ABUNDANCE AND DIVERSITY OF MAMMALS ON THE CRANE MEADOWS OF MORMON ISLAND, HALL COUNTY, NEBRASKA

by

Joseph T. Springer
Department of Biology
Kearney State College
Kearney, NE 68847

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JOSEPH TUCKER SPRINGER, Department of Biology, Kearney State College, Kearney, Nebraska 68847

Abstract. In order to determine the abundance and diversity of mammals, 3 methods were employed. Small mammals were investigated by using snap-trap transects and live-trap grids, and larger mammals were investigated by observing strip-transects. Snap-trapping was done in 3 habitat types: 519 trap-nights within the narrow riparian woods bordering the Platte River (River), 72 trap-nights along the edge of grasslands and woods, at least 20 m from the river (Woods-Field), and 50 trap-nights in 2 cottonwood (Populus deltoides) dominated woodlots, where traps were at least 10 m from either the river or grasslands (Woods). Deer mice (Peromyscus maniculatus) were the most frequently captured of 6 species during snap-trapping, a high rate indicating that small mammal productivity was high. Live-trapping was conducted primarily during 2 sessions on 2 1-ha grids, both in ungrazed hay meadows, though the grasses of Grid I averaged 1.5 times taller than those of Grid II. Meadow voles (Microtus pennsylvanicus) were the most common of the 5 species caught on Grid I, with 20.4 captures/100 trap-nights and 9.8 captures/100 trap-nights for the 2 sessions. Deer mice were the most common of the 7 species caught on Grid II, with 11.3 captures/100 trap-nights and 8.9 captures/100 trap-nights for the 2 sessions. Strip-censuses were conducted twice, for

3 nights each time. There were 8 species of larger mammals observed, with the most abundant being black-tailed jackrabbits (Lepus californicus) at a density of 42.2/km^2 and 6.1/km^2 for the 2 sessions. From all methods, 26 mammal species were identified, 17 of which were collected.

This study was designed to identify the majority of mammals present on Crane Meadows, to determine their relative densities and habitat preferences, and when possible to determine age and sex ratios.

Crane Meadows is delineated by the dashed line in Fig. 1, and comprises an area of 7.7 km^2. This land was purchased in 1979 by the Whooping Crane Trust Fund, and since then, has been managed by The Nature Conservancy. During this study, 42% of this land was grazed by cattle, 40% in native hay meadows, and about 18% was cultivated cropland (mainly alfalfa and corn).

Crane Meadows is only the western end of Mormon Island, which is surrounded by the multi-channeled, braided Platte River. The uncultivated parts of Crane Meadows are dominated by native grasses. There is a narrow strip of riparian habitat along the Platte River channels consisting mainly of deciduous trees: cottonwood (Populus deltoides), boxelder (Acer negundo), dogwood (Cornus spp.), and some willow (Salix spp.).

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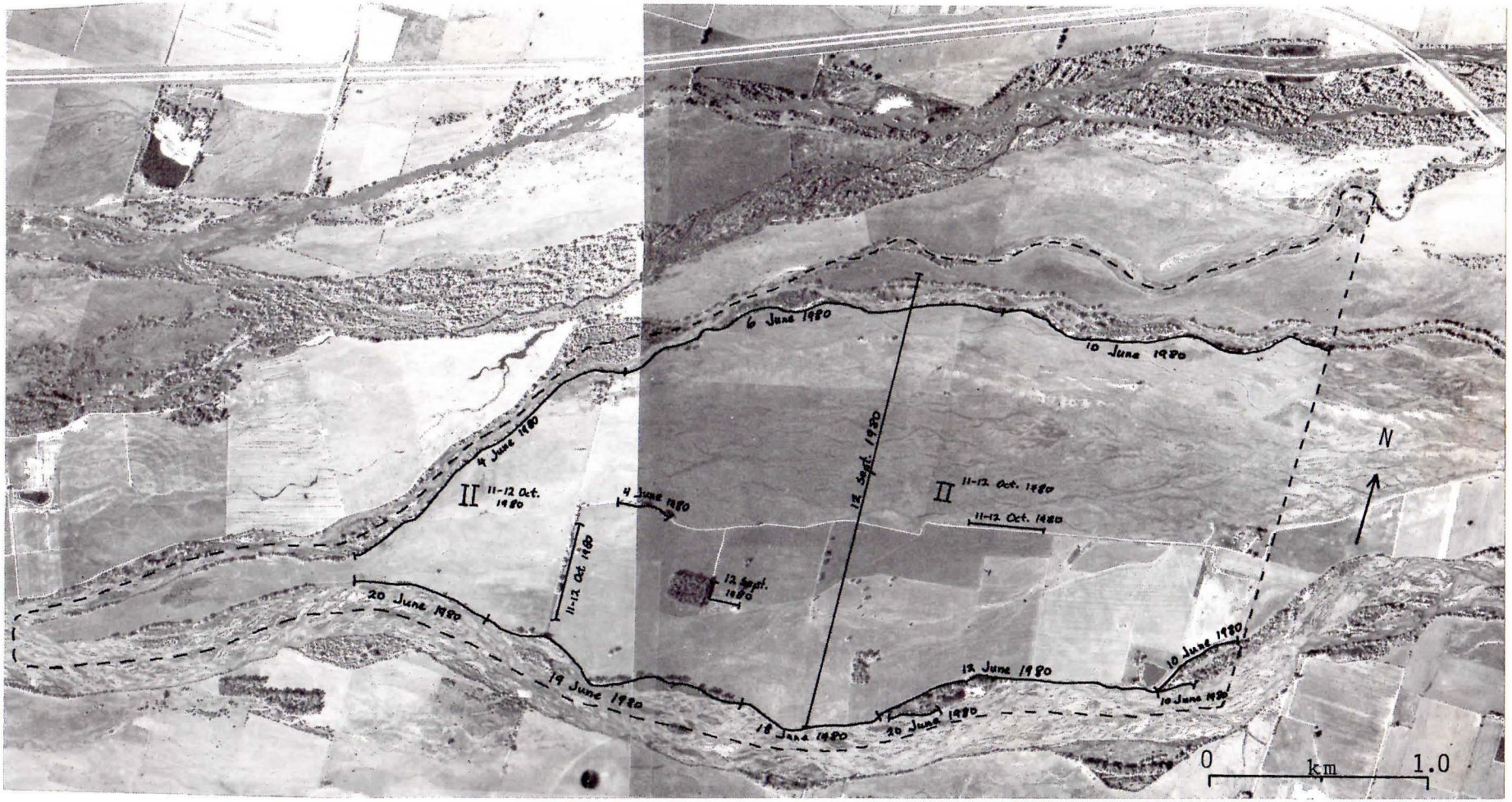

Fig. 1. Crane Meadows (outlined by dashed line) of Mormon Island, Hall County, Nebraska. Trapping transects are dated and are shown as solid lines.

MATERIAL AND METHODS

In order to determine the diversity and relative abundance of all mammal species on Crane Meadows, 3 basic methods were employed. Snap-trapping was used to index small mammals along the perimeter of the study area in places where trapping grids could not be established, yet where cattle were excluded. Live-trapping grids were used to index small mammals within 2 fairly different grassland habitats. The third method was to conduct strip-censuses of larger mammals from the roadways of the study area.

Snap-trapping

Snap-trap transects were run on 8 nights between 3 and 24 June 1980. The traps, Museum Specials and Victor Rat Traps, were set at 10-m intervals within the narrow strip of riparian habitat along the perimeter of the main island (Fig. 1). Where the strip exceeded 20 m, the traps were set at the edge of the riparian habitat toward the island's center as well as along the river in order to sample 2 habitat types. Transects were also run within 2 woodlots: one in the southwest part of the main island and the other at the southeast corner. Thus, 3 habitat types were trapped in: riparian strip (River, edge of this wooded strip and grasslands (Woods-Field), and the central portions of woodlots (Woods).

In the fall, a line of snap-traps was set running north and south through the middle of Crane Meadows. Unfortunately, virtually all the traps within the pasture area were disturbed and sprung by cattle which were still using the pasture. At this same time, a few additional traps were set around the barn and haystacks near the live-trapping Grid II.

Live-trapping

The 2 live-trapping grids were set up in late June, and are shown in Fig. 2. Each grid measured 90 m/side, with 100 sites/grid set at 10-m intervals. The corners of both grids were marked with 1.5-m steel fence-posts, and each trap-site was marked with a 0.5-m surveyor's flag. The traps were 7.6- x 7.6- x 25.4-cm box traps based on the Sherman-trap style. Some were collapsible aluminum traps, but most were non-collapsible traps of galvanized steel. Old hay was used to form a nest on top of each trap to provide shelter from the direct radiation of the sun.

Grid I was located on the north island of Crane Meadows in an area where no summer grazing was to occur, and which has been mowed for hay every fall for several years. The habitat was dominated by big bluestem (Andropogon gerardi) and Indian grass (Sorghastrum avenaceum). This area remained wet for a long period of time, as evidenced by the abundance of horsetail (Equisetum spp.). The average vegetation height on Grid I was slightly greater than 1.0 m, which made it difficult to locate the surveyor's flags from a distance.

Grid II was in the southcentral part of the main island, also a hay meadow with no cattle grazing. This site was mowed on 13 August 1980, the afternoon before the first night of the second trapping session. The habitat was dominated by brome and a variety of forbs. The average vegetation height of slightly more than 0.5 m was less than that of Grid I, and the surveyor's flags were generally visible.

Both grids were pre-baited for 4 days prior to the 1st session, in order to accustom the animals to the traps. The 1st session traps were set on 29 June through 11 July 1980, with traps being set for 10 nights.

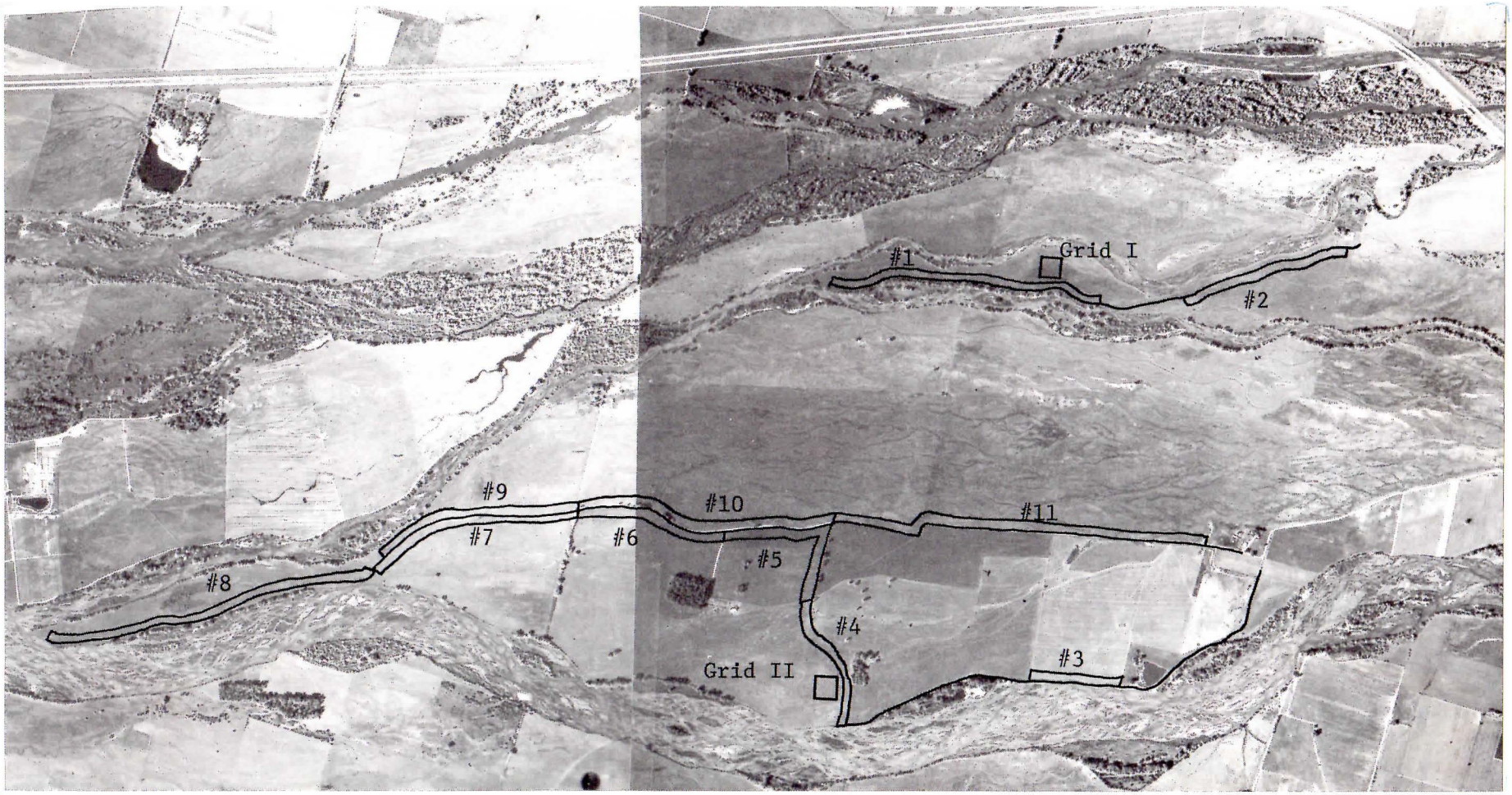

Fig. 2. Locations of Grid I (north) and Grid II (south) used for live-trapping during the summer on Crane Meadows, and strip census route used to count large mammals.

The 2nd session began on 13 August and ended on 22 August 1980, with traps set for 9 nights.

Because cattle were to be grazed at some time on the entire northern half of the main island and at the west end, no live-trapping was conducted in those regions. Some exclosures within those areas were live-trapped in fall in order to note any species differences when compared to the mowed areas.

During most of the 1st session, only every other trap was set. After 2 nights, these traps were closed and the other half of the traps were set. Thus, 50 traps/grid were set at any given time, but the entire area of the grid was covered.

Traps remained set at all times, and were checked every morning. Each trap was baited with 5 pieces of large elbow macaroni. These allow easy handling unlike peanut butter, would not lodge beneath the trap treddle as sunflower seeds do, and since macaroni is unsalted, it does not draw much moisture from humid air. Macaroni probably does not act as an attractant as typical baits are expected to (though this is generally unproven in small mammals). However, it does provide calories to the entrapped animals, and thus keeps them alive until they are released.

Strip-census

The route and transects used for the strip census (Flinders and Hansen 1973) are shown in Fig. 2. The censuses were run on 3 nights in July and on 3 nights in October. Each night, the census began 0.5 hour after sunset, and continued for about 1.5 hour.

While 1 person drove the car, another person sat on the car roof and aimed a 150,000 candle-power spotlight onto the transect. Both the driver and the spotlighter looked for animals, which were usually first detected by observing their eyeshine.

Visibility differed according to the condition of the vegetation on each transect and the species of mammal being looked for. Thus, the total area of all strips examined each night varied from 0.435 km^2 for lagomorphs in July up to 1.16 km^2 for deer in July and October. Five habitat types were found on the transects: Ungrazed, mixed-grass in July; moderately grazed mixed-grass in October; mowed grass in October; heavily grazed pasture; and cut alfalfa (less than 15 cm high).

Data obtained during the strip censuses were adjusted in 2 ways. The first way was to calculate the number of animals on all 7.7 km^2 of Crane Meadows based on the number seen/area of habitat and the total area covered by that habitat on Crane Meadows. Thus, if 1 white-tailed deer were seen on the cut alfalfa transect 1 night, but none were seen on the other 2 nights, nor were any seen on any other transects, the calculation would be as follows:

1 deer/.240 km^2 of alfalfa =

4.17 deer/km^2 of alfalfa;

(4.17 deer/km^2 of alfalfa) (0.40 km^2 of alfalfa/Crane Meadows) =

1.67 deer/Crane Meadows;

(1.67 deer/Crane Meadows) (Crane Meadows/7.7 km^2) =

an overall density of deer on Crane Meadows of 0.22 deer/km^2.

This will be referred to as the "habitat adjustment".

The second, and somewhat independent method, of adjusting the strip-census data was to simply determine the results if there had been a fourth night of data. The extremes of data used here were the least number of that species seen on any of the 3 nights data were collected, and also the greatest number of that species seen on any of those 3 nights. Then, given the same results of white-tailed deer, there would be a minimum of none seen, and a maximum of 1 more deer on this hypothetical fourth night. The habitat type is not considered; only the total area examined. In 3 nights, a total area of 3.49 km^2 was examined. With 1 deer seen in 3 nights, this would yield 0.29 deer/km^2 on Crane Meadows. By adjusting this as indicated, there could be 1 deer in 4 nights (4.65 km^2) or 0.22 deer/km^2 on Crane Meadows. Or there could be 2 deer in 4 nights, for a maximum density estimate of 0.43 deer/km^2. These 2 estimates bracket the unadjusted estimate, though not necessarily evenly. Yet, a reasonable sort of range is shown. This will be referred to as the "area adjustment".

RESULTS AND DISCUSSION

Snap-trapping

Sprung traps were counted as unset traps and were accounted for accordingly in the trap-night calculation as suggested by Andersson (1976) and Nelson and Clark (1976). Probably, traps that have caught 1 species should be adjusted for in catch effort of all other species, but this has not been done here. It seems that the relative probability of catching any individual nocturnally active small mammal in a functional snap-trap is nearly enough equal to allow comparing data without such adjustments.

During the summer snap-trapping, the following species were caught: deer mouse (Peromyscus maniculatus), jumping mouse (Zapus hudsonius), least weasel (Mustela nivalis), masked shrew (Sorex cinerus), meadow vole (Microtus pennsylvanicus) and white-footed mouse (P. leucopus). The snap-trap results are shown in Table 1, and include a breakdown by species, age, sex, and habitat preference. The species trapped are discussed in the order of their abundance.

Deer Mouse. Deer mice were by far the most abundant, with 141 individuals caught, representing 63.2% of all snap-trap captures, and an overall capture rate of 21.6 captures/100 trap-nights. The ratio of males to females, 1.5:1.0, showed a significant excess of males ($P < .025$). The age ratio of adults to juveniles was 3.3:1.0. There was a pronounced preference for the Woods-Field ($P < .10$) habitat over River and Woods, as evidenced by comparing captures/100 trap-nights which were 30.1, 21.2, and 12.0, respectively. M'Closkey (1975) suggested that deer mice prefer areas with large foliage height-diversity suggesting an orientation toward shrubby and forested habitats. Kaufman and Fleharty (1974) found deer mice to occur in all 10 of the grassland habitats but not in the 2 wooded areas studied. Deer mice in this study were trapped in a habitat edge that contained shrubs, trees, as well as grasses.

White-footed Mouse. The second most abundant small mammal species were white-footed mice, with 57 captures, constituting 25.6% of all snap-trap captures and a capture rate of 8.7 captures/100 trap-nights. The sex ratio of males to females was 1.0:2.4, a significant excess of females ($P < .005$). The age ratio of adults to juveniles was 2.6:1.0.

Table 1. Snap-trap results from Crane Meadows, by species and by habitat 4-24 June 1980.

Species	River					Woods					Woods-Field					Total
	M		F		Total	M		F		Total	M		F		Total	
	A	J	A	J		A	J	A	J		A	J	A	J		
deer mouse *Peromyscus maniculatus*	48	14	30	14	110[a]	5	--	1	--	6	13	2	9	1	25	141
jumping mouse *Zapus hudsonius*	2	--	1	--	7[b]	--	--	--	--	--	--	--	1	--	1	8
least weasel *Mustela nivalis*	--	--	--	--	1[c]	--	--	--	--	--	--	--	--	--	--	1
masked shrew *Sorex cinerus*	--	--	--	--	6[d]	--	--	--	--	--	--	--	--	--	--	6
meadow vole *Microtus pennsylvanicus*	4	--	--	--	5[e]	--	--	--	--	--	--	--	--	--	--	5
white-footed mouse *Peromyscus leucopus*	5	3	19	6	35[f]	3	2	6	2	13	2	1	6	--	9	57
Unidentifiable Mammal or Non-mammal Vertebrate	--	--	--	--	4[g]	--	--	--	--	--	--	--	--	--	1[h]	5
Trap-nights			519					50					83			652
Total Captures			168					19					36			223
Captures/100 trap-nights			32.4					38.0					43.4			34.2

Table 1. Continued.

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[a]Includes 2 juveniles and 2 adults, sex unknown.

[b]Includes 4 adults, sex unknown.

[c]Includes 1 adult, sex unknown.

[d]Includes 6 individuals, age and sex unknown.

[e]Includes 1 juvenile, sex unknown.

[f]Includes 2 juveniles, sex unknown.

[g]Includes 1 red-sided garter snake, 1 Brewer's Blackbird, and 2 unidentifiable mammals.

[h]Includes 1 unidentifiable mammal.

White-footed mice prefered Woods significantly ($P < .001$) over Woods-Field and River with captures/100 trap-nights at 26.0, 10.8, and 6.7. As noted by numerous authors (Burt 1940, Gunderson 1950, Getz 1961, Brown 1964), Springer 1971, Kaufman and Fleharty 1974) white-footed mice clearly prefer areas with woody vegetation that affords a high degree of canopy cover.

Jumping Mouse. Only 8 jumping mice were captured representing 3.6% of the total snap-trap captures. Their capture rate was only 1.2 captures/100 trap-nights. The male:female ratio was 1.0:1.0 and the adult:juvenile ratio was 8.0:0.0. No significant habitat preference between River and Woods-Field was found; captures/100 trap-nights were 1.3 and 1.2, respectively. No jumping mice were caught in the Woods habitat, but with only 50 trap-nights within Woods habitat, this is not a statistically significant finding either ($P > .10$).

Masked Shrew. Though all 6 masked shrews (2.7% of all captures) were caught in River habitat, the capture rate of 0.9/100 trap-nights was so low that no statistically significant habitat preference was revealed ($P > .25$). All specimens were adults, but sex was not determined.

Meadow Vole. The 5 meadow voles (2.2% of all captures) were also all caught in the River habitat, with a capture rate of 0.7/100 trap-nights. Again, no significant habitat preference was revealed ($P > .50$). Meadow voles, as a rule, prefer wet meadow habitat, and snap-traps were not set in wet meadows. The fact that 4 males but no females were caught was significant ($P < .05$).

Least Weasel. Only 1 least weasel was captured. Actually, it was surprising that a weasel would have been attracted to a peanut butter baited mouse trap.

Live-trapping

Renzulli, et al. (1980) found in their computer study that 2-, 4-, and 6-week intervals between trapping gave adequate density estimates, whereas 8-week intervals did not. They also suggested that 15.2-m trap-spacing would accurately indicate population density whereas 7.6-m spacing would underestimate density. There was a 5-week interval between trapping sessions in this study, and there was a 10-m spacing between trap sites.

The following mammals were caught: deer mouse, jumping mouse, least weasel, meadow vole, plains harvest mouse (Reithrodontomys montanus), short-tailed shrew (Blarina brevicauda), thirteen-lined ground squirrel (Spermophilus tridecemlineatus), and western harvest mouse (R. megalotis).

During both trapping sessions on both grids, there were 158 individuals caught a total of 631 times. There were 3,207 trap-nights, resulting in a capture rate of 19.7 captures/100 trap-nights, a relatively high rate. Results from the 1st session differed greatly from the 2nd session on both grids, probably the result of the dry summer compared to the very wet spring. Live-trapping results are shown in the following tables: Grid I, 1st session (Table 2); Grid I, 2nd session (Table 3); Grid II, 1st session (Table 4); Grid II, 2nd session (Table 5).

Table 2. Live-trap results from Grid I on Crane Meadows, first session (30 June 1980 - 11 July 1980).

Species	M				F				Total	
	A		J		A		J			
	N[a]	T[b]	Na	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]
deer mouse *Peromyscus maniculatus*	1	1	--	--	2	16	--	--	3	17
jumping mouse *Zapus hudsonius*	1	1	--	--	2	3	--	--	3	4
meadow vole *Microtus pennsylvanicus*	36	90	9	18	15	69	9	35	69	212
thirteen-lined ground squirrel *Spermophilus tridecemlineatus*	--	--	--	--	--	--	1	1	1	1
Non-mammalian vertebrates	--	--	--	--	--	--	--	--	3	3
Trap-nights									720	
Total captures									237	
Captures/100 trap-nights									32.9	

[a]N = Number of individuals captured.

[b]T = Total number of captures.

Table 3. Live-trap results from Grid I on Crane Meadows, second session (14 August 1980 - 23 August 1980).

Species	M				F				Total	
	A		J		A		J			
	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]
deer mouse *Peromyscus maniculatus*	1	1	--	--	--	--	--	--	1	1
least weasel *Mustela nivalis*	1	--	--	--	--	--	--	--	1	1
meadow vole *Microtus pennsylvanicus*	7	28	2	2	16	53	4	4	29	87
short-tailed shrew *Blarina brevicauda*	--	--	--	--	2	2	1	1	3	3
Non-mammalian vertebrates	--	--	--	--	--	--	--	--	3	3
Trap-nights										885
Total captures										95
Captures/100 trap-nights									10	.7

[a]N = Number of individuals captured.

[b]T = Total number of captures.

Table 4. Live-trap results from Grid II on Crane Meadows, first session (30 June 1980 - 11 July 1980).

Species	M				F				Total	
	A		J		A		J			
	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]
deer mouse *Peromyscus maniculatus*	11	36	2	11	6	21	4	14	23	82
jumping mouse *Zapus hudsonius*	3	3	1	1	2	6	--	--	6	10
meadow vole *Microtus pennsylvanicus*	10	16	5	7	3	11	4	7	22	41
plains harvest mouse *Reithrodontomys montanus*	2	9	--	--	3	9	--	--	5	18
short-tailed shrew *Blarina brevicauda*	1	1	--	--	--	--	--	--	1	1
western harvest mouse *Reithrodontomys megalotis*	11	22	--	--	3	11	1	1	15	34
Non-mammalian vertebrates	--	--	--	--	--	--	--	--	2	2
Trap-nights									724	
Total captures									188	
Captures/100 trap-nights									26.0	

[a]N = Number of individuals captured.

[b]T = Total number of captures.

Table 5. Live-trap results from Grid II on Crane Meadows, second session (14 August 1980 - 23 August 1980.

Species	M				F				Total	
	A		J		A		J			
	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]	N[a]	T[b]
deer mouse *Peromyscus maniculatus*	9	44	2	9	8	22	1	3	20	78
jumping mouse *Zapus hudsonius*	1	1	--	--	--	--	--	--	1	1
meadow vole *Microtus pennsylvanicus*	4	6	2	3	4	5	--	--	10	14
thirteen-lined ground squirrel *Spermophilus tridecemlineatus*	1	1	--	--	--	--	--	--	1	1
western harvest mouse *Reithrodontomys megalotis*	4	11	--	--	2	3	--	--	6	14
Non-mammalian vertebrates	--	--	--	--	--	--	--	--	3	3
Trap-nights									878	
Total captures									111	
Captures/100 trap-nights									12.6	

[a] N = Number of individuals captured.

[b] T = Total number of captures.

Meadow Vole. Altogether, 116 individual meadow voles were captured 354 times, accounting for 73.9% of all individuals and 56.2% of all live-trap captures. Only 14 (12.1%) of the meadow voles were captured during both sessions, indicating rather high turnover.

The ratio of males to females was 1.58:1.0, which represents a significantly greater number of males ($P < 0.025$). Overall, the ratio of adults to juveniles was 2.7:1.0.

Grid I consistantly had a higher population of meadow voles than Grid II ($P < .005$), probably due to the greater amount of moisture that produced a denser, taller vegetative crop. Both grids had precipitous declines in vole populations between the 2 sessions, with the percentage decline being greatest on Grid I. Only 42.0% as many individuals were caught during the 2nd session on Grid I, and the capture rate delcined from 29.4 to 9.8 captures/100 trap-nights. Both are statistically highly significant declines ($P < .005$). The Lincoln Index during the lst session provided population densities ranging from 54.8 voles/ha to 65.1 voles/ha, which dropped to only 10 voles/ha as a high estimate the 2nd session.

The decline on Grid II was not as drastic, but nevertheless it was also significant. Only 45.5% as many individuals were caught ($P < .05$), and the capture rate declined from 5.7 to 1.6 captures/100 trap-nights ($P < .005$). Such declines might have been expected on Grid II due to the mowing that occurred immediately prior to the second trapping session. However, the coincident decline on Grid I suggests other factors were probably more important.

The initial density on Grid I was incredibly high and was probably higher than the 65.1/ha estimated by the Lincoln Index. (Often, more

than half the traps on Grid I held an animal, and that could result in a serious underestimation of the density. To gain more sensitivity in this estimator, one would need to have at least 2 traps/trap-site.) Since this high density also delcined, even without mowing, the major cause of vole population decrease was probably related to the dryness of the summer. This would have resulted in decreased lushness and nutritional quality of the vegetation that had been supporting this high density.

Because these hay meadows have been mowed every fall for the last several years, it is highly unlikely that a normal 3-year population cycle of voles had ever become established. Thus, the high population density had to be the result of a high reproductive rate by a small population that either survived in the mowed habitat or immigrated in from the narrow, unmowed strips of grassland along the Platte River. The exact mechanisms involved here would make a fascinating study.

Deer Mouse. There were 39 individual deer mice captured 178 times, accounting for 24.8% of all individuals and 28.3% of all captures. Eight (20.5%) of the deer mice were captured during both sessions, showing less population turnover than was seen in meadow voles.

The ratio of males to females was 1.3:1.0, not statistically different from equal ($P > .25$). The ratio of adults to juveniles was 2.9:1.0, very similar to the 2.7:1.0 found for voles.

Grid I only had 3 individuals during the 1st session, which declined to only 1 individual the 2nd session. This low density would be expected when there is a high density of voles; their habitat preferences in regard to vegetative density are exactly opposite (Springer 1971). They are not

competitively exclusive. Rather, deer mice prefer an open understory (regardless of vegetative height), where there in no litter accumulation and where the density of grass stems/area is rather low (Phillips 1936, LoBue and Darnell 1959, Tester and Marshall 1961, and Springer 1971). Voles prefer accumulated litter and dense grass stems/area. While neither grid had any litter, Grid I had very dense vegetation.

Grid II had a much higher density of deer mice than Grid I ($P < .005$), with 23 individuals during the 1st session, and 20 individuals the 2nd session. The Lincoln Index during the 1st session ranged from 16.0 to 20.0 mice/ha, and during the 2nd session from 16.0 to 18.0 mice/ha. It seems obvious that neither mowing nor the dry summer adversely affected the deer mouse population on Grid II. The small decline indicated here in not significant ($P > .50$). The decline on Grid I from 3 to 1 individuals is likewise insignificant ($P > .25$).

Western Harvest Mouse. There were 20 individual western harvest mice caught 48 times, accounting for 12.7% of all individuals and 7.6% of all captures. Only 2 individuals were caught both sessions. The capture rate of 2.4 captures/individual is significantly lower than the overall rate of 4.0 captures/individual ($P < .005$). Thus, either they are generally less trapable than other rodents trapped here, or at least less attracted to the bait used here. This would suggest that they are probably more abundant than the live-trapping data would indicate.

The ratio of adult males to females was 3.0:1.0, showing a significant excess of males in the population ($P < .05$). The ratio of adults to juveniles was an incredible 20.0:1.0, but this was probably due to the light weight of harvest mice (average of about 11.5 g for adults) in general and the insensitivity of the live-traps to light-weight animals.

Western harvest mice were only caught on Grid II, and they experienced a noteable population decline from 15 individuals in the 1st session to only 6 in the 2nd session ($P < .05$). The Lincoln Index also dropped from a 12.0 mice/ha in the 1st session to 5.0/ha in the 2nd session.

It is not possible to determine if the population decline was due solely to the mowing or the dry summer or some combination. However, the turnover in individuals between trapping sessions indicates that mowing may have been the prime factor. Residents would have emigrated out of the area, while other harvest mice, moving out of their former home range, may have taken refuge in the traps and/or the surrounding 2- x 2-m patches of uncut grass around each trap-site.

Jumping Mouse. There were 10 individual jumping mice caught 15 times, accounting for 6.4% of all individuals and 2.4% of all captures. This capture rate of 1.5 captures/individual in also significantly lower than the overall average of 4.0 captures/individual ($P < .005$). As with the western harvest mice, this indicates that either they are generally less trapable or at least less attracted to the bait used here.

The ratio of males to females, 1.5:1.0, was not significantly different from equal ($P > .05$). Only 1 juvenile was trapped; why no more were caught is not known, but in all my trapping experience, I have caught very few juvenile jumping mice.

During the 1st trapping session, 6 jumping mice were caught on Grid II and only 3 were caught on Grid I. Though one would expect a higher population on Grid II due to its less dense vegetation and the presumed jumping mouse preference for such habitat, the difference with such low numbers in insignificant ($P > .25$).

However, during the 2nd session, only 1 jumping mouse was caught on either grid (Grid II), and this reduction was highly significant ($P < .025$). Again, since the reduction occurred on both grids, it was probably due more to dry weather and a corresponding decrease in food than to mowing and a corresponding decrease in cover.

Plains Harvest Mouse. There were 5 plains harvest mice caught 18 times, accounting for 3.2% of all individuals and 2.9% of all captures.

The ratio of males to females was 1.0:1.5, but was not significantly different from equal, due to the small sample size ($P > .50$). However, all plains harvest mice were caught during the 1st session on Grid II, thus showing both a significant habitat preference and a significant population decline ($P < .005$). The fact that no juveniles were captured was probably due to the very light weight of this species (as with the western harvest mouse), and not to a low reproductive rate.

Short-tailed Shrew. There were 4 short-tailed shrews caught 4 times, accounting for 2.5% of all individuals and 0.6% of all captures. The ratio of males to females was 1.0:3.0, but due to the low number of captures, this was not a significant difference ($P > .25$).

The distribution between grids was not statistically significant, nor was the distribution between sessions ($P > .05$), although Grid I showed an increase from none during the 1st session to 3 during the 2nd.

Thirteen-lined Ground Squirrel. Only 2 thirteen-lined ground squirrels were caught, 1 time each, accounting for 1.3% of all individuals and 0.3% of all captures. They were caught on each grid, 1 on Grid I during the 1st session and 1 on Grid II during the 2nd session. No substantial analyses were possible here.

Least Weasel. Only 1 least weasel was live-trapped, and it was immediately collected, thus accounting for 0.6% of all individuals and 0.2% of all captures. It was caught on Grid I during the 2nd session. No statistical analyses were possible here.

Other Possible Mammals. Because Mike Wetovick was not familiar with all small mammal species when he began helping on this project, he learned as he worked. He tentatively identified 1 particular microtine on Grid I as either a meadow vole (as it has been included in the data here) or possibly as a prairie vole (M. ochrogaster) or a bog lemming (Synaptomys cooperi). I asked him to collect this specimen the next time it was captured, but it never was recaptured. Either of these other species could be on Crane Meadows according to their species range in Nebraska (Jones 1964), but neither species has been trapped here otherwise.

Wetovick also noted 1 particular mouse as a white-footed mouse on Grid II but he had previously identified it an 2 occasions as a deer mouse. It is unlikely that an adult white-footed mouse would have strayed so far from a woodlot and remained for several days.

Strip Census

The habitat and visibility of each transect for each species are shown in Table 6. The areas of Crane Meadows consisting of each habitat type in the summer was: mixed-grass (Ungrazed) = 3.06 km^2; heavily grazed pasture = 3.64 km^2; cut alfalfa = 0.40 km^2. The only changes between summer and fall was that much of the mixed grass area was mowed for hay, and the rest had been moderately grazed. Thus, the 3.06-km^2 ungrazed, mixed-grass area was divided into: mixed-grass (moderately grazed) = 1.72 km^2, and mowed grass = 1.38 km^2.

Table 6. Description of the 11 strip-census transects used to count the large mammals of Crane Meadows in summer 1980.

		Distance (m) and Area (km^2)					
		Lagomorphs		Coyotes		Deer	
Transect #	Length (km)	m	km^2	m	km^2	m	km^2
1[a]	1.1	25	.0275	50	.0550	75	.0825
1[b]		100	.1100	100	.1100	100	.1100
2[a]	1.1	25	.0275	50	.0550	100	.1100
2[b]		100	.1100	100	.1100	100	.1100
3[a]	0.6	25	.0150	50	.0300	100	.0600
4[a]	0.8	25	.0200	50	.0400	100	.0800
4[b]		100	.0800	100	.0800	100	.0800
5[c]	0.8	100	.0800	100	.0800	100	.0800
6[a]	0.6	25	.0150	50	.0300	100	.0600
6[b]		100	.0600	100	.0600	100	.0600
7[a]	1.1	25	.0275	50	.0550	100	.1100
8[a]	1.6	25	.0400	50	.0800	100	.1600
9[a]	1.1	25	.0275	50	.0550	100	.1100
10[d]	1.3	50	.0650	50	.0650	100	.1300
11[d]	1.8	50	.0900	100	.1800	100	.1800
Total: summer		0.4350		0.7250		1.1625	
fall		0.750		0.9050		1.1900	

[a]mid-grass, ungrazed.

[b]mowed grass during October session only.

[c]cut alfalfa

[d]grazed pasture

During the 2 strip-census sessions, 8 different large mammals were seen on transects: badger (Taxidea taxas), black-tailed jackrabbit (Lepus californicus), coyote (Canis latrans), eastern cottontail (Sylvilagus floridanus), raccoon (Procyon lotor), striped skunk (Mephitis mephitis), Virginia opossum (Didelphis virginianus), and white-tailed deer (Odocoileus virginianus). The results for the 2 sessions are shown in Tables 7 and 8, and will be discussed in alphabetical order.

Badger. Only 1 badger was seen, and it was in the fall census. It was in the moderately grazed, mixed-grass habitat toward the west end of Crane Meadows. The habitat adjustment yields an estimated population density of 0:68 badgers/km^2. The area adjustment yields 0.47 badgers/km^2, with limits of 0.35/km^2 and 0.71/km^2.

Black-tailed Jackrabbit. This species was seen on every habitat during the summer census, but on only 2 of the 4 fall habitats. The estimated population density in summer based on habitat adjustment was 44.0 jackrabbits/km^2, which declined to 5.7/km^2 in fall.

The area adjustment yields a summer density of 42.2 jackrabbits/km^2, with a minimum of 40.2/km^2 and a maximum of 46.0/km^2. This declined to 3.8/km^2 in fall, with a minimum of 2.8/km^2 and a maximum of 4.3/km^2. Although these values are all lower than the habitat-adjusted value, they are reasonably close, and all are drastically lower than the summer levels.

The severe reduction in jackrabbits may be correlated with the vole population reduction, which appears to be related to the dry summer and the coincident decrease in available food. Although predation or hunting could have been a factor in the jackrabbit decline, no evidence of either was ever observed.

Table 7. Numbers and density of large mammals seen on Crane Meadows in each habitat type during the 3 nights of strip census in summer 1980. Areas in km^2.

Species (Total Area)	Habitat			Density
	Mixed grass	Pasture	Cut Alfalfa	
	N (Area)	N (Area)	N (Area)	N/km^2
black-tailed jackrabbit *Lepus californicus* (1.305)	2 (.600)	39 (.465)	14 (.240)	42.15
coyote *Canis latrans* (2.175)	1 (1.20)	0 (.735)	0 (.240)	0.46
eastern cottontail *Sylvilagus floridanus* (1.305)	2 (.600)	0 (.465)	0 (.240)	1.53
striped skunk *Mephitis mephitis* (1.305)	0 (.600)	1 (.465)	0 (.240)	0.77
Virginia opossum *Didelphis virginianus* (1.305)	1 (.600)	0 (.465)	0 (.240)	0.77
white-tailed deer *Odocoileus virginianus* (3.490)	6 (2.32)	0 (.930)	9 (.240)	4.30

Table 8. Numbers and density of large mammals seen on Crane Meadows in each habitat type during the 3 nights of strip-census in fall 1980. Acres in km^2.

Species (Total area)	Habitat				Density
	Mowed grass	Mixed-grass	Pasture	Cut Alfalfa	N/km^2
	N(Area)	N(Area)	N(Area)	N(Area)	
badger (2.115) *Taxidea taxus*	0(1.08)	1(.330)	0(.465)	0(.240)	0.47
black-tailed jackrabbit (2.115) *Lepus californicus*	0(1.08)	0(.330)	5(.465)	3(.240)	3.78
eastern cottontail (2.115) *Sylvilagus floridanus*	2(1.08)	0(.330)	0(.465)	0(.240)	0.95
raccoon (2.115) *Procyon lotor*	0(1.08)	1(.330)	0(.465)	0(.240)	0.47
striped skunk (2.115) *Mephitis mephitis*	1(1.08)	1(.330)	0(.465)	0(.240)	0.95
Virginia opossum (2.115) *Didelphis virginianus*	0(1.08)	2(.330)	0(.465)	0(.240)	0.95
white-tailed deer (3.570) *Odocoileus virginianus*	0(1.08)	1(1.32)	0(.930)	8(.240)	2.52

Coyote. Only 1 coyote was seen, and that was in the summer. The habitat-adjusted estimate was 0.33 coyotes/km^2 (or 1 coyote/3.06 km^2). The area-adjusted estimate was 0.46/km^2 (min. = 0.34/km^2; max. = 0.69/km^2).

It is unlikely that the coyote population on Crane Meadows was totally absent by fall, but is is reasonable that it would have been lower. Had the fall census continued 1 more night, perhaps 1 coyote would have been seen on a transect. That would have yielded a density of .21/km^2, or 1 coyote/4.8 km^2. Coyotes, as relatively large predators rarely have densities even this large. In a study done in Washington (Springer 1981) on a moderately dense coyote population, the density was estimated to be only 1/5 mi^2 or 1/13 km^2. This strip-census technique, therefore, cannot be sensitive to such a low population density unless the total area included on transects approaches 13 km^2. Only 2.2 km^2 and 3.6 km^2 of Crane Meadows were examined in the summer and fall respectively.

Eastern Cottontail. This species was observed on only 1 habitat in both summer and fall, mixed-grass and mowed-grass, respectively. In both seasons, 2 individuals were seen, but because the fall census involved a larger area of coverage, this actually represented a substantial decline.

The summer and fall habitat-adjusted density estimates were 1.3 cottontails/km^2 and 0.33/km^2, respectively. The density estimate based on area adjustment for summer was 1.5/km^2 (min. = 1.1/km^2; max. = 1.1/km^2), and for fall was 0.95/km^2 (min. = 0.71/km^2; max. = 1.1/km^2). This estimate suggests less decline, but in either case, the decline is far less drastic than that seen for jackrabbits.

Raccoon. This species was only seen in the fall, though no doubt there was a population present in the summer. Had 1 been seen on the hypothetical 4th night, the summer density estimate would have been only 0.57/km^2 or 1 raccoon/1.8 km^2, a fairly dense estimate considering their favored habitat would be the riparian strip. Again, the method is not sensitive enough to their probable densities.

The fall habitat-adjusted estimate was 0.65/km^2, while the area-adjusted estimate was 0.47/km^2 (min. = 0.35/km^2; max. = 0.71/km^2). These are probably high estimates.

Striped Skunk. One skunk was seen on transects in the summer and 2 were seen in the fall. Several others were seen on both occasions, though not on transects. They seemed to be on all parts of Crane Meadows and to have no specific preferences.

Summer habitat-adjusted density was 1.0 skunk/km^2 and the area-adjusted estimate was 0.77/km^2 (min. = 0.57/km^2; max. 1.2/km^2). The fall habitat-adjusted estimate was 0.95/km^2 (min. = 0.71/km^2; max. = 1.1/km^2), essentially no change.

Virginia Opossum. As with striped skunks, 1 opposum was seen in the summer 2 were seen in the fall, and several others were seen both times off of transects. The summer habitat-adjusted estimate was 0.65/km^2, lower than the same estimate for skunks because a different habitat was involved. The area-adjusted estimate in the same, however: 0.77/km^2 (min. = 0.57/km^2; max. - 1.2/km^2).

The fall habitat-adjusted estimate was 1.3/km^2, higher than for skunks, also because of different habitats involved. Again, the fall area-adjusted estimate was the same as that for skunks: 0.81/km^2 (min. = 0.71/km^2; max. = 1.1/km^2).

White-tailed Deer. Several deer were seen on both occasions, both on and off transects. The summer habitat-adjusted estimate was 3.0/km^2 while the area-adjusted estimate was 4.3/km^2 (min. = 3.2/km^2; max. 8.5/km^2). The area-adjusted estimate is probably high due to the large numbers seen on alfalfa, and the small total area of alfalfa available.

The fall habitat-adjusted density was 1.9/km^2, with an area-adjusted estimate of 2.5/km^2 (min. = 1.9/km^2; max. = 3.4/km^2). Though it appears that the deer population may have declined somewhat from summer to fall, the estimates are all fairly close to each other, indicating only slight declines, if any.

Fall Trapping

In the fall, some students from my mammalogy class and I trapped on 3 different nights, using both live-traps and snap-traps. The totals for each species are shown in Table 9.

None of this trapping was done in areas already covered by previous live-trapping or snap-trapping, as can be seen in Fig. 2. The 1 additional species picked up in the fall was the house mouse (Mus musculus) which was caught by the haystacks near the barn in the south central part of the main island.

The fact that masked shrews were caught by live-traps in the fall indicates that their absence from the live-trapping results during the summer was not due solely to their light weight and insensitivity of the traps. They must have been simply quite scarce. Likewise, 1 western harvest mouse was snap-trapped, suggesting they simply were not present in the previously snap-trapped habitats.

Table 9. Results of 3 nights of live-trapping and snap-trapping on Crane Meadows in fall 1980.

Species	Snap-trap	Live-trap	Total
	N (Capture rate)[a]	N (Capture rate)[a]	N (Capture rate)[a]
deer mouse *Peromyscus maniculatus*	5 (7.6)	24 (14.5)	29 (12:6)
House mouse *Mus musculus*	0 (0.0)	2 (1.2)	2 (0.9)
jumping mouse *Zapus hudsonius*	1 (1.5)	0 (0.0)	1 (0.4)
masked shrew *Sorex cinereus*	0 (0.0)	3 (1.8)	3 (1.5)
meadow vole *Microtus pennsylvanicus*	0 (0.0)	8 (4.8)	8 (3.5)
short-tailed shrew *Blarina brevicauda*	0 (0.0)	2 (1.2)	2 (0.9)
western harvest mouse *Reithrodontomys megalotis*	1 (1.5)	2 (1.2)	3 (1.3)
white-footed mouse *P. leucopus*	1 (1.5)	4 (2.4)	5 (2.2)
Total	8 (12.1)	45 (27.3)	53 (22.9)
T-N	66	165	231

[a]Captures/100 trap-nights

MANAGEMENT RECOMMENDATIONS AND CONCLUSIONS

Presumably, the Whooping Crane Trust Fund purchased Crane Meadows with the purpose of managing it as Sandhill Crane (Grus canadensis) roosting and loafing habitat. This portion of the Platte River has been 1 of the most heavily utilized sites for Sandhill Cranes as they stage along the northward migration every spring. Further, management to enhance all other species would depend on how the cranes would be affected, i.e. compatibility with crane management schemes.

There is no need to detail habitat requirements of the cranes here, but it seems that in general they prefer an open river channel to roost, and open, wet grassland with short growth for loafing and some feeding. Without mowing, grazing, or burning Crane Meadows, it seems probable that the entire area would soon be overgrown by woody vegetation, and would become unsceptable to the cranes. Therefore, 1 or all of these methods will continue, and management for mammals will have to include these techniques.

My main recommendation would be to do whatever is necessary to maintain as much diversity in mammal species as possible, which generally means maintaining a large degree of diversity in plant species and in plant communities. Therefore, do not eliminate the woodlots or the strip of riparian habitat along the Platte River. Keep these restricted to their current locations, however, in order to maintain the openness of the grasslands for the cranes.

It would benefit both diversity and total numbers of most taxa if the cultivated areas were returned to native prairie. Black-tailed jackrabbits and white-tailed deer used the alfalfa heavily, although they

also used other habitats too. However, small mammal use of alfalfa, especially once it is cut, is usually restricted to deer mice only. Corn production at 25 bushels/acre is so unproductive that even a farmer might argue that native hay would be a better crop.

The primary management problem in terms of mammals vs. cranes is the grazing-mowing-burning question. As shown by Springer (1971) and Springer and Schramm (1972), a burning schedule of once every 4 years with at least 4 different areas being burned in rotation provides the greatest diversity. Species that prefer a lot of litter (voles and shrews) will be at greatest densities in areas unburned for 2 or 3 years. Species that prefer no litter (deer mice, jumping mice, pocket mice, white-footed mice) will be at greatest densities in areas that have just been burned or burned in the last year. Species with intermediate preferences (harvest mice) would be at greatest densities in areas burned 1 or 2 years previously. Of course, that would require only light to moderate grazing and no mowing to allow the litter to accumulate. Such a scheme will have to be weighed against the economic return of heavy grazing and haying.

Burning should be in mid- to late-spring, probably when the cranes are already present. This allows rapid recovery of the burned areas by the vegetation, leaving only a few days with no cover for the small mammals. Fall burning would result in a 2- to 4-month desert as far as small mammals are concerned. Early spring burning would be less devastating to mammals, but less effective in controlling non-native vegetation (eg. blue grass, Poa spp.) or woody vegetation that would undoubtedly invade.

Allowing litter to accumulate for a few years might actually benefit cranes as well as some small mammals. Short-tailed shrews prefer heavily

littered areas, not so much for its cover as for the increased concentrations of invertebrates, their main food (Whitaker and Ferraro 1963, Springer and Schramm 1972). These same invertebrates may be of great importance to cranes as well, and cannot be very numerous without accumulated litter. If cranes are intollerant of tall standing grass, as the previous year's cropcrop of big bluestem (Adropogon gerardi), Indian grass (Sorghastrum nutans) and switch grass (Panicum vergatum) would be, it would be wise to flatten all cured, standing grass each spring. This could be done by using a large roller behind a tractor. It should not be so heavy that the soil would be compacted; simply enough to lay the stems down.

Light-grazing prevents some litter accumulation, but leaves more cover and litter than mowing. Fees generated by leasing pasture will have to be considered in deciding if grazing should continue on Crane Meadows and to what extent. Probably light-grazing should be considered as a middle-ground between burning and mowing in terms of the effects on small mammals. The ungrazed standing vegetation left through the winter could be knocked down by rollers, thus adding to litter accumulation and not detracting from the areas usefulness to cranes.

Moderate to heavy grazing is probably as detrimental (or more detrimental) to small mammals as mowing, in that most of the standing crop is removed for a long period of time at least; at worst, the vegetation never provides much food or cover for small mammals, and very little litter ever accumulates. This alternative should be considered as the last choice, from the standpoint of maintaining the greatest possible mammal abundance and diversity.

Mowing at the end of the growing season is devastating to small mammals, and hence their predators, too, in the long run. With little

food and no cover, very few small mammals could be expected to survive until spring. Spring and summer populations would have to rise each year from immigrants from the small refugia surrounding the hay meadows. A better alternative would be to mow before the growing season ends, with enough growing time remaining to leave a 20- to 25-cm (8- to 10-inch) stand of vegetation through the winter. This would ultimately allow some litter accumulation and would provide some cover. Another possibility would be to cut hay toward the end of the growing season, but to leave it 20 to 25 cm high. This would be better still, since the small mammals would never have to cope with 3-cm high vegetation.

The effects burning vs. grazing vs. mowing on mammals needs much more study before a truly best choice can be made based on facts. (A study on the short-term effects of mowing is being conducted by Steinauer and Springer during the summer of 1981 at Kearney State College. Results should be available by September 1981.)

Though not trapped or seen during the strip census, several other mammals have been seen on Crane Meadows. Some of these were collected in addition to the small mammals collected by snap-trapping. The total list of all mammals known to have been on Crane Meadows during the summer or fall 1980 is as follows:

1. badger (Taxidea taxus) -- seen but not collected.
2. beaver (Castor canadensis) -- only sign was seen.
3. black-tailed jackrabbit (Lepus californicus) -- collected.
4. black-tailed prairie dog (Cynomys ludovicianus) -- seen but not collected.
5. coyote (Canis latrans) -- seen but not collected.
6. deer mouse (Peromyscus maniculatus) -- collected.

7. eastern cottontail (Sylvilagus floridanus) -- collected.
8. eastern mole (Scalopus aquaticus) -- possible sign seen.
9. fox squirrel (Sciurus niger) -- seen but not collected.
10. Franklin's ground squirrel (Spermophilus franklinii) -- skeleton collected.
11. hispid pocket mouse (Perognathus hispidus) -- seen but not collected.
12. house mouse (Mus musculus) -- collected.
13. jumping mouse (Zapus hudsonius) -- collected.
14. least weasel (Mustela nivalis) -- collected.
15. masked shrew (Sorex cinereus) -- collected.
16. meadow vole (Microtus pennsylvanicus) -- collected.
17. muskrat (Ondatra zeibethicus) -- collected.
18. plains harvest mouse (Reithrodontomys montanus) -- collected.

8a. plains pocket gopher (Geomys bursarius)-- possible sign seen; same sign as 8.

19. raccoon (Procyon lotor) -- seen but not collected.
20. short-tailed shrew (Blarina brevicauda) -- collected.
21. striped skunk (Mephitis mephitis) -- collected.
22. thirteen-lined ground squirrel (Spermophilus tridecemlineatus) -- collected.
23. Virginia opossum (Didelphus virginianus) -- collected.
24. western harvest mouse (Reithrodontomys megalotus) -- collected.
25. white-footed mouse (Peromyscus leucopus) -- collected.
26. white-tailed deer (Odocoileus virginianus) -- seen but not collected.

27. mule deer - 1 seen by G. Hingle in June 1981.

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Kearney State College, Kearney, Nebr. 68847

24 June 1981

Mr. Gary Lingle
Preserve Manager, Morman Island
The Nature Conservancy
P. O. Box 2123
Grand Island, NE 68801

Dear Mr. Lingle:

Enclosed is my final report on the abundance and diversity of mammals on Crane Meadows, including management recommendations and future research suggestions, effects of various land-use practices, and methodology.

Range maps of the species seemed unnecessary since none of the mammals seen or collected were on or near the species range, nor do any of them have disjunct ranges to my knowledge. None of the species was rare or unusual within Nebraska or the United States in general.

Copies of raw data can be provided, if you have need of them. There are about 95 pages of data, and therefore they were not included as appendices.

I would like to submit the major portion of this report for publication, perhaps in the Prairie Naturalist, if this meets with your approval. I would also appreciate receiving a copy of your final report compiling all of our individual reports, whenever you have that completed.

Sincerely yours,

Joe Springer

Joseph T. Springer, Ph.D.
Department of Biology

JTS:gm
Encls.