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Edwin P. Martin

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Biographical Sketch of the Author

Edwin Perry Martin was born in Joliet, Illinois, in 1922. After four years in military service, he graduated from Cornell College, Mt. Vernon, Iowa, in 1947. He received the Master of Science degree from Kansas State College in 1948 and the Doctor of Philosophy degree from the University of Kansas in 1955. In 1948 he joined the staff of Fort Hays Kansas State College as an Instructor of Zoology and has been a member of the department since that time, serving now as professor of zoology. While at Hays, he has done extensive research on the ecology of the animals of the mixed prairie.

Distribution of Native Mammals Among the Communities of the Mixed Prairie

Introduction

FROM October, 1952, until August, 1958, the small mammals on a relict area near Hays, Kansas, were studied. The observations were undertaken to establish a standard to which the mammals of variously disturbed areas could be compared; also, information concerning the relations of the species of mammals to the communities of the mixed prairie was sought.

After six years of study information has accumulated which may be of interest to ecologists. Some conclusions can be drawn concerning the distribution and ecology of several species of mammals of the mixed prairie. Until March, 1957, the period of study was one of severe drought; from that month to the end of the study period rainfall was above average (Table 1). This situation permitted study of the responses of populations to drought and to wet years.

For these reasons it was thought desirable to prepare a report of the study. In addition to entering the results to date into the literature, preparation of this report has helped to clarify what we have learned and to plan future work more efficiently.

1
The Study Area

THE area studied is a relict area of approximately 35 acres and is 1.5 miles southwest of Hays, Kansas. The land has belonged to Fort Hays Kansas State College since 1902, and before that time was part of the Fort Hays Military Reservation. It has been undisturbed, except for sporadic grazing, since the native ungulates disappeared and has not been disturbed at all for more than 50 years.

Fortunately for one wishing to study the animals of the area, it has been the site of numerous ecological studies by Professors F. W. Albertson and G. W. Tomanek (and several generations of graduate students) of the Department of Botany of Fort Hays Kansas State College. Together with studies of other mixed prairie sites by these men, the reports of these investigations contain an enormous amount of information on the structure of the plant communities of the mixed prairie and changes in these communities over long periods of time.

Albertson (1937) provided the foundation for investigations of the ecology of the mixed prairie of Kansas, and later work by him (1938, 1939, 1943, 1945) added still more data. Albertson and Weaver (1942), Tomanek and Albertson (1953), Hopkins *et al.* (1952) and Weaver and Albertson (1956) also contributed valuable insights into the plant ecology of the area studied. Pertinent zoological literature was considerably less abundant; useful papers were those of Allen (1940), Black (1937), Brown (1945, 1946, 1947), Cockrum (1952), Hall (1955), Hibbard (1944), Reigel (1941, 1942) and Wooster (1931, 1935, 1936, 1938, 1939.)

The area studied contained all of the major types of mixed prairie communities except the upland short grass type. Within the relict

area a trapping plot was established which was 1000 feet long and 250 feet wide, and which drew animals from an area estimated to be 5.75 acres. One hundred traps, modified from those used by Fitch (1950), were set in a grid with 50 foot intervals. The trap line was operated from seven to ten days each month.

TABLE 1. Monthly precipitation and deviation from normal at Hays.

Month	Rainfall, inches	Deviation from normal	Month	Rainfall, inches	Deviation from normal
Oct., 1952	0.46	−1.66	Oct., 1955	0.16	−1.28
Nov., 1952	1.22	0.27	Nov., 1955	0.09	−0.86
Dec., 1952	0.83	0.19	Dec., 1955	0.25	−0.39
Jan., 1953	0.17	−0.17	Jan., 1956	0.63	0.17
Feb., 1953	0.69	−0.08	Feb., 1956	0.60	−0.08
Mar., 1953	1.99	1.11	Mar., 1956	0.17	−0.97
Apr., 1953	1.25	−0.96	Apr., 1956	1.28	−0.85
May, 1953	1.64	−1.87	May, 1956	1.42	−2.36
June, 1953	2.67	−1.42	June, 1956	0.38	−3.89
July, 1953	5.22	2.35	July, 1956	2.79	0.24
Aug., 1953	2.67	−0.41	Aug., 1956	1.07	−1.85
Sept., 1953	0.66	−1.61	Sept., 1956	0.06	−2.15
Oct., 1953	0.48	−0.96	Oct., 1956	0.74	−0.48
Nov., 1953	2.48	1.53	Nov., 1956	0.05	−0.89
Dec., 1953	1.15	0.51	Dec., 1956	0.02	−0.58
Jan., 1954	0.02	−0.32	Jan., 1957	0.19	−0.27
Feb., 1954	0.61	−0.16	Feb., 1957	0.11	−0.57
Mar., 1954	0.22	−0.66	Mar., 1957	2.44	1.30
Apr., 1954	1.73	−0.48	Apr., 1957	2.14	0.01
May, 1954	5.57	2.06	May, 1957	4.08	0.30
June, 1954	2.65	−1.44	June, 1957	6.74	2.47
July, 1954	1.06	−1.81	July, 1957	3.11	0.56
Aug., 1954	2.66	−0.42	Aug., 1957	3.92	1.00
Sept., 1954	1.98	−0.29	Sept., 1957	3.49	1.28
Oct., 1954	1.93	0.49	Oct., 1957	1.22	0.00
Nov., 1954	Trace	−0.95	Nov., 1957	0.80	−0.14
Dec., 1954	0.13	−0.51	Dec., 1957	0.09	−0.51
Jan., 1955	0.45	0.11	Jan., 1958	0.25	−0.21
Feb., 1955	0.64	−0.13	Feb., 1958	0.99	0.31
Mar., 1955	0.15	−0.73	Mar., 1958	3.98	2.84
Apr., 1955	3.01	0.80	Apr., 1958	1.62	−0.51
May, 1955	2.48	−1.03	May, 1958	6.81	3.03
June, 1955	3.70	−0.39	June, 1958	2.33	−1.94
July, 1955	2.09	−0.78	July, 1958	7.82	5.27
Aug., 1955	0.51	−2.57	Aug., 1958	4.35	1.43
Sept., 1955	7.63	5.36			

II

Plant Communities

WITHIN the trapping area five communities were identified on the basis of vegetative composition. For convenient reference, they were named big bluestem, little bluestem, wheatgrass, mixed grass and weed communities. Basal area and composition of the grassy vegetation were estimated by the point transect method (Clark, *et al,* 1942). The frequency and abundance of other plants were estimated as described by Weaver and Fitzpatrick (1934). Soil textures were determined by the method of Bouyoucos (1936).

A big bluestem community covered 1.49 acres of the upper hillsides of the study area (Fig. 1). On the east-facing slope this community extended farther down than on the more xeric west-facing slope. The soil underlying this community was a silty loam less than 16 inches deep, underlain by a limestone penetrable by roots.

Big bluestem *(Andropogon gerardi)* dominated this community. Its frequency was 100 per cent, and it made up approximately 70 per cent of the grassy vegetation. Little bluestem (*Andropogon scoparius*), having a frequency of 85 per cent, and side-oats grama *(Bouteloua curtipendula),* having a frequency of approximately 80 per cent, each contributed slightly more than ten per cent of the cover in this community. Other grasses having frequencies greater than 50 per cent but not an important part of the cover were switch grass *(Panicum virgatum)* and blue grama *(Bouteloua gracilis).*

Basal cover of this community was reduced to less than ten per cent after five years of drought, but it increased rapidly when the rains came to exceed 16 per cent in 1958. All major species of grass increased in abundance during 1957 and 1958, but blue grama in-

creased its percentage composition, big bluestem decreased, and little bluestem, side-oats grama and switch grass remained at the same percentage.

Eighty-six species of forbs and weeds were listed in the big bluestem community. Those most important in their effects on the bioata were soapweed *(Yucca glauca)*, wild alfalfa *(Psoralea tenuiflora)*, many-flowered aster *(Aster multiflorus)* and, after the rains in early 1957, the annual sunflower *(Helianthus annuus)*. Such weeds as wild lettuce *(Lactuca ludoviciana)* and Russian thistle *(Salsola pestifer)* were abundant in wetter years.

Perennial and warm season grasses were the most important types in this community as the annuals and cool season grasses were of negligible importance. Three layers of grass were evident. An upper story of big bluestem and frequent bunches of switch grass, was over an intermediate layer of little bluestem and side-oats grama. The understory was relatively sparse and consisted primarily of blue grama. Local areas of this community were domi-

FIG. 1. View from western end of trap line. In the foreground is a big bluestem community. The lighter area on the lower part of the far slope is a western wheatgrass community. Below the big bluestem in the foreground is a mixed grass community. The weedy draws can be seen on the left of the near slope and crossing between the two slopes.

nated by societies of rigid-leafed goldenrod *(Solidago rigida)* and many-flowered aster, which more or less controlled the vegetation and made small areas virtually useless to mammals since the plants were not used at all.

To summarize, the big bluestem community had a high proportion of perennials (approximately 80 per cent of the species) and produced most of its growth during mid and late summer. Annual grasses and weeds completed their life cycles early in the summer and probably made important contributions to cover and forage in spring and early summer. This community produced an abundance of seeds, fruits, and forage, and a heavy mulch provided a good ground cover. The community differed from the others studied in the abundance of tall grasses having high forage production, in the relatively sparse understory and in the greater importance of the societal forbs.

An area of 0.24 acres along a rocky break on a west-facing slope was occupied by a community named by Albertson and Weaver (1942) as open type little bluestem (Fig. 2). A steep slope, a

FIG. 2. View near the east end of the trap line. The big bluestem community in the immediate foreground borders a little bluestem community on the break. The open cover, surface rock and bunch grass characteristic of the little bluestem community are easily seen.

sandy loam less than eight inches deep and a large amount of surface rock characterized this community. Little bluestem was the dominant grass. It had a frequency of 100 per cent and made up approximately 60 per cent of the grassy vegetation. Big bluestem was the only other grass of importance in the community, although scattered plants of blue grama and hairy grama (*Bouteloua hirsuta*) were present.

Fifty-four species of forbs were recorded from the little bluestem community. Nearly half (24) of these appeared only after the end of the drought in 1957. The most common species were the rigid-leafed goldenrod, sensitive briar (*Morangia uncinata*), slender tetraneuris (*Tetraneuris stenophylla*) and narrow-leafed houstonia (*Houstonia angustifolia*). The plants were sparsely distributed over the area and, as a group, were noticeably less vigorous than the forbs from other communities.

Little stratification was evident in this community. The dominant feature of its spatial organization was the bunch form of little bluestem. The lack of mulch and the sparseness of the vegetation produced a community that was nearly devoid of ground cover. Both forage and seed production were insignificant when compared with other communities. Most of the useful vegetation that was produced matured in late summer and the community was especially desolate in winter.

A community dominated by western wheatgrass (*Agropyron smithii*) occupied 0.69 acres across the bottom of a west-facing slope (Fig. 1). The soil under the wheatgrass community was a silty clay loam more than three feet deep. This cool season grass showed little decrease in cover during the drought but was noticeably more vigorous in wetter seasons. Its spring and fall growth habits appeared to have permitted maximum use of available rainfall.

Western wheatgrass, having a frequency of 100 per cent, made up approximately 34 per cent of the grassy vegetation. Other grasses of importance were blue grama, side-oats grama and Japanese brome *(Bromus japonicus).* Blue grama filled much of the space between the stems of western wheatgrass and made up approximately 30 per cent of the cover. Side-oats grama was distributed throughout the community and during midsummer appeared to be codominant with wheatgrass; it actually constituted but 17 per cent of the cover.

Fifty-six species of forbs and weeds were identified in the western wheatgrass community. Most abundant of the non-grassy

plants were western ragweed (*Ambrosia psilostachya*), many-flowered aster, and fire weed (*Kochia scoparia*). After the rains began, such weeds as bedstraw (*Galium aparine*) and tansy mustard (*Sophia* spp.) became abundant in the community. Its weediness, greater than that of any other grass-dominated community, was probably due to the fact that it was adjacent to a weedy community and to the early maturing of the dominant grass, before the weeds made most of their growth.

This community had a number of interesting features. Both the dominant wheatgrass and the annual Japanese brome were cool season grasses and provided an abundance of early forage. Also, wheatgrass often resumed growth after the usual fall rains and produced significant amounts of forage in October and even November. The upper stratum of wheatgrass and the understory of blue grama produced a community with the high basal area of the short grasses and the high forage production of the mid-grasses.

To summarize, the western wheatgrass community yielded more forage than any community studied except the big bluestem community. The cool season grasses made especially important contributions to the vegetation in spring and fall. A fairly dense understory of blue gama added to the productivity of the community and provided ground cover. The relatively large weedy component increased seed production in the community and provided a winter food source.

A weedy community occupied 1.03 acres of the study area (Fig. 3). It lay in a draw that was once a typical lowland community (Albertson, 1937) but had been heavily silted from a pond in an adjacent pasture. In 1951, the dam of the pond broke and it was not repaired for several years; consequently the silting was repeated many times. As a result, a weedy community developed on the deep heavy soil.

By 1956, perennial grasses were invading the community, and they increased during 1957 and 1958. Big bluestem and western wheatgrass were both abundant by 1958, and switch grass and wild rye *(Elymus canadensis)* were abundant in spots. Kentucky bluegrass *(Poa pratensis)* appeared in significant amounts after the rains began in 1957. The most abundant grass, however, was the weedy annual, Japanese brome.

More important than the grasses in this community were the forbs and weeds; 62 species of non-grassy plants were recorded. Of

these, western ragweed, annual sunflower, wild lettuce, bedstraw and the purple poppy mallow (*Callirrhoe involucrata*) were the most important.

Wheatgrass, bluegrass, and Japanese brome, all cool season grasses, produced most of their forage in spring and early summer. During late summer and fall, weeds overtopped the grasses and provided a heavy seed crop available through the winter. A clear stratification of three layers was observed. The upper story was largely wild lettuce during the first half of the growing season, but big bluestem and annual sunflower were added after midsummer. A middle layer included western wheatgrass, tansy mustard and many-flowered aster; the understory contained blue grama, Kentucky bluegrass, Japanese brome and bedstraw. Thus the community produced forage, especially in early summer, provided a high foliage cover throughout the growing season and offered an abundant seed crop for fall and winter consumption.

The remaining 2.29 acres of the study area was named a mixed grass community (Fig. 1). Lying on both east and west-facing

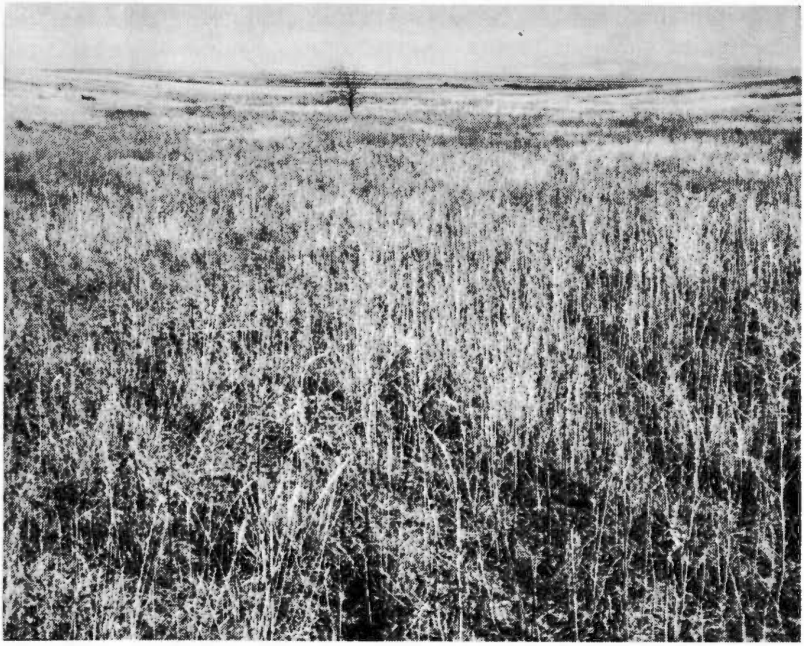

FIG. 3. View of the weedy draw bisecting the trap line. The picture was taken in November after much of the foliage was gone. The tree in the background is a hackberry tree.

slopes below the bluestems and above the wheatgrass and weeds, this community was an arbitrary grouping of a variety of types of vegetation. The underlying soils were silty loams and silty clay loams less than two feet deep in some places and more than three feet deep in others. No one type of vegetation occupied sufficient area to justify subdivision.

Big bluestem, western wheatgrass, side-oats grama, blue grama and wild rye each achieved local dominance. Some areas, usually sites of disturbance by animals, were nearly pure buffalo grass *(Buchloe dactyloides),* but the buffalo grass was not common over the area as a whole. Some parts of the community were weedy; these were usually sites of recent disturbances.

One hundred and six species of forbs and weeds were identified in the mixed grass community. Of these, eight were most obvious: the many-flowered aster, snake root *(Echinacea angustifolia),* wild alfalfa, wavy-leafed thistle *(Cirsium undulatum),* lead plant *(Amorpha canescens),* western ragweed, annual sunflower and sensitive briar. Some stratification was observed. Blue grama, widely distributed and relatively abundant, provided an understory over most of the community. The middle layer was characterized by western wheatgrass, side-oats grama, wild alfalfa and many-flowered aster. In spots, an upper story of big bluestem, wild rye or annual sunflower was also present. Wheatgrass and buffalo grass were present as pure stands on small areas. The mixed grass community had the greatest variety of species of plants of any community studied.

III

Mammalian Populations

DURING the period here described, 1139 mammals were captured 2636 times (Table 2). Eight species were represented in the group. One of them, *Reithrodontomys montanus albescens* Cary, was represented by only a single capture and will not be considered further. The animals captured were marked by toe clipping (Fitch, 1952) and released. The use of live-trapping to study mammalian populations has been discussed by many authors (*e. g.* Blair, 1948; Stickel, 1946; 1948; Cockrum, 1947) and will not be analyzed here.

Habitat preferences were analyzed by testing the hypothesis of random distribution; significant deviations were interpreted as positive or negative preferences. Explanations for the distributions observed were sought by examination of the life history data and the properties of the plant communities.

TABLE 2. Number and kind of mammals captured on the live-trap line between October, 1952, and August, 1958.

SPECIES	Number of individuals	Number of captures
Reithrodontomys montanus albescens Cary	1	1
Microtus ochrogaster haydeni (Baird)	266	607
Peromyscus maniculatus luteus Osgood	403	1,082
Sigmodon hispidus texianus (Audubon and Bachman)	172	355
Spermophilus tridecemlineatus arenicola (A. H. Howell)	137	464
Reithrodontomys megalotis dychei J. A. Allen	110	324
Perognathus hispidus paradoxus Merriam	31	86
Onychomys leucogaster arcticeps Rhoads	19	42

The year was divided into four seasons which seemed to me to be natural ones for the location of the study: winter—December and January; spring—February, March, and April; summer—May, June, July, August, and September; fall—October and November. The basis for this division was a combination of patterns of vegetative growth, patterns of mammalian populations, and patterns of variation of climatic factors.

Mammals were named after Hall (1955).

Microtus ochrogaster haydeni (Baird)

The prairie vole, *Microtus ochrogaster haydeni*, was captured every month between June, 1955, and September, 1956, and between September, 1957, and the end of the study period in August, 1958. Prior to 1955, single voles had been captured in each of three trapping periods. During the study, 266 voles were captured 607 times.

In the fall of 1958, after the end of the period described, voles again disappeared from the study area. They appear to have been sporadic inhabitants of the area for several years. During the early thirties they were abundant (Wooster, 1937; 1936; 1939) and during the late forties and early fifties they were rare (Martin, 1956). Some workers (*e. g.* Black, 1937) reported them as absent from Ellis County. My data indicated that they fluctuated violently in numbers, but probably were always present. No explanation of the alternation of abundance and scarcity was discovered. In this study, for example, one of the periods of abundance was during an extremely dry period and the other during a relatively wet period. One factor, possibly involved in regulating the population levels of voles, was the abundance of cotton rats (*Sigmodon hispidus texianus*). A relationship, suggested in an earlier paper (Martin, 1956), in which the cotton rats depressed population levels of voles received further support in this study. Peaks of abundance of voles and of cotton rats alternated during the six years (Fig. 4). The two populations were especially interesting during 1958. During the winter of 1957-58, cotton rats were abundant and voles were rare. A heavy snow fell at the end of February, 1958, and remained on the ground through March (30 inches deep in some parts of the study area). In April, when the traps could be operated again, the cotton rats had disappeared and they did not return in significant numbers until September. During the summer of 1958, voles were abundant but their numbers began to decline in September. The decline continued as the cotton rat population rose until, at the end of 1958, no voles were trapped.

Previously, an annual population cycle, with peaks in spring and fall, has been described for voles in Kansas (Martin, 1956). During the times voles were present in this study they reached their highest densities in July, August and September, with a secondary peak in March. The decline toward winter lows began in October and usually continued through January. A slight midsummer decrease in the number of voles trapped might have been due to their reluctance to enter the traps (Fitch, 1954). In the winter of 1955-56, the populations remained somewhat higher than expected. Perhaps an unusual fall growth of grasses, due to more than seven inches of rain in September, 1955, raised the carrying capacity of the trap line. That unusual survival rather than unusual reproduction maintained the unexpected population level was indicated by the fact that reproductive activity almost ceased by November, as usual.

Reproductive activity was measured by the percentage of females having a vaginal orifice (Fitch, 1957). Some breeding was recorded in every month of the year. The highest percentages of perforate females were recorded in June, July and October; lowest percentages were recorded in January and February. In spite of earlier reports relating reproductive activity to rainfall (Fitch, 1957; Martin, 1956), no consistent difference in levels of

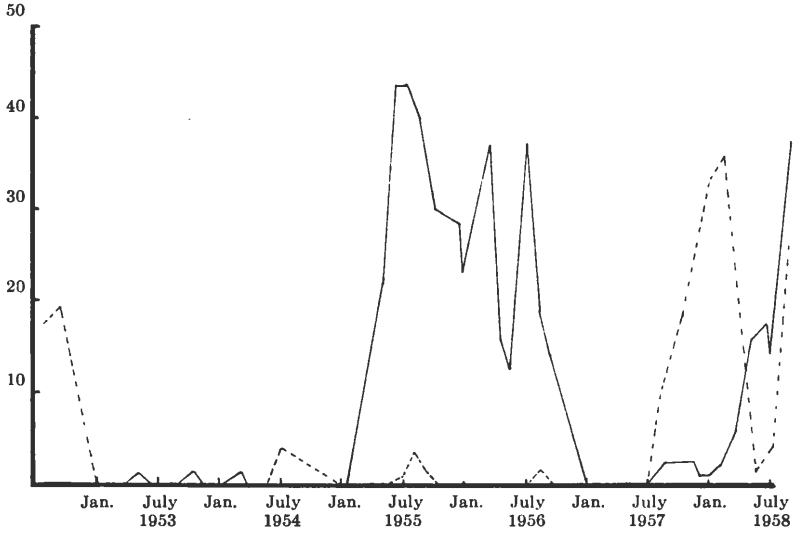

FIG. 4. Graph of numbers of individuals captured. The solid line represents voles and the broken line cotton rats. During the fall of 1958, immediately after the end of the graph, voles declined sharply while cotton rats continued to increase.

reproductive activity between wet years and dry years was observed. No pattern of variation in reproductive activity was identified in this study. Perhaps the subspecies studied, in its adjustment to semi-arid grassland, has other key stimuli for reproductive activity than the rainfall and plant growth described in the studies cited.

Population densities of voles were considerably less than those reported for the species in less arid regions (Brumwell, 1951; Martin, 1956) and during earlier studies on the mixed prairie (Wooster, 1939). Probably reduced rainfall and forage production explain the differences in the different regions studied, but the greater rainfall in 1957 and 1958 did not lead to higher densities of voles in this study. The highest density recorded for the entire trapping area was 7.49 voles per acre.

The voles were not, of course, distributed evenly over the study area but were more abundant in some communities than in others (Table 3). During all seasons of the year voles showed a preference for the western wheatgrass community. The preference was greatest in spring and fall, when densities as high as 21.74 voles per acre were recorded in the wheatgrass community. The heterogeneous composition of this community and its relatively high forage production combined with a high foliage and basal cover probably explained the general preference. The exaggerated preference shown in spring and fall was probably due to the early and late growth of the dominant wheatgrass that provided young

TABLE 3. Community preference of mammalian species. Plus signs indicate an abundance greater than expected from an hypothesis of random distribution and minus signs an abundance less than expected. Differences were asserted only when they were significant at the five per cent level of confidence. Descriptions of the communities named are in the text; seasons of the year are defined in the text. sp—spring; s—summer; f—fall; w—winter.

Community	Big bluestem				Little bluestem				Western wheatgrass				Mixed grass				Weed			
Season	sp	s	f	w	sp	s	f	w	sp	s	f	w	sp	s	f	w	sp	s	f	w
SPECIES																				
Vole	−	−	−		−	−			+	+	+	+	−	−	−			+		
Deer mouse	+	+	+		+	+	+	+			+		−		−			−	−	
Cotton rat	−	−	−		−	−	−	−		+	+	+		−			+	+		
Ground squirrel		−				−														
Harvest mouse	−	−			−	−			−	−					−			+	+	+
Pocket mouse	no preference shown																			
Grasshopper mouse	no preference shown																			

grass tissues at times when they were scarce in the other communities. Blue grama, more abundant in the wheatgrass than in the other communities, provided an understory that made the habitat more desirable to voles (Martin, 1956).

During summer only, voles showed a preference for the weedy community. In spite of a low basal cover, the rank growth habits of the plants in the weedy community provided nearly 100 per cent foliage cover in the summer. The variety of plants also insured a continual supply of young tissue during the growing season, and the greater succulence of the weeds as compared to grass probably was also attractive to voles. Seeds, harvested and stored by voles, were also abundant in the weeds. During the remainder of the year, the dead weed stalks were apparently inadequate cover and voles were seldom captured in this community.

A marked negative preference for the little bluestem community was shown by voles. The bunch grass form of the dominant grass left too much bare ground for voles, since ground cover of some sort seems to be one of their requirements. In spite of previous statements associating voles with big bluestem (Wooster, 1935; Allen, 1940), the vole showed either a negative response or were indifferent to it (in winter) in this study. The same was true of the mixed grass association. At the time the earlier observations were made western wheatgrass was much less abundant in the mixed prairie than now and was not mentioned as vole habitat. It is my opinion that the voles choose the best habitat on the site studied, in this case western wheatgrass, but would use the other communities rather than disappear with the elimination of the favorite habitat type. Such a response has been indicated also in exclosures in pastures; voles are found in all exclosures at some time, whether the community be shortgrass, bluestem, or wheatgrass, and are rarely found in grazed areas. Apparently a wide variety of grassy communities are acceptable to voles, but among the five types available on the trapping area studied, western wheatgrass was most heavily used.

Some information on habitat needs was obtained from an analysis of the situation of particular traps which were either especially successful or unsuccesful in capturing voles. For example, trap 33 in the mixed grass community was attractive to voles. Since the community in general was not, the fact that the trap sat in an area dominated locally by western wheatgrass (see description of communities) probably explained the attraction.

Violent and irregular fluctuation of the vole population suggested the extreme sensitivity to environmental changes reported previously (Jameson, 1955; Martin, 1956). Other than the above-mentioned relationship with the cotton rats, however, no environmental variant was observed to be related clearly to the fluctuations of the population.

Peromyscus maniculatus luteus Osgood

The prairie deer mouse, *Peromyscus maniculatus luteus,* was the most abundant mammal on the study area. Except for March, April, June and July of 1957, it was captured each month of the study. During the study period, 403 individuals were captured 1082 times. Several earlier studies have commented on the abundance and wide distribution of this species in Kansas (Cockrum, 1952; Black, 1937; Brown, 1946). Because of its abundance in a variety of habitats, its ecology is of considerable importance.

Population densities of the deer mouse were more regular in their fluctuations than were those of the other species studied. Each year peaks occurred in the April-May and October-November periods; populations declined in both midsummer and midwinter, with July and August levels reaching the annual low points. The only obvious irregularity was observed from October, 1956, to September, 1957, when very few mammals of any kind were trapped.

As reported by Brown (1945; 1946), the deer mice in western Kansas breed throughout the year. Reproductive activity seemed to be less from July to December than during the first half of the year. No definite pattern of reproduction was perceived.

Part of the apparent midsummer slump in population probably was due to the abundance of insects for food and consequent greater reluctance to enter traps (Fitch, 1954). In addition to insects, the deer mouse eats seeds, which are more abundant in fall and winter than in summer; thus food habits perhaps partially account for the annual population pattern. Jameson (1955) reported that populations of the deer mouse were more adaptable to changes in environmental conditions and fluctuated less violently than voles; such an idea was supported for the two species in the area of this study.

Over the area as a whole, the highest population density reached by the deer mice was 9.41 individuals per acre. For most of the study, the densities varied between three and seven individuals per acre. If the population levels within communities were studied, however, densities as high as 30 individuals per acre were recorded, and most densities in favored communities were between eight and

20 individuals per acre. In the mixed prairie, deer mice are ordinarily more abundant in moderately grazed grassland or middle seral stages of secondary succession than in climax vegetation as in the area of this study.

The deer mouse was most obviously associated with the little bluestem community. Bunch grass and relatively large expanses of bare ground were the most obvious features of this community. Together with the responses of the species to grazing and the statements of previous writers on deer mouse habitat (Fitch, 1958; Brown, 1946), these data indicated that the deer mouse preferred only a moderate basal cover together with a relatively high seed production. A preference for the big bluestem community, except during the winter, and a negative preference toward the weed community in summer and fall did not fit such an idea too well, however.

An examination of the environment of traps especially attractive to deer mice in the big bluestem area provided a possible explanation of its use. Without exception, these traps were surrounded by more forbs and weeds than was typical of the community in general. Since seeds comprised a major share of the diet of these creatures, they may have used parts of the big bluestem community intensively because of a desirable food supply. The one exceptionally successful trap in the western wheatgrass community was adjacent to the weeds, which perhaps supports that explanation. In the mixed grass area, most deer mice were captured in areas of disturbance (*e. g.* badger workings) where the vegetation was sparse.

From all of the information available, I gained the impression that the deer mouse could live more or less successfully in all of the communities of the mixed prairie. Perhaps its preferences in any situation are partly determined by competition with other less adaptable species.

Sigmodon hispidus texianus (Audubon and Bachman)

The hispid cotton rat, *Sigmodon hispidus texianus*, was first captured in the area of the study in 1949. It has been extending its range north and west in Kansas for several years. The stages of the extension have been described by Black (1937), Allen (1940), Cockrum (1948; 1952) and Rinker (1942).

During the period of study, 172 cotton rats were captured 355 times. At the beginning of the trapping, in the fall of 1952, cotton rats were abundant, but the populations declined during the winter and did not recover until after the rains of 1957. During the last half of 1957 and in 1958 the rats were abundant, except for a period

during and after an unusually heavy snow. Deep snow covered the trapping area during all of March, 1958; afterward, no cotton rats were taken until June, when the population recovered rapidly. The cotton rats were successful in the mixed prairie whenever rainfall was abundant but almost disappeared during the drought. Although severe winters caused severe population depression, recovery was rapid if rainfall was sufficient.

Densities between five and seven individuals per acre were maintained by the cotton rats, over the whole area, when they were present. In favored habitats, however, densities as high as 14 rats per acre were recorded. During summer and fall, the cotton rats showed a strong preference for the wheatgrass community. Weeds were also favored in summer. Little bluestem areas were avoided at all seasons, and big bluestem and mixed grass were also avoided in summer. The traps that were especially successful in capturing cotton rats were in the weedy community, and the heavy catches were made in late summer and fall when the heavy seed crop of the weedy community was available. During periods of scarcity cotton rats were captured in the weeds in summer.

In general, populations of cotton rats on the study area behaved as one might expect marginal populations to do. They occupied the more productive sites, they were abundant during unusually productive years, and their numbers were quickly and radically reduced by drought and hard winters. Their relations with the prairie vole have been discussed earlier.

Spermophilus tridecemlineatus arenicola (A. H. Howell)

Spermophilus tridecemlineatus arenicola, the thirteen-lined ground squirrel, was a prominent part of the summer fauna of the mixed prairie. In this study, 137 individuals were captured 464 times. The ground squirrels disappeared from the area in October and the first captures of each year were made in March. Most individuals were captured in July and August after the weaning of the litters had freed the females and added numerous subadults to the population. Densities varied from one to six per acre.

This species was the only one in which the sex ratio of the captures differed significantly from unity. Since no report of a real difference was found in the literature, the variation was probably due to the lower mobility of the females, especially during the spring and early summer.

No preference for any community was observed. Individual ground squirrels were often caught in traps hundreds of feet apart.

Apparently, the ground squirrels used the whole mixture of the mixed prairie. Those traps which were especially successful in capturing ground squirrels were set in weedy parts of the mixed grass community.

Reithrodontomys megalotis dychei J. A. Allen

The western harvest mouse, *Reithrodontomys megalotis dychei,* was represented in the study by 110 individuals captured 325 times. Almost all of these were captured in 1952 and 1953. Since the beginning of 1954, only a few harvest mice have been taken. Hibbard (1944) and Fitch (1952; 1958) have suggested that these mice are restricted to the lusher vegetation and the drought of the fifties left little such vegetation on the study area. However, no marked recovery of the population was observed after the rains began in 1957.

Those individuals caught did not demonstrate an annual cycle of abundance. Most individuals were trapped in late winter and early spring, but this probably reflected bait acceptance rather than population densities (Fitch, 1954).

During all seasons of the year, the harvest mice showed a strong preference for the weedy community. In part, this was probably due to their reliance on seeds for food. In late fall and early winter, harvest mice were often observed to climb tall weeds to reach the seeds. During early 1953, harvest mice reached a density of eight individuals per acre over the area as a whole, but the density was as high as 18 per acre in the weedy community. The relatively open little bluestem community was always avoided by the harvest mice, as were traps in the more open parts of the mixed grass community.

Perognathus hispidus paradoxus Merriam

The hispid pocket mouse, *Perognathus hispidus paradoxus,* was also present on the study area. Thirty-one individuals were trapped 86 times. Usually but one or two individuals were trapped during a monthly trapping period. No clear annual cycle was observed nor a preference for any community. These negative observations were doubtless due to the small number of individuals captured. Some pocket mice were captured in every month of the year; consequently presumptions of hibernation in the species (Hall, 1955) were not supported in west central Kansas.

Onychomys leucogaster arcticeps Rhoads

Onychomys leucogaster arcticeps, the northern grasshopper mouse, was caught sporadically and infrequently. Nineteen individuals were captured 42 times. The small number trapped permitted few conclusions to be drawn. Specimens in the collection at Fort Hays Kansas State College suggested that some genes from the eastern subspecies, *O. l. breviauritus*, may have entered the population studied, but all specimens were referred to *O. l. arcticeps*.

Other Vertebrates

Many other vertebrates were, of course, present on the study area. While in most cases their numbers were small, some information was gained by rather casual observation. The following list is annotated when comments seemed appropriate.

Mammals

Didelphis marsupialis virginianus—opossum. An occasional individual seen, especially in winter; several killed on adjacent road.

Blarina brevicauda carolinensis—short-tailed shrew.

Cryptotis parva parva—little short-tailed shrew. Both shrews were captured occasionally in the more luxuriant vegetation.

Sylvilagus floridanus similis—eastern cottontail.

Lepus californicus melanotis—black-tailed jackrabbit. Jackrabbit populations fluctuated violently on the study area. They appeared to congregate in the ungrazed vegetation in the winters, probably for shelter and grass seed. They were a nuisance in winter because they kicked over traps in in an effort to get the bait.

Canis latrans latrans—coyote.
One family of coyotes lived and bred on the study area. The den was well up on a north-facing slope. Scat analysis indicated that rodents and rabbits made up almost their entire diet. One scat containing hair of a calf was found.

Procyon lotor hirtus—raccoon. No coons were seen on the study area but scats were found.

Mustela frenata longicauda—long-tailed weasel.

Taxidea taxus taxus—badger. Several badgers lived on the study area. Their most obvious importance was to cover surprisingly large areas with dirt and thereby initiate local secondary seres.

Birds

Cathartes aura—turkey vulture.

Circus cyaneus—marsh hawk. Each year of the study, a pair of marsh hawks nested in the weedy community. Pellets contained remains of deer mice, primarily.

Phasianus colchicus—ring-necked pheasant. Pheasants nested in the study area, and were also abundant in winter in the draws.

Zenaidura macroura—mourning dove. Doves nested on the ground in the study area. Their nests were often exposed and nest mortality was high. (Fig. 5).

Chordeiles minor—nighthawk. Nighthawks frequently were seen sitting on rocky parts of the study area during daytime.

Tyrannus arkansensis—western kingbird. Western kingbirds nested, one year, in a scrubby hackberry tree, the only tree on the area.

Eremophila alpestris—horned lark. Several horned larks nested in the study area; however, they were less abundant than in adjacent moderately grazed grassland.

Sturnella neglecta—western meadowlark. The meadowlark was a common inhabitant of the study area. Usually, its nest was at the base of such vegetation as lead plant or switch grass. (Fig. 6.)

Agelaius phoeniceus—red-wing blackbird. The red-wing was a regular nester in the weedy community. Nests were suspended from tall weeds and tall grasses. (Fig. 7.)

Spiza americana—dickcissel. The dickcissel was perhaps the most abundant nesting bird on the study area. Primarily an inhabitant of the weedy community, its nests were also found in the mixed grass community.

Calamospiza melanocorys—lark bunting. In some years, lark buntings were abundant on the study area, nesting in the big bluestem and mixed grass areas. In other years, none was present.

Ammodramus savannarum—grasshopper sparrow.

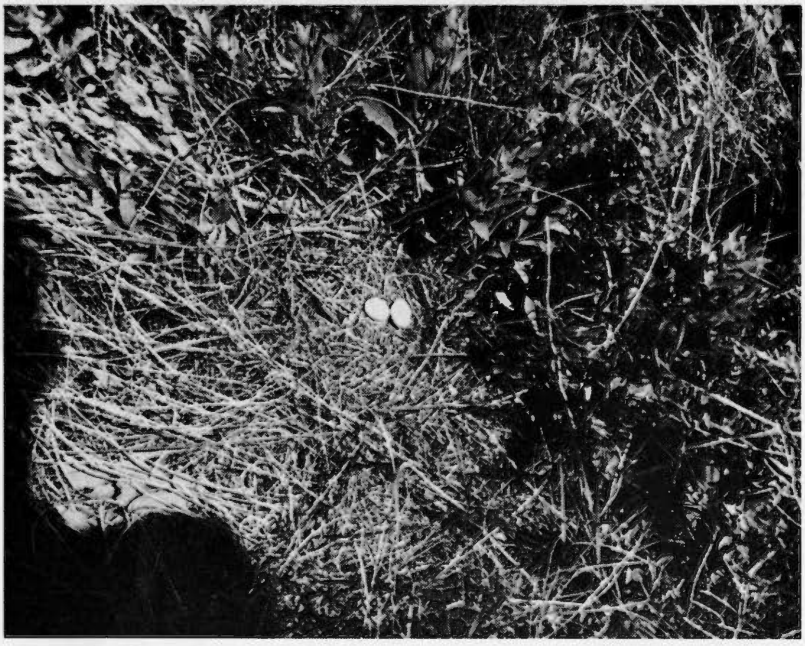

FIG. 5. Nest of mourning dove. The eggs are completely exposed and the nest is little more than a pile of grass. The grass in the picture is mostly western wheatgrass and the most obvious forb is the prairie goldenrod.

FIG. 6. Nest of western meadowlark. The eggs are almost hidden by mulch of big bluestem. The opening was enlarged to permit the nest to be photographed.

Reptiles

Crotalus viridis—prairie rattlesnake.
Thamnophis radix—garter snake.
Pituophis melanoleucus—bull snake.
Coluber constrictor—blue racer.
Eumeces obsoletus—Sonoran skink.
Phrynosoma cornutum—horned lizard.
Sceloporus undulatus—rough-scaled lizard.
Terrapene ornata—box turtle.

Amphibians

Bufo cognatus—plains toad.

FIG. 7. Nest of red-wing blackbird. This nest was suspended in a clump of switchgrass and was photographed from above.

IV

Discussion

DETAILED descriptions of various habitats used by native mammals may help to reveal ecological relationships not obvious when distributions are plotted on a larger scale. These relationships should increase the ability of biologists to explain many of the fluctuations of populations as well as the vagaries of distribution.

Population densities estimated from sampling heterogenous areas, without consideration of the type of distribution among communities described in this paper, may lead to erroneous conclusions in both applied and theoretical ecology. The effects of native mammals on range condition and the ecological role of a mammalian species would both be misunderstood without relating density and distribution to plant communities.

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