, 9.7% in upland woods, 6.7% in grassy streamsides, and 6.1% in disturbed areas. A total of 714 individual small mammals representing 15 species were captured: *Blarina hylophaga* (Elliot's short-tailed shrew), *Cryptotis parva* (least shrew), *Chaetodipus hispidus* (hispid pocket mouse), *Reithrodontomys fulvescens* (fulvous harvest mouse), *R. humulis* (eastern harvest mouse), *R. megalotis* (western harvest mouse), *R. montanus* (plains harvest mouse), *Peromyscus gossypinus* (cotton mouse), *P. leucopus* (white-footed mouse), *P. maniculatus* (deer mouse), *Sigmodon hispidus* (hispid cotton rat), *Neotoma floridana* (eastern woodrat), *Microtus ochrogaster* (prairie vole), *M. pinetorum* (woodland vole), and *Mus musculus* (house mouse) (Table 1).

The number of species of small mammals trapped (Table 1) in the prairie-grass habitat (13 species), disturbed areas (9 species), grassy streamsides, (7 species), wooded streamsides, (6 species), rock outcrops (6 species), or upland woods (6 species) habitats did not vary much. There was no statistically significant difference in number of species per habitat ($X^2 = 4.980$; $P > 0.05$).

Percent occurrence of small mammal species among habitats varied. When examining Table 1, it appears as though several species had a preference for certain habitats. For example, 92% of *M. ochrogaster* and 71% of *S. hispidus* were captured in prairie-grass habitat. A Chi square test for a uniform occurrence among all habitat types was made for *P. leucopus*, *P. maniculatus*, *S. hispidus* and *M. ochrogaster*. All the Chi-square tests for these species were statistically significant suggesting habitat preferences. Too few individuals of the other species in Table 1 were captured to discern if there was a habitat preference because the expected frequency assumption for the Chi-square test was not satisfied. The log-likelihood ratio, an alternative to Chi-square, could not be used for these either because of zero values in the data. If the species with low numbers of individuals, had been combined together under a common genus to meet the assumption of expected frequency size for Chi-square, it would have produced misleading results. For

TABLE 1. Small mammals trapped in prairie grasses (PG), rock outcrops (RO), wooded streamsides (WS), upland woods (UW), grassy streamsides (GS), and disturbed areas (DA) in the Tallgrass Prairie Preserve.

Species	PG	RO	WS	UW	GS	DA
Blarina hylophaga	9(2.4/82)[1]	—	—	1(1.5/9)	1(2.1/9)	—
Cryptotis parva	3(0.8/60)	—	—	—	—	2(2.5/40)
Chaetodipus hispidus	—	1(1.6/50)	—	—	—	1(1.2/50)
Reithrodontomys fulvescens	3(0.8/30)	2(3.3/20)	3(3.6/30)	—	1(2.1/10)	1(1.2/10)
R. humulis	14(3.7/100)	—	—	—	—	—
R. megalotis	5(1.3/100)	—	—	—	—	—
R. montanus	31(8.2/97)	—	—	—	1(2.1/3)	—
Peromyscus gossypinus	—	—	9(10.7/90)	1(1.5/10)	—	—
P. leucopus	6(1.5/5)	1(1.6/1)	62(73.8/49)	51(78.5/40)	1(2.1/1)	5(6.2/4)
P. maniculatus	96(25.5/47)	30(49.2/15)	—	6(9.2/3)	18(38.3/9)	53(65.4/26)
Sigmodon hispidus	129(34.3/71)	13(21.3/7)	2(2.4/1)	4(6.2/2)	23(48.9/13)	11(13.6/6)
Neotoma floridana	3(0.8/11)	14(23.0/52)	6(7.1/22)	2(3.1/7)	—	2(2.5/7)
Microtus ochrogaster	71(18.9/92)	—	2(2.4/3)	—	2(4.3/3)	2(2.5/3)
M. pinetorum	5(1.3/100)	—	—	—	—	—
Mus musculus	1(0.3/20)	—	—	—	—	4(4.9/80)
Total number of species	13	6	6	6	7	9

[1] The numbers preceding parentheses are the number of individuals captured. Numbers within the parentheses are the percentage of species composition within a habitat and percent occurrence of a species among habitats respectively.

example, if all the *Peromyscus* had been combined, then the preference of *P. gossypinus* for woods (*5*) would have been obscured. Therefore, no species were combined.

Table 2 contains species diversity and evenness values. During the study, species diversity values ranged from a low of 0.000 which was calculated at least once in all habitats to a high of 0.695 in the prairie-grass habitat. Mean species diversity for all habitats combined was 0.314. Mean species diversity values varied from a low of 0.142 in upland woods habitat to a high of 0.456 in the prairie-grass habitat. The Kruskal-Wallis one-way ANOVA ($P \leq 0.05$) detected some of the mean-ranks of species diversity values among habitats were significantly different. Dunn's multiple comparison test indicated that the only significant differences among mean-ranks of species diversity values were between the prairie-grass habitat and those of wooded streamsides, and upland woods.

Mean species evenness for all habitats combined was 0.596 and ranged from zero which was calculated at least once in all habitats to 1.000 in prairie-grass, rocky outcrops, and upland woods habitats (Table 2). Mean evenness values varied from a low of 0.348 in the upland woods habitat to a high of 0.769 in prairie-grass habitat. However, no significant differences were detected among the mean ranks of evenness values of the six habitats (Kruskal-Wallis one way ANOVA; $P \geq 0.05$).

Horn's community similarity values (Table 3) suggested high similarity in species composition between wooded streamsides, and upland woods and high similarity among communities in prairie-grass, rock outcrops, grassy streamsides, and disturbed area habitats.

Thirteen species were represented among the 376 individuals captured in prairie grass. *Sigmodon hispidus, P. maniculatus,* and *M. ochrogaster* were abundant, comprising 34.4, 25.5, and 18.9%, respectively, of the individuals captured (Table 1). That contrasted with results from the USIBP tallgrass prairie site in Osage County in 1970 (*9*), where no *P. maniculatus* were taken in live-traps on the ungrazed site but were captured on a grazed site. Instead, the single most abundant species on the ungrazed site was *M. ochrogaster*. At this same site in 1971, Hoffman and Birney (*10*) reported *M. ochrogaster* and *S. hispidus* were the most abundant mammals. Differences between estimates of abundance of *P. maniculatus* and *M. ochrogaster* in the preserve compared with the USIBP site could be due to the amount of vegetative cover. *Microtus ochrogaster* prefers high vegetative cover (*11*), whereas *P. maniculatus* prefers more open

TABLE 2. Diversity/evenness values for each collecting period in prairie grasses (PG), rock outcrops (RO), wooded streamsides (WS), upland woods (UW), grassy streamsides (GS), and disturbed areas (DA) in the Tallgrass Prairie Preserve.

Date			PG	RO	WS	UW	GS	DA
1991	Jun.	22	—	0.276/0.917	—	—	—	0.413/0.86
		29	—	—	0.244/0.811	—	—	—
	Jul.	12	0.000/0.000	—	0.292/0.970	0.301/1.000	—	—
		13	—	—	0.000/0.000	0.000/0.000	—	—
	Aug.	10	0.477/1.000	0.301/1.000	—	—	—	—
		16	—	—	—	0.000/0.000	0.216/0.718	—
		17	0.000/0.000	—	—	0.000/0.000	0.276/0.917	0.528/0.877
		29	0.320/0.671	—	—	—	—	0.641/0.917
	Sept.	6	0.301/1.000	0.413/0.866	—	—	—	—
		7	0.276/0.917	0.000/0.000	—	—	0.244/0.811	—
		20	0.244/0.811	—	—	—	—	—
	Oct.	21	0.415/0.870	0.276/0.917	—	0.000/0.000	—	—
		25	—	—	0.000/0.000	—	—	—
	Nov.	8	—	—	—	—	0.578/0.960	0.000/0.000
		23	0.377/0.790	—	—	0.185/0.388	—	0.319/0.530
	Dec.	7	0.286/0.475	0.531/0.882	—	0.594/0.850	0.255/0.424	0.390/0.818
		26	0.528/0.877	0.448/0.744	—	—	0.000/0.000	0.276/0.917
		27	0.681/0.714	—	0.517/0.665	0.301/1.000	—	—
1992	Jan.	4	0.695/0.893	—	—	0.178/0.591	—	—
		17	—	—	0.251/0.526	0.000/0.0		
		31	—	0.313/0.656	—	—	0.452/0.948	—
	Feb.	14	0.399/0.836	—	0.276/0.917	—	—	
		15	0.423/0.887	—	—	—	—	0.244/0.811
		28	0.602/1.000	—	0.000/0.000	—	—	—
	Mar.	15	0.579/0.962	—	0.102/0.339	—	—	—
		16	0.671/0.862	—	—	—	—	0.000/0.000
		17	0.630/0.901	—	—	—	0.000/0.000	—
		26	0.643/0.826	—	—	—	—	—
	Apr.	10	0.646/0.830	—	—	0.000/0.000	—	—
		25	0.588/0.841	0.398/0.832	—	—	—	—
	May	13	0.645/0.763	—	—	—	—	—
		14	0.516/0.738	—	—	—	—	—
	Means		0.456/0.769	0.328/0.757	0.187/0.470	0.142/0.348	0.253/0.597	0.312/0.637

TABLE 3.—Horn's community similarity values for prairie grasses (PG), rock outcrops (RO), wooded streamsides (WS), upland woods (UW), grassy streamsides (GS), and disturbed areas (DA) in the Tallgrass Prairie Preserve.

Habitat	PG	RO	WS	UW	GS	DA
PG	1.00					
RO	0.72	1.00				
WS	0.22	0.25	1.00			
UW	0.32	0.42	0.87	1.00		
GS	0.88	0.81	0.22	0.41	1.00	
DA	0.76	0.84	0.35	0.48	0.68	1.00

tallgrass prairie habitats (*12*). The preserve was grazed until December 1990; thus, it was in its first growing season, and perhaps vegetative cover was not yet dense enough to inhibit *P. maniculatus.* Lower vegetative cover also might explain the lack of capture of *M. ochrogaster* in the preserve until December, 1990. Another possible explanation might be that densities of *M. ochrogaster* cycle every 2 y (*11*), and trapping in the preserve began during a low period of the cycle. No *Spermophilus tridecemlineatus* were captured although they have been observed in grassland areas of the preserve.

Six species were represented among the 61 individuals captured in rock outcrop habitat (Table 1). *Peromyscus maniculatus* comprised nearly one-half (49.2%) of the individuals taken. *Sigmodon hispidus* and *N. floridana* were also abundant, 21.3 and 23.0%, respectively. Most (52%) *N. floridana* were captured from rock outcrops. This finding was consistent with Finck and coworkers (*13*), who reported *N. floridana* densities were greatest in shrub-covered limestone outcrops in Konza Prairie, Kansas. They suggested *N. floridana* used crevices as den sites. Rock outcrops habitat was not the primary habitat for *S. hispidus* or *P. maniculatus.* Occurrence of these species in rock areas was probably due to movement onto the outcrop to feed on the abundant forbs.

In wooded streamside habitat, six species of small mammals were represented among the 84 individuals captured (Table 1). Nearly three-fourths (73.8%) of the animals captured in this habitat were *P. leucopus*. This habitat contained 90% of the *P. gossypinus* captured. McCarley (*14*) suggested that in areas where *P. gossypinus* and *P. leucopus* were sympatric, *P. gossypinus* might displace *P. leucopus* in upland woods. On the preserve, this did not appear to be happening. *Peromyscus leucopus* was found about equally in wooded streamsides (49%) and upland woods (40%) habitats. The capture of *P. gossypinus* in the preserve was a significant range extension from the nearest previously known locality in Haskell County, Oklahoma (*15*). If *P. gossypinus* has only recently dispersed to this area of Oklahoma, it would be interesting to continue to monitor any changes in the relative abundance of *P. gossypinus* and *P. leucopus* in wooded streamsides and upland woods.

Six species of small mammals were represented in the 65 individuals captured in upland woods habitat (Table 1). The most abundant was *P. leucopus,* comprising 78.5% of the animals captured. Of the *P. leucopus* captured on the preserve, 40% were taken from upland woods habitat. In Kansas, *P. leucopus* selected habitats with complex vertical structure (*16*). The high occurrence of *P. leucopus* in wooded streamside and upland woods habitats, which had the greatest vertical complexity of the habitats on the preserve, was consistent with Kaufman and coworkers. (*16*). These authors suggested *P. leucopus* was also common in shrubby rock outcrops; however, that was not the situation in this study. The rock outcrop habitat in the preserve was disjunct from wooded and riparian habitats; thus it might not have been easy for *P. leucopus* to colonize this habitat across the wide expanses of grass.

In grassy streamside habitat, seven species of small mammals, 47 individuals, were captured (Table 1). The most abundant mammal in this habitat was S. *hispidus,* which represented almost half (48.9%) of the mammals caught. *Peromyscus maniculatus* was also abundant (38.3%). Caire and coworkers (*5*) suggested grassy habitats were preferred by *P. maniculatus* and *S. hispidus.* The composition of these grassy streamsides was similar to the prairie-grass habitat, but it was frequently flooded with water, which might have made this habitat less available. Since *M. ochrogaster* prefers dense vegetative cover (*11*) and because the vegetation was usually more dense than in prairie-grass habitat, it was expected that *M. ochrogaster* would have been more abundant than the results indicated. Perhaps frequent flooding also inhibited *M. ochrogaster.*

Nine species of small mammals were represented in the 81 individuals captured in the disturbed areas habitat (Table 1). *Peromyscus maniculatus* (65.4%) was the most abundant. Disturbed areas contained the second highest percent occurrence of *P. maniculatus.* Of all the disturbed areas, most (64%) *P. maniculatus* were captured at oil production sites. Because oil production sites were often mowed or trampled down by human activity, the abundance of *P. maniculatus* might be because they prefer more open microhabitat (*12*).

The number of species alone was not a very representative way of comparing habitats, nor was the percent capture rate. A better comparison of habitats was species diversity, which considered both the number of species and their relative abundance.

It was evident that fewer species were present in wooded streamside and upland woods habitats than in the prairie-grass habitat. These two habitats not only had fewer total species, they also had only one species that contained most of the individuals, resulting in lower species diversity values. *Peromyscus leucopus* accounted for 78.5% and 73.8% of all the individuals captured in upland woods and wooded streamside habitat, respectively.

Only one species was captured on several occasions in wooded streamsides (3 times) and upland woods (6 times), which resulted in diversity values of zero. Diversity values of zero were used in the computation of mean species diversity, resulting in lower values.

A concern with using species diversity indices to compare habitats is that diversity values are correlated with sample size (*7*). Species diversity values (Table 2) were significantly correlated ($r = 0.509$, $P < 0.05$) with sample size (number of individuals). This correlation suggested that care should be taken when considering differences in mean species diversities. The number of traps available was limited and the placement of a large percentage of the traps in the prairie grasses limited the number of traps available for use in the wooded streamsides, and upland woods. Originally, an attempt was made to equate the percentage of traps in each habitat to the percentage of each habitat found in the preserve. However, low capture rates made this impractical. With capture rates low, placement of a small number of traps in each habitat other than prairie grasses would not have allowed many, if any, mammals to be caught. For example, rock outcrops were determined to comprise only 0.2% of the preserve, and if a small number of traps (*22*) had been placed in this habitat few individuals or species would have been captured. This would have underrepresented the species composition of these habitats.

Evenness is a ratio of the observed diversity to maximum diversity (*6*). Maximum diversity is a function of the number of species. Evenness values were probably overestimated because of rare species. The absence of rare species in a habitat species list would not adversely affect observed diversity values (*7*). However, because maximum diversity is dependent on the total number of categories (species) present, it would be underestimated if a rare species was not accounted for in a particular habitat. Because some diversity values were zero, the evenness values were also zero and resulted in lower mean evenness values.

Because they included the Shannon diversity index, Horn's information theory based community similarity results among habitats (Table 3) were not markedly different than the relationship among habitats suggested by mean species diversity. Two groups of habitats, each with relatively high similarity values, are evident in Table 3. One group, which included wooded streamsides and upland woods, had a similarity value of 0.87 (Table 3). The second group, which contained the habitats prairie-grass, rock outcrops, grassy streamsides, and disturbed areas, had relatively high similarity values ranging from 0.68 to 0.88 (Table 3). One explanation for the two groups might be the limited occurrence of *P. leucopus* and *P. gossypinus* and their preference for vertical complexity in the wooded habitats. Care should be taken when comparing these community similarity values because they are only relative values and, to our knowledge, no statistical test of significance exists.

Low species diversity, 0.75, (*17*) and high abundance of *Microtus* (*11*) were characteristic of an ungrazed tallgrass prairie on the USIBP Osage site. In contrast, high diversity, 1.09, and low abundance of *Microtus* were characteristic of grazed tallgrass prairie. For the USIBP tallgrass site, Hoffman and Birney (*10*) reported that, when *Microtus* populations were dense in 1970, no *P. maniculatus* were taken; however, in 1971, when *Microtus* abundance was low, *P. maniculatus* was common. Mean species diversity for prairie-grass habitat on the preserve was 0.456, and this suggested the Tallgrass Prairie Preserve was probably in a transitional stage in terms of small mammal species composition. Mean species diversity (0.456) for prairie-grass habitat was low, suggesting the prairie diversity was similar to that of the ungrazed prairie on the USIBP Osage Site. However, high abundance of *P. maniculatus* suggested the preserve was more similar to a grazed prairie. *Microtus ochrogaster* was not abundant; in fact, it was not captured until December 1991, and its low abundance suggested a similarity to a grazed prairie.

Grant and coworkers (*17*) reported ungrazed tallgrass prairie was dominated by microtines, whereas currently ungrazed but transitional prairie (grazed the year before sampling began) was dominated by cricetines. Because prairie-grass

habitat on the preserve was inhabited mostly by the cricetine rodents, *P. maniculatus* and *S. hispidus* (Table 1), and not microtines suggests the preserve was in a transitional stage.

Bison have been reintroduced to various parts of the Tallgrass Prairie Preserve, and as the vegetative cover is reduced by grazing it is expected that small mammal species diversity will increase, and cricetines will continue to dominate. Some species (e.g., *Blarina hylophaga, Reithrodontomys megalotis,* and *Microtus ochrogaster)* will probably become less abundant. Other species (e.g., *Spermophilus tridecemlineatus, Chaetodipus hispidus,* and *R.. montanus)* will probably become more abundant. Birney (*18*) found *S. tridecemlineatus* was absent on an ungrazed tallgrass prairie site in Osage County, but present on a grazed site. A decrease in above-ground vegetation to < 700 g/m² results in a decline in the densities of *Microtus (19);* thus, *Microtus* occurrence would decrease with grazing.

Controlled burning will probably have effects similar to grazing in that some species will increase in abundance and others will decline. For example, Kaufman and coworkers (*16*) reported that *P. maniculatus* was more abundant in the sparse litter after a burn than in areas with greater litter cover; however, *R. megalotis* decreased in abundance. Schramm and Willcutts (*20*) indicated *M. ochrogaster* responded differently to controlled burns than to grazing. In burn areas, *M. ochrogaster* abundance increased rather than decreased, as it did in grazed areas. These authors suggested the increase is due to the colonization of the more xeric and open burned habitat.

The results of the present study of the mammal species composition in the Tallgrass Prairie Preserve should serve as a comparative base for future studies. Long-term monitoring of the Tallgrass Prairie Preserve will provide insight into the process of secondary succession in a tallgrass prairie. Community structure changes through time and niche-packing studies are potentially feasible because of these baseline data.

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REFERENCES

1 . Risser PG, Birney EC, Blocker HD, May SW, Parton WJ, Wiens JA. The true prairie ecosystem. Stroudsburg (PA): Hutchinson Ross Publishing Company; 1981. 557 p.
2. Auclair AN. Ecological factors in the development of intensive-management ecosystems in the midwestern United States. Ecology 1976;57:431-444.
3. Madson J. On the Osage. Nature Conservancy 1990;40:7-15.
4. Chaplin SJ. Natural area programs of The Nature Conservancy. Trans KS Acad Sci 1988;91:7-10.
5. Caire W, Tyler JD, Glass BP, Mares MA. Mammals of Oklahoma. Norman (OK): University Oklahoma Press; 1989. 567 p.
6. Zar JH. Biostatistical analyses. 2 nd ed. Englewood Cliffs (NJ): Prentice-Hall 1984. 718 p.
7. Brower JE, Zar JH. Field and laboratory methods for general ecology. Dubuque (IA): Wm. C. Brown; 1984. 226 p.
8. Bourlier BG, Nichols JD, Ringwald WJ, Workman PJ, Clemmons S. Soil Survey of Osage County, Oklahoma, United States Department of Agriculture 1979.
9. Hoffman RS, Jones JK Jr., Genoways HH. Small mammal survey on the Bison, Bridger, Cottonwood, Dickinson, and Osage sites. US Int Biol Program, Colorado State University, Fort Collins Grassland Biome Tech Rep 109:1-69; 1971.
10. Hoffman RS, Birney EC. Ecological studies of small mammal populations at the Cottonwood and Osage sites, 1971. US Int Biol Program, Colorado State University, Fort Collins Grassland Biome Tech Rep 187:1-45; 1972.
11. Birney EC, Grant WE, Baire DD. Importance of vegetative cover to cycles of *Microtus* populations. Ecology 1976;57:1043-1051.

12. Stroh JC, Fleharty ED. Microhabitat utilization and the effect of species removal on a population of *Peromyscus maniculatus* and *Reithrodontomys megalotis.* Trans KS Acad Sci 1988;91:132-138.
13. Finck EJ, Kaufman DW, Kaufman GA, Gurtz SK, Clark BK, McLellan LJ, Clark BS. Mammals of the Konza Prairie Research Natural Area, Kansas. Prairie Nat 1986;18:153-166.
14. McCarley H. Distributional relationships of sympatric populations of *Peromyscus leucopus* and *P. gossypinus.* Ecology 1963;44:784-788.
15. Payne T, Caire W. Occurrence of the cotton mouse, *Peromyscus gossypinus,* in northcentral Oklahoma. Proc OK Acad Sci 1992;72:67.
16. Kaufman DW, Peterson SK, Fristik R, Kaufman GA. Effect of microhabitat features on habitat use by *Peromyscus leucopus*. Am Midl Nat 1983;110: 177-185.
17. Grant WE, Birney EC, French NR, Swift DM. Structure and productivity of grassland small mammal communities related to grazing-induced changes in vegetative cover. J Mamm 1982;63:248-260.
18. Birney EC. Dynamics of small mammal populations at the Cottonwood and Osage site, 1972. US Int Biol Program, Colorado State University, Fort Collins Grassland Biome Tech Report 257:1-87; 1974.
19. Lemen CA, Clausen MK. The effects of mowing on the rodent community of a native tall grass prairie in eastern Nebraska. Prairie Nat 1984;16:5-10.
20. Schramm P, Willcutts BJ. Habitat selection of small mammals in burned and unburned tallgrass prairie. Proc Eighth North American Prairie Conf 1982;8:49-52.

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