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HABITAT UTILIZATION OF MAMMALS IN A MAN-MADE FOREST
IN THE SANDHILLS REGION OF NEBRASKA

A Thesis

Presented to the
Department of Biology
and the
Faculty of the Graduate College
University of Nebraska

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
University of Nebraska at Omaha

by

Richard W. Manning

November, 1983

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ACKNOWLEDGMENTS

I would like to thank Warren DuBois and Mak Deveraux, district rangers at the Bessey Division, for allowing me the use of the facilities at Halsey. George Mandeville and John Hinz were also helpful, and a special thanks to Pete Clark for his assistance during my research.

Thanks goes to Dr. David Sutherland for his help, especially with the botanical aspects of my work, and to Dr. George Engelmann for serving on my committee. I would like to thank Dr. Kenneth Geluso, who piqued my interest in mammalogy, and was invaluable throughout the planning, research, analysis, and editing of my thesis, I couldn't have done it without his enthusiastic support. Thanks Ken!

Finally, I thank my parents, James and Rosemarie Manning, for their continuous support throughout my educational career.

THESIS ACCEPTANCE

Accepted for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts, University of Nebraska at Omaha.

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ABSTRACT

The Sandhills Region of Nebraska is located in the central and northern portion of Nebraska. Within this region is the Bessey Division of the Nebraska National Forest. The Bessey Division encompasses 36,560 ha of which approximately 8,900 ha are forested; all forested lands are man-planted. Forest types include monocultures of three species; ponderosa pine (Pinus ponderosa), jack pine (Pinus banksiana), and Eastern red cedar (Juniperus virginiana). This represents the largest man-made forest in the National Forest System of the United States. The remaining 27,660 ha are of native grasses. Also a narrow strip of riparian habitat runs along the northern and southern boundaries of the Bessey Division.

The primary objective of my study was to determine what influence this man-made forest has had on the native mammals (43 species) inhabiting the Sandhills Region. Results indicate that 32.6% of mammalian species on the Bessey Division have been inhibited in their distribution or have decreased in relative numbers; 39.5% of mammalian species have expanded their ranges or increased in relative numbers as a result of afforestation, and the remaining species were unaffected by the planting of a forest. Although there were some notable exceptions, grassland species were inhibited, woodland species expanded, and those species which are ecologically tied to water remained unaffected. Cedar plantations were found to have the greatest abundance of small mammals, higher than the other plantations or the native habitats, and the species diversity was similar to the native habitats.

INTRODUCTION

The Sandhills Region of Nebraska, an area approximately 52,000 km², is located in the northern and central portion of Nebraska. The Region is characterized by a rolling topography of sloping sand dunes covered with native grasses. Within the Sandhills Region, near a town of Halsey, in Thomas and Blaine counties is the Bessey Division of the Nebraska National Forest. Originally called "The Dismal River Forest Reserve" the forest was established on 16 April 1902 by President Theodore Roosevelt. The forest was later renamed in honor of Dr. Charles Edwin Bessey of the University of Nebraska. Dr. Bessey, a botanist, was the dominant figure in the inception and subsequent formation of the Nebraska National Forest (Pool, 1953). The Bessey Division encompasses 36,560 ha of which 8,900 ha are forested; all forested lands are man-planted (Hunt, 1965). These trees were planted for fence posts and commercial lumber. This represents the largest man-made forest in the National Forest System of the United States. The remaining 27,660 ha are native grasses.

By studying the distributional maps of mammals in Nebraska (Jones, 1964; Hall, 1981), I compiled a list of mammals collected in or reported from Thomas County, and adjacent Blaine, Hooker, Cherry, and Custer counties. The list contains 43 species that have been taken in these counties, or with reasonable certainty, should be found on the Bessey Division. The primary objective of my study was to determine what effect this man-made forest has had on these native mammals inhabiting and Sandhills Region. To accomplish this objective, I compared the relative abundance and species composition of these mammals in the major communities on the Bessey Division. Before the early 1900's this region was almost

entirely native grasslands. The grasslands and the riparian communities, the native habitats, served as my controls. Mammals present in these native habitats represent those species which were likely in the area prior to afforestation. Present distribution of mammals indicates how this group has responded to the man-made forest. Each mammalian species in these native habitats could (1) be inhibited in its distribution or decrease in relative numbers because of the plantations, (2) expand its range or increase in relative numbers because of the plantations, or (3) show little or no change in its distribution or relative number as a result of afforestation. My expectations were: (1) mammalian species adapted to grasslands would be inhibited in their distribution or relative numbers, (2) mammalian species adapted to woodlands would expand their distributions to include the plantations, and (3) mammalian species that are ecologically tied to water or the lush vegetation associated with the waterways would remain unaffected.

METHODS AND MATERIALS

A preliminary survey of the Bessey Division of the Nebraska National Forest at Halsey was conducted between 16 April and 18 April, 1982. The purpose of this reconnaissance was to identify the major habitats of the area according to vegetation, topography, soils and management practices. Three major habitats were found (plantations, grasslands, and riparian communities), and each was further divided into smaller units (see next section). Using information gathered on the trip, a systematic trapping strategy was set up to determine the relative abundance and species composition of native mammals in the major habitats and their subdivisions.

Field work was conducted from 10 May - 2 June, 26 July - 3 August, and 15 October - 18 October, 1982. Sherman live-traps were used to determine the relative abundance of most species, especially small-bodied ground-foraging types. In the afternoon, traps were baited with oatmeal, millet, and sunflower seed, and set approximately 10 m apart in the various habitats. The following morning, mammals captured were identified, had their sex determined and were released. Animals with questionable identity were prepared as study skins and are deposited in the vertebrate collection at the University of Nebraska at Omaha (Appendix). Trap lines were concurrently set in the native habitats and the man-made habitats to reduce bias if inclement weather occurred; trap lines also were never left in the same area for more than one night.

While in the various habitats, data were collected on mammalian signs including fecal material, mole tunnels, gopher mounds, porcupine workings, and beaver and muskrat cuttings. All encounters with mammals themselves were recorded. Volant species (bats) required the use of mist

nets which were set over metal stock tanks and earthen ponds in the different habitats. The buildings on the forest property were inspected on three separate occasions to determine if bats were using them as roosting spots.

DESCRIPTION OF HABITATS

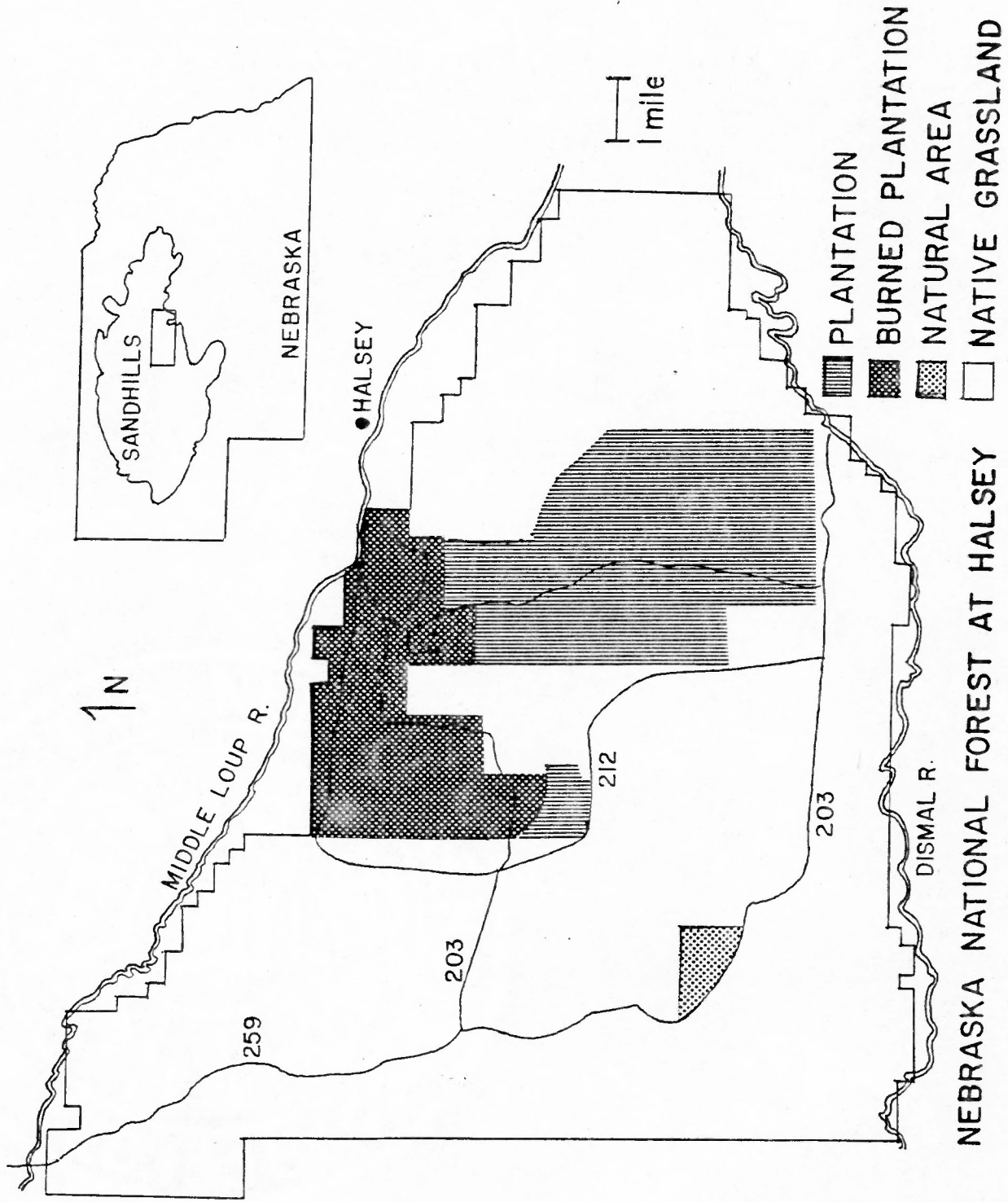
The Sandhills Region of Nebraska is located in the northern and central portion of the state (Figure 1). The region is characterized by a rolling topography of sand dunes covered with native grasses. These dunes made of fine sand vary in height from a meter to nearly 60-70 m. The region varies from 610-1120 m above sea level and has an average of 40-60 cm of precipitation per year. Annual temperature is between 8.9 and 10.6°C with an annual frost free period of 130-155 days (Bose, 1977). Soils in the area developed in sand that was deposited by wind and water. Dominant plants of the sandhills are described as an association of bluestem (Andropogon), sandreed (Calamovilfa), needle grasses (Stipa), and yucca (Yucca) (Kaul, 1975). For a detailed account of sandhills vegetation see Burzlaff (1962) and Weaver (1965). The Bessey Division is located in a portion of the sandhills known as the "choppy sandhills" ; here dunes are gently rolling to very steep, usually with a slope of at least 16 degrees. Slopes often show a ridge or "catstepped" pattern (Sherfrey et al., 1965).

Field work was conducted in the three major habitats, native and man-made, on the Bessey Division, and a description of these habitats follows:

A. Riparian Communities

1. Middle Loup River -- the Bessey Division is bounded on the north by the Middle Loup River. The riparian zone along this river exists mainly as narrow bands along the north and south banks. Along the western portion of the river, the grasslands simply abut the river. Within the riparian habitat there are areas immediately adjacent to the banks that are subirrigated and very wet. Other areas occur which are much higher and

Figure 1. Location of the Bessey Division of the Nebraska National Forest within the Sandhills and the location of the major habitats of the Bessey Division. Major access roads are numbered.



NEBRASKA NATIONAL FOREST AT HALSEY

drier a little further from the river. The subirrigated habitat was dominated by the following plants: cattails (Typha latifolia), sedges (Carex sp.), canary grass (Phalaris arundinacea), yellow willow (Salix rigida), and red osier dogwood (Cornus stolonifera). In the higher drier areas, dominant trees include: cottonwood (Populus deltoides var. occidentalis), green ash (Fraxinus americana), Siberian elm (Ulmus pumila), boxelder (Acer negundo), hackberry (Celtis occidentalis), and Eastern red cedar (Juniperus virginiana). Other common plants in the drier areas include; wild plum (Prunus americana), Eastern chokecherry (Prunus virginiana), indigo plant (Amorpha fruticosa), goldenrod (Solidago sp.), river bank grape' (Vitis riparia), poison ivy (Toxicodendron sp.), virfinia creeper (Parthenocissis vitacea), stinging nettle (Urtica dioica), European brome (Bromus inermis), switchgrass (Panicum virgatum), orchard grass (Dactylis glomerata), and sand bluestem (Andropogon hallii). There are several large cottonwoods that have fallen in the area, and a thin layer of leaf litter has accumulated on the sandy soil.

2. Dismal River -- the Dismal River bounds the property on the south. Along this river, the riparian zone is discontinuous. There are isolated spots in which trees occur, mostly on the eastern end, but for the most part the Dismal River merely abuts the grasslands. Where trees do occur dominant species include; cottonwood, hackberry, and green ash. Other common types of vegetation include; wild plum, buckbrush (Symphoricarpus sp.), western snowberry (S. occidentalis), virginia creeper, poison ivy, red osier dogwood, yellow willow, goldenrod, little bluestem (Andropogon scoparius), and blue gamma (Bouteloua gracilis). This riparian community, where it exists, is much narrower and relatively more open than the riparian zone on the Middle Loup River. There are fewer fallen

trees and less litter accumulation along the Dismal River.

B. Plantations

Monocultures of three species have been planted on the Bessey Division of the Nebraska National Forest; Eastern red cedar (Juniperus virginiana), ponderosa pine (Pinus ponderosa), and jack pine (Pinus banksiana). Each plantation is man-planted; trees are planted in straight rows spaced fairly uniformly apart.

1. Cedar -- planted in rows approximately 2-3 m apart, cedars are individually spaced from 1-2 m apart. Diameter at breast height is estimated between 8-10 cm. There is very little accumulation of litter under these trees, however, "berries" and seeds of the cedars are abundant on the sandy soil. Lower branches are dead and overlap adjacent trees making the stands very thick and nearly impenetrable. A very sparse covering of sedges occurs in open sandy areas in the plantations. Prickly pear (Opuntia sp.) is found growing at scattered sites throughout the stands.

2. Ponderosa Pine -- trees of these plantations are in rows approximately 2-3 m apart and individually spaced 2-3 m from each other. Diameter at breast height of these pines is 20-30 cm. An accumulation of pine needles covers the ground. Litter is deepest directly below the trees (15-20 cm) and thinner (8-12 cm) further from the base of the pines. Because of this litter, there is no vegetative ground covering in these stands. Poison ivy is found growing in scattered spots through the pines. There are no areas in these plantations where dead trees or their branches have built up any brush piles or snags.

3. Jack Pine -- plantations of the species also are planted in rows, approximately 2-3 m apart and individually spaced 2-3 m from each other. Diameter at breast height is estimated at 15-20 cm. The litter accumulation is 5-10 cm.

Vegetative covering also is lacking in these stands. Some stands of jack pine have been thinned (alternate trees removed) and where this had happened plants have invaded, notably; western snowberry, eastern red cedar, and poison ivy.

4. Burned Plantations -- as a result of a fire that occurred in 1965, an estimated 4,500 ha of trees were destroyed. This fire, which occurred in the northern and central portion of the forest, created a new habitat (Figure 1). It is characterized by scattered clumps or stands of pine and cedar that survived the fire, interspersed with grasses. Deteriorating logs are abundant on the ground throughout the burned plantations. Many young cedars have invaded the burned plantations and young jack pine are also found in the area. Besides the bluestem grasses, sandreed grasses, needle grasses, and yucca; sand lovegrass (Eragrostis trichoides), switchgrass, prairie June grass (Keoheria pyamidata), sand cherry (Prunus besseyi), poison ivy, western snowberry, buckbrush, prickly pear, wild rose (Rosa arkansana), and leadplant (Amorpha canescens), are commonly found in the burned plantations. Large open sandy areas are often found in the burn area. Two of the common species of grasses in this type of habitat are sandhill muhly (Muhlenbergia pungens), and blowout grass (Redfieldia flexuosa). Basically the burned plantations are grasslands with scattered trees and many fallen deteriorating logs.

C. Grasslands

1. Ungrazed Grasslands -- on the Bessey Division (T21N, R27W, S3 and 4) is a 285 ha plot set aside, ca 1950, and designated as a "Natural Area" (Figure 1). This land remains fenced off and free of any grazing pressure from cattle. No improvements (wells and roads) have been made on this land. Vegetation on this allotment is noticeably thicker and taller than vegetation on the adjacent grazed grasslands. Besides the bluestem grasses,

sandreed grasses, needle grass, and yucca, common plants include sand cherry, New Jersey tea (Ceanothus herbaceus), leadplant, prairie mugwort (Artemisia ludoviciana), sunflower (Helianthus rigidus), wild rose, and prickly pear.

2. Grazed Grasslands -- seasonal grazing of cattle, supervised by forest service personnel, is allowed on the Bessey Division. Dominant grasses on the grazed grasslands include little bluestem, needle-and-thread grass, switchgrass, and blue grama. Forbes and shrubs are the same as those found on the ungrazed grasslands but are fewer in number and often grazed to a low profile. The managed areas are rather uniform in appearance and frequently have blowouts and catstepped slopes as described below.

3. Blowouts and Catstepped Slopes -- naturally occurring in areas that are found in the grazed and ungrazed grasslands. Often large open sandy blowouts are present as well as sandy, ridged, "catstepped" slopes in the grasslands. Very sparse vegetation is found in these areas. Common plants include blue grama, sedges, sandhill muhly, blowout grass, yucca, prickly pear, and wild rose.

RESULTS

Preface

Prior to afforestation the native habitats on the Bessey Division were grasslands and riparian communities. Each of these habitats had a characteristic mammalian fauna. Grasslands were grazed by bison (Bison bison) during the Recent epoch, and there probably were a few scattered trees but no forests in the region. Today these grasslands are seasonally grazed by cattle. The riparian communities are primarily composed of deciduous trees. My study was conducted to determine how the mammals in these two habitats were influenced by the planting of a coniferous forest in the grasslands. Each mammalian species was evaluated as to whether or not it has been (1) inhibited in its distribution or decreased in relative numbers because of the plantations, (2) expanded its range or increased in relative numbers because of the plantations, or (3) showed little or no change in its distribution or numbers as a result of afforestation. Riparian species of mammals could expand their range to include this new wooded area or remain along the rivers. Grassland species of mammals could be excluded from the new forest, could increase their numbers, or they could remain unaffected as a result of man planting a coniferous forest. Evidence of the effects of afforestation for most species is based on live-trapping records, for bats, on netting records, and for the remaining species by direct observation.

Evidence Based on Live-Trapping

Three hundred and seventy-five small mammals were captured in 3050 trap nights to determine the relative abundance and species composition in the different habitats on the Bessey Division of the Nebraska National Forest and Halsey, and the results are presented in Table I.

Table I. Results of live-trap study on the Bessey Division of the Nebraska National Forest at Halsey, Thomas County. Numbers indicate individuals captured per one hundred trap nights. Numbers in parentheses indicate the total number of individuals captured.

Habitat Type	Trap Nights	Species										Total (375)			
		Sc (2)	Pl (121)	Pm (104)	Rmg (18)	Rmt (2)	Ol (8)	Mp (15)	Mo (10)	Pf (44)	Ph (1)		Do (50)		
A. Riparian															
1) Middle Loup River	625	0.3	13.3	0.2	1.4	-	-	2.4	1.0	-	-	-	-	-	18.6
2) Dismal River	100	-	5.0	-	-	-	-	-	-	-	-	-	-	-	5.0
B. Grasslands															
1) Ungrazed by Cattle	425	-	-	6.8	1.4	0.2	0.5	-	0.7	2.1	-	-	0.2	0.2	12.0
2) Grazed by Cattle	450	-	-	2.9	0.2	0.2	0.4	-	-	1.3	-	-	0.2	0.2	5.3
3) Blowouts and Catstepped	250	-	-	1.2	-	-	-	-	-	2.0	-	-	4.0	4.0	7.2
C. Plantations															
1) Cedar	300	-	9.7	6.3	-	-	1.3	-	-	1.7	0.3	7.0	-	-	26.4
2) Ponderosa Pine	300	-	0.7	6.0	0.3	-	-	-	-	-	-	-	-	-	7.0
3) Jack Pine	200	-	-	1.0	-	-	-	-	-	0.5	-	-	-	-	1.5
4) Burned Plantations	400	-	0.5	4.8	0.3	-	-	-	0.3	4.5	-	-	4.3	4.3	14.5
Total	3050														

Sc = Sorex cinereus (Masked Shrew)
 Pl = Peromyscus leucopus (White-footed Mouse)
 Pm = Peromyscus maniculatus (Deer Mouse)
 Rmg = Reithrodontomys megalotis (Western Harvest Mouse)
 Rmt = Reithrodontomys montanus (Plains Harvest Mouse)
 Ol = Onychomys leucogaster (Northern Grasshopper Mouse)
 Mp = Microtis pennsylvanicus (Meadow Vole)
 Mo = Microtis ochrogaster (Prairie Vole)
 Pf = Perognathus flavescens (Plains Pocket Mouse)
 Ph = Perognathus hispidus (Hispid Pocket Mouse)
 Do = Dipodomys ordii (Ord's Kangaroo Rat)

Sorex cinereus (Masked Shrew). -- The masked shrew is locally common and most frequently found in marshy areas with lush vegetation, often restricted to riparian associations in Nebraska (Jones, 1964). Only five individuals were taken during my study, two were live-trapped in wet lush vegetation adjacent to the Middle Loup River and three were captured in pitfall traps in the drier wooded areas of the riparian habitat. No specimens were taken in any of the plantations, the grasslands, or the burned plantations. Sorex cinereus remains unaffected by the planting of this forest.

Cryptotis parva (Least Shrew). -- This shrew is more common in the upland habitats of Nebraska than is the masked shrew. The least shrew was not reported from Thomas County by Jones (1964). The mammalogy class from the University of Nebraska at Omaha did however capture one individual on a field trip in 1978 in a dry grassy area of the burned plantation. I don't feel that I have enough data on this species to say whether or not it has been affected by the planting of a forest because this record is at the periphery of this species range.

Peromyscus (White-footed Mice). -- Two species of Peromyscus are found in Nebraska, the white-footed mouse (P. leucopus) which is a common inhabitant of wooded areas (especially riparian habitats) and the deer mouse (P. maniculatus) which is ubiquitous although more common in the upland habitats covered with grasses (Jones, 1964). Before planting a coniferous forest on the Bessey Division, P. leucopus was restricted to the deciduous community along the rivers. As a result of the planting project, P. leucopus has expanded its range to include the cedar plantations in relatively high numbers and to a much lesser degree ponderosa pine

stands and the burned plantations. No P. leucopus were taken in the grasslands, grazed or ungrazed. Peromyscus maniculatus was found in all habitats. The highest number of individuals was taken in the ungrazed grasslands. This species appears to remain unaffected by man's activity on the Bessey Division, as high numbers of deer mice also were taken in the cedar, ponderosa, and burned plantations.

Reithrodontomys (Harvest Mice). -- Two species of Reithrodontomys also are found in Nebraska, the western harvest mouse (R. meglotis) which is a common inhabitant of grassy areas throughout Nebraska, but frequently restricted to riparian habitats in the western portion of the state; and the plains harvest mouse (R. montanus) which is almost exclusively restricted to drier upland habitats (Jones, 1964). On the Bessey Division, the western harvest mouse was taken in similar numbers in the riparian habitat and the ungrazed grasslands. The number of captures was less in the grazed grasslands, ponderosa pine, and burned plantations. None were taken in the other habitats. It appears that the western harvest mouse has been inhibited as a result of man's activity. The plains harvest mouse was taken only in the grasslands, grazed and ungrazed, but not in any of the other available habitats, man-made or native. It appears as though the plains harvest mouse also has been inhibited in its distribution as a result of afforestation.

Onychomys leucogaster (Northern Grasshopper Mouse). -- In Nebraska, Jones (1964) found this species to be frequently taken along the borders of little used roads, upland grain fields, and in relatively undisturbed prairies of western Nebraska. Eight Onychomys were taken during my live-trap

study. Two individuals were captured in the ungrazed grasslands, two in the grazed grasslands, and the remaining four were taken in the cedar plantations (all four in the same night). No O. leucogaster were taken in the ponderosa pine, jack pine, or the burned plantations. This grassland species appears to have been inhibited in its distribution on the Bessey Division in all the plantations except the cedar stands, although I suspect it would be found in the burned plantation with additional trapping. The overall effect of planting a forest probably is negative on the distribution of the northern grasshopper mouse.

Microtis (Voles). -- Three species of voles are found in Nebraska, two of which have distributions in western Nebraska; meadow voles (M. pennsylvanicus) which inhabits low, wet, grassy areas and the prairie vole (M. orchrogaster) which occurs in drier grassy areas (Jones, 1964). Meadow voles were captured only in the lush wet vegetation adjacent to the Middle Loup River. This species remains unaffected by the planting of a forest. Prairie voles were taken on the drier grassy edges of the riparian habitat, the burned plantations, and the ungrazed grasslands, in areas of thick grasses. None of this species was taken in the unburned plantations. The lack of vegetation ground cover under the coniferous trees seems to be the limiting factor for this genus. Prairie voles appear to have been inhibited in their distribution as a result of afforestation.

Perognathus (Pocket Mice).-- Three species of Perognathus are found in Nebraska, only two of which occur on the Bessey Division. Plains pocket mice (P. flavescens) are most often taken in the relatively sandy areas of the Nebraska sandhills while the hispid pocket mouse (P. hispidus)

is a prairie species (Jones, 1964). On the Bessey Division, plains pocket mice were taken in sandy blowouts and the catstepped areas in about equal numbers as in the ungrazed grasslands. No pocket mice were taken in the ponderosa pine but were found to be utilizing cedar and jack pine plantations. The highest numbers of P. flavescens were taken in the burned plantations. It appears that this burned plantation has the right combination of open sandy soils, grasses, and fallen logs that allows this mammal to increase in relative numbers in this habitat. In general this pocket mouse seems unaffected as a result of man's activity. The hispid pocket mouse is rare on the Bessey Division; only one individual was captured. Although too little information is known to say how the forest has influenced this species, the fact the P. hispidus was taken in the cedar plantations seems to indicate that it is utilizing at least some of the man-made habitats on the Bessey Division.

Dipodomys ordii (Ord's Kangaroo Rat). -- Ord's kangaroo rat is one of the most conspicuous small mammals on the sandhills, preferring sandy soils, especially blowouts (Jones, 1964). Equal numbers of D. ordii were captured in blowouts and catstepped areas as in the burned plantations. Surprisingly, however, the highest numbers were taken in the cedar plantations (Table I). None of these heteromyids were taken in the ponderosa pine or jack pine plantations. I believe the reason for the higher numbers in the cedars is because, unlike ponderosa and jack pine plantations, the cedars have open sandy areas and no accumulation of pine needles under the trees. This species has been inhibited in the ponderosa and jack pine plantations and appears to be unaffected in the burned plantations and the cedar stands. Because it is inhibited in at

least some of the man-made habitats, in general I am considering this species to be inhibited by the planting of a coniferous forest.

Zapus hudsonius (Meadow Jumping Mouse). -- The meadow jumping mouse is found only in riparian habitats near rivers and marshes in western Nebraska (Jones, 1964). This species has been taken in Thomas County, near the Dismal River. I did not catch any jumping mice during my study however. Since this mammal prefers lush habitats, the planting of a forest would have no influence on this animal's distribution or relative numbers.

Evidence Based On Direct Observations

Data were collected on the remaining species whenever the mammals themselves or their sign were encountered.

Sciurus niger (Fox Squirrel). -- Fox squirrels are an arboreal species found essentially along the major rivers in the western part of Nebraska (Jones, 1964). This mammal surely was restricted to the woodlands of riparian community before the forest was planted. As a result of planting a coniferous forest, this species has expanded its range to include the ponderosa and jack pine plantations. I have seen the fox squirrel in these plantations as far as 10 km from the nearest riparian habitat. This species has benefited from the planting of a forest.

Erethizon dorsatum (Porcupine). -- Being an arboreal species, porcupines also benefited from the planting of a forest. Jones (1964) considered this species to be numerous on the Bessey Division but sparingly distributed along the Loup drainage in central Nebraska. The new coniferous forest provided habitat and more food for the porcupines.

I have evidence of porcupine workings of trees in the unburned and the burned plantations. Johnson and Higgins (1952) reported that during the winter of 1951-52 forest employees killed 68 of these rodents on the Bessey Division.

Didelphis virginiana (Opossum). -- Opossums are widely distributed in Nebraska in the eastern part of the state. The species seems to be expanding its range northward and westward by utilizing riparian communities as avenues of travel. This species has been reported from Thomas County, but it is considered rare (Jones, 1964). Because this is a forest species, it is probable that this mammal also has benefited from the planting of a coniferous forest.

Scalopus aquaticus (Eastern Mole). -- Jones (1964) reported moles to be limited to moist soils along the rivers in western Nebraska. Mole tunneling was seen near the Middle Loup and Dismal rivers, and often occur near stock tanks in the grazed grasslands. However, tunneling also was found in the grasslands at least 8 km from the nearest river in high dry ungrazed area known as the "Natural Area", which contains no stock tanks; one specimen was collected from this site. On the other hand, ponderosa pine plantations were found to be riddled with feeding runs of the eastern mole. While walking through these stands, one can randomly pick a tree and dig down through the litter and find a run. Runs also were found crossing the sandy roads in these stands. Evidence of moles was found most commonly in the ponderosa pine plantations; therefore, I consider the mole to be benefiting from the planting of a forest on the Bessey Division.

Geomys bursarius (Plains Pocket Gopher). -- Jones (1964) considered this species to be distributed statewide in Nebraska. Pocket gophers are abundant on the Bessey Division of the Nebraska National Forest. Gopher mounds were observed in the riparian community, the grasslands, and in the burned plantations, but I have never seen any gopher mounds deep inside these plantations. This grassland species has been inhibited in its distribution as a result of afforestation.

Cynomys ludovicianus (Black-tailed Prairie Dog). -- Several isolated populations of prairie dogs are found on the Bessey Division, notably in the southern portion of the property in the short grass areas. These grassland mammals were never seen in or near any of the plantations. As a result of planting a forest these mammals have been inhibited in their distribution because colonies are formed only in the open short-grass areas.

Spermophilus (Ground Squirrels). -- Three species of Spermophilus have been taken in Thomas County. Spermophilus franklinii (Franklin's ground squirrel) is a species common to the tall grasslands of eastern Nebraska; in the western part of the state, however, it is often restricted to the riparian systems. Spermophilus spilosoma (Spotted ground squirrel) is sympatric with S. tridecemlineatus (Thirteen-lined ground squirrel) in the sandhills; where the two are found together, S. spilosoma inhabits the drier sandy areas whereas S. tridecemlineatus inhabits the more mesic areas (Jones, 1964). All three species are grassland species. None of these ground squirrels were seen during my study. One specimen of S. tridecemlineatus was collected on the Bessey Division by the mammalogy

class from the University of Nebraska at Omaha in 1979. This animal was taken on the southern portion of the property near a prairie dog town in a short grassy habitat. A thirteen-lined ground squirrel was also seen in 1982 near another prairie dog town in similar habitat (Pete Clark, per. comm.). I personally saw one Franklin's ground squirrel 20 km east of Halsey, Nebraska near the Middle Loup River in May 1982. This sight record, however, is off the Bessey Division. No spotted ground squirrels were seen during my study. Probably all three of these grassland mammals have been inhibited in their distribution by the unburned plantations.

Castor canadensis (Beaver). -- This semi-aquatic species was seen on the Middle Loup River. Evidence of feeding also was noted here and along the Dismal River. There is no evidence that this species is utilizing any of the man-made habitats. Planting a forest has had no effect on this species.

Ondatra zibethicus (Muskrat). -- Like the beaver, this semi-aquatic species was seen in the Middle Loup River. There is no evidence that this species is using the forest; it remains only along the riparian systems of the rivers on the Bessey Division.

Sylvilagus floridanus (Eastern Cottontail). -- In central Nebraska the cottontail is somewhat restricted to the riparian community (Jones, 1964). Before afforestation the cottontail was surely found along the Middle Loup and Dismal rivers on the Bessey Division. As a result of afforestation, the cottontail also can be found in the burned plantation and in the cedar plantations. I also have seen their fecal material in these two habitats but have seen no cottontails or their fecal material in the ponderosa or jack pine plantations. The cottontail has expanded

its range as a result of man's activity on the Bessey Division.

Lepus (Hares). -- Two species of jackrabbits occur nearly statewide in Nebraska; L. californicus (Black-tailed jackrabbit) is more common in the southern part of the state, and L. townsendii (White-tailed jackrabbit) is more common north of the Platte River in Nebraska (Jones, 1964). Jackrabbits are grassland or open area species. I have only one sight record for the white-tailed jackrabbit; this was recorded in the southern part of the Bessey Division on a prairie dog town, a short grass area. I have no records for the black-tailed jackrabbit on the Bessey Division during my study. It appears as though both species have been inhibited as a result of planting a coniferous forest.

Odocoileus (Deer). -- Two species of deer are found on the Bessey Division. Odocoileus hemionus (Mule deer) is often wide spread in the sandhills and prefers open grasslands, whereas O. virginiana (White-tailed deer) is often restricted to the wooded areas along the riparian community in western Nebraska (Jones, 1964). Both species of deer are ecotone animals. With the planting of a forest, the amount of edge (ecotone) was increased. Mule deer are seen in all habitats except the riparian, while white-tails were seen in all habitats (Table II). It appears that both species have benefited from the planting of a forest. Forest service personnel estimate the population size (both species combined) to be approximately 500 animals.

Antilocapra americana (Pronghorn). -- The pronghorn is an open grassland species in western Nebraska (Jones, 1964). I have two sight records for this species during my study. One was recorded in the short grass area on the southeastern portion of the property and one on the southwestern

Table II. Numbers of encounters with native artiodactyls on the Nebraska National Forest at Halsey during my study. Numbers in parentheses indicate the total number of individuals.

Habitat Type	Species		
	<u>Odocoileus virginiana</u> (20)	<u>Odocoileus hemionus</u> (33)	<u>Antilocapra americana</u> (2)
Riparian	3	-	-
Grasslands	2	2	2
Unburned Plantations	1	6	-
Burned Plantations	4	3	-

portion near a prairie dog town. No pronghorn were seen in or near the plantations, the burn area, or the riparian habitats. This grassland species has been inhibited in its distribution as a result of planting a forest. Forest service personnel estimate the pronghorn population size at about 30 animals.

Carnivores. -- The only carnivore that I have sight records for during my study is Canis latrans (Coyote). Coyotes were seen in the grasslands and in the burn area. The planting of a forest probably has had no effect on this species. Through interviews with Pete Clark and George Mandeville, range conservation officers on the Bessey Division, I feel that I can hypothesize about how some of the other carnivores, which are seldom seen, are being influenced by the planting of a forest. Woodland species that probably have benefited include; Spilogale putorius (Spotted Skunk), Mephitis mephitis (Striped Skunk), Vulpes vulpes (Red Fox), Felis rufus (Bobcat), and Mustela frenata (Long-tailed Weasel). Two species which are often restricted to the riparian community, near water, that appear to remain unaffected by the planting of a forest are; Mustela vison (Mink) and Procyon lotor (Raccoon). One species, an open area or grassland species, that probably has been inhibited in its distribution because of the forest is Taxidea taxus (Badger).

Evidence Based on Netting

Four species of bats have been taken in Thomas County, Nebraska (Jones, 1964; Czaplewski et al., 1979). Three are migratory species; Lasiurus borealis (Red Bat), L. cinereus (Hoary Bat), and Lasionycteris noctivagans (Silver-haired Bat). The other species, Eptesicus fuscus (Big Brown Bat), is a hibernator. All four species are known to use

trees for roosting; leaves, under bark, or in holes in the trees (Barbour and Davis, 1969).

Lasiurus borealis was the only bat captured during my study (Table III). Three individuals were netted in the ponderosa pine plantations. These individuals were taken in October, and it is possible that they were migrating south. Trees provide roosting spots for bats and also probably increase the number of insects in the area. Stock tanks and earthen ponds, installed for livestock and wildlife, provide drinking water. The planting of a forest appears to have benefited bats because prior to planting a forest, bats would likely have been restricted to the riparian habitats. On three occasions I inspected the buildings on the Bessey Division for roosting bats but none were found. John Hinz (nursery personnel) occasionally finds what he described as "small brownish-black bats" in the refrigerated seedling storage building. I was unable to get any of these bats to make a positive identification.

Table III. Summary chart of bat netting, on the Nebraska National Forest at Halsey, during my study.

Habitat Type	Date (1982)	Netting Site (Surface area, m ²)	(# of captures & sex)	Species
Riparian	25 May	man-made pond	90*	-
	25 May	"	90**	-
	26 July	"	90*	-
	26 July	"	90*	-
	27 July	"	75**	-
Unburned Plantations	27 July	metal stock tank	10*	-
	15 October	"	10*	<u>Lasiurus borealis</u> , 1M
	15 October	man-made pond	20**	<u>Lasiurus borealis</u> , 1M
	16 October	metal stock tank	10*	-
	16 October	man-made pond	20**	<u>Lasiurus borealis</u> , 1M
Burned Plantations	28 July	metal stock tank	10*	-
	28 July	man-made pond	30**	-
	1 August	metal stock tank	10*	-
	1 August	man-made pond	30**	-

* 18 foot mist net used

** 30 foot mist net used

DISCUSSION

Results of my study indicate that: (1) 32.6% (14/43) of mammalian species on the Bessey Division have been inhibited in their distribution or have decreased in relative numbers as a result of afforestation, (2) 39.5 % (17/43) of the species have expanded their ranges or increased in relative numbers, and (3) 23.2% (10/43) of the species remain unaffected, showing little or no change in their distribution or relative numbers as a result of man's activity on the Bessey Division. Too little information exists for Cryptotis parva and Perognathus hispidus to determine the affect of the forest on them.

Seventeen species of mammals found on the Bessey Division are grassland or prairie forms. The following fourteen grassland species appear to have been inhibited by the plantations: Reithrodontomys megalotis, R. montanus, Onychomys leucogaster, Microtis ochrogaster, Geomys bursarius, Cynomys ludovicianus, Spermophilus tridecemlineatus, S. spilosoma, S. franklinii, Lepus townsendii, L. californicus, Antilocapra americana, Taxidea taxus, and Dipodomys ordii. These species are adapted to open grassy areas. They use grasses as a food source and for protection. Trees planted on the Bessey Division displaced the grasses and thereby the mammals associated with this particular type of habitat. Peromyscus maniculatus, Perognathus flavescens, and Canis latrans are also grassland forms, but these three species appear to remain unaffected by the planting of a coniferous forest; apparently also are able to utilize this new habitat.

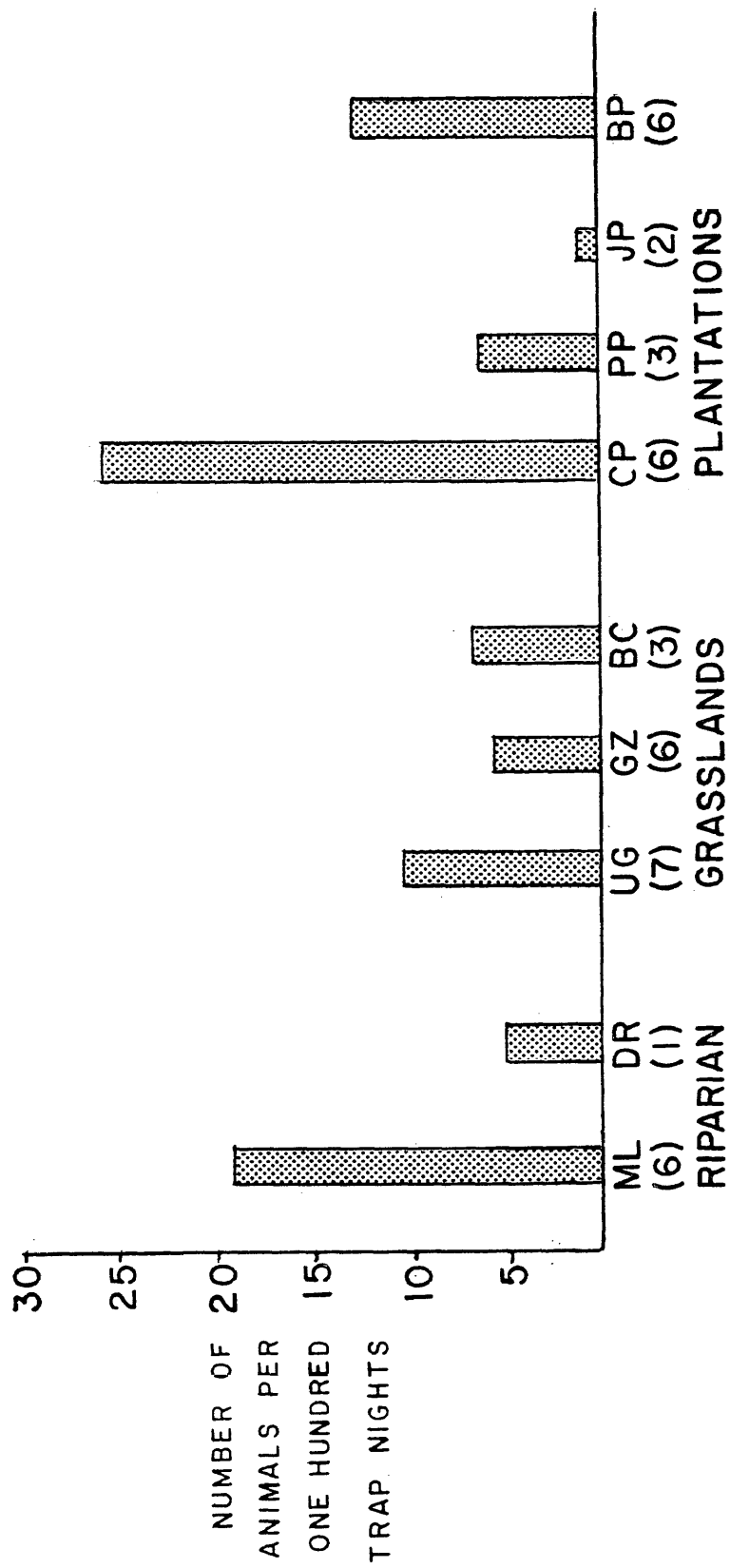
Seventeen species of mammals are believed to have benefited from the planting of the forest and include the following: Peromyscus leucopus,

Sciurus niger, Erethizon dorsatum, Didelphis virginiana, Scalopus aquaticus, Sylvilagus floridanus, Odocoileus virginiana, O. hemionus, Mephitis mephitis, Spilogale putorius, Vulpes vulpes, Felis rufus, and Mustela frenata. These species are ecologically tied to woodlands (Deciduous forest) and have adapted to the planting of a coniferous forest. These species are utilizing the trees, moist soils under the trees, or the litter layer associated with the plantations. All four species of bats; Eptesicus fuscus, Lasiurus borealis, L. cinereus, and Lasionycteris noctivagans are thought to have benefited from the planting of a forest.

Seven species of mammals on the Bessey Division appear to be unaffected by the planting of a forest. Castor canadensis, Ondatra zibethicus, Mustela vison, and Procyon lotor are normally restricted to the waterways in the state and planting a forest has not increased their preferred habitat. Microtis pennsylvanicus, Sorex cinereus, and Zapus hudsonicus are ecologically tied to the lush vegetation often associated with riparian communities and since this mesic type of habitat is not found in the plantations, these mammals remain unaffected by the plantations.

Species diversity and relative abundance of small live-trapped mammals is presented in figure 2. The Middle Loup riparian community is noticeably higher in species diversity (6) than is the dismal River riparian community (1) Relative abundance of small mammals also is more than three times as high in the Middle Loup habitat (18.5 vs. 5.0 animals per one hundred trap nights). I suspect the reason for the higher diversity and numbers of small mammals on the Middle Loup community is because of the following characteristics; (1) more and thicker

Figure 2. Relative abundance of small mammals (all species) live-trapped in each of the major habitats and its subdivisions on the Bessey Division of the Nebraska National Forest at Halsey during my study. Numbers in parentheses indicate the number of different species taken in each of the habitats. ML = Middle Loup, DS = Dismal River, UG = Ungrazed Grasslands, GR = Grazed Grasslands, BC = Blowouts and catstepped areas, CP = Cedar Plantations, PP = Ponderosa Pine Plantations, JP = Jack Pine Plantations, BP = Burned Plantations.



vegetation, (2) greater numbers of fallen logs, (3) more litter, and (4) a broader more closed riparian zone.

Grasslands on the Bessey Division are grazed by cattle today. In the past, bison grazed the area in a way that produced a mosaic pattern, areas of grazed and ungrazed grasses (Koford, 1958). When comparing these types of grasslands, ungrazed areas had more than twice as many individuals as the grazed area. In terms of species diversity, one additional species, Microtis ochrogaster, which requires thick vegetation, also was taken in the ungrazed grasslands. Ungrazed areas had higher numbers because thicker vegetation provides more food and more protective cover for small mammals. Blowouts and catstepped slopes had low diversity because only those species adapted to open sandy habitats were found in these areas.

Not surprisingly, burned plantations, which resemble grasslands with scattered trees and fallen logs, had species diversity equal to the grassland habitats. Relative numbers of mammals was slightly higher in the burned plantations than in the grasslands. Surprisingly, however, cedar plantations were as high as the native habitats in species diversity and much higher than the other two unburned plantations. In terms of relative abundance, the cedar plantations had the highest number of captures (26.4 animals per 100 trap nights); higher than either of the native habitats on the Bessey Division. Several factors may contribute to the high numbers of small mammals in the cedar plantations: (1) cedar trees produce abundant amounts of seeds which fall to the ground and are readily available as food for many species, (2) cedar stands are extremely

thick, making it difficult for large predators to capture prey, (3) mammals living in the cedar stands would experience less environmental (climatological) stress than the mammals living in the open grasslands. Niederhof and Stahelin (1942), studying the Bessey Division, showed that wind velocity is 72% lower in the plantations than in the grasslands; evaporation is 58% lower in the plantations; and soil temperatures are slightly warmer in the winter (December--February) and slightly cooler in the spring, summer, and fall (March--November). Precipitation reaching the ground in the plantations is 26% lower inside the plantations, and (4) trapping success may be higher in plantations because it is darker under these trees and some literature suggests more activity and therefore higher number of captures on dark nights.

Ponderosa pine had higher numbers of animals than jack pine. This may be due to the following: (1) in Thomas County only ponderosa pine is growing in its historical range (Little, 1971) and probably produces more seeds per tree, (2) ponderosa pine normally produces larger seeds (6-7mm) than jack pine (4-5mm), and (3) ponderosa pine cones open on the trees, releasing their seeds which accumulate on the ground. On the other hand, cones of the jack pine often remain on the trees for several seasons and often fall intact, making them harder for small mammals to process.

My expectations were born out. Semi-aquatic mammals and those species ecologically tied to lush vegetation along waterways were unaffected by the plantations. Woodland species of mammals appear to be able to utilize the coniferous plantations and grassland species of mammals except Canis latrans, Peromyscus maniculatus, and Perognathus flavescens, appear to have been inhibited as a result of afforestation.

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APPENDIX

Appendix I. List of voucher specimens, collected during my study, on the Bessey Division of the Nebraska National Forest at Halsey, Thomas County, on deposit at the University of Nebraska at Omaha, Department of Biology. T # N = Township # North, R # W = Range # West, S = Section.

Species	UNO #	SEX	LOCATION			DATE COLLECTED (1982)
			T # N,	R # W,	S	
<u>Sorex cinereus</u>	473	M	22	26	2	29 July
	474	F	22	26	3	16 Oct.
	475	M		"		"
<u>Peromyscus leucopus</u>	354	M	21	26	13	18 May
	375	M	22	26	16	20 May
	377	F	22	26	3	11 May
	378	F		"		21 May
	379	F		"		"
	477	F		"		16 Oct.
	478	F		"		"
	493	M	22	26	21	18 Oct.
	492	M		"		"
<u>Peromyscus maniculatus</u>	355	M	22	27	24	19 May
	357	M	22	26	24	"
	361	M	22	26	21	12 May
	362	F		"		"
	368	F	22	26	5	11 May
	371	M	22	26	20	14 May
	484	F	21	27	4	17 Oct.
	485	M		"		"
	494	M	22	26	21	18 Oct.
	495	M		"		"
	<u>Onychomys leucogaster</u>	353	F	21	27	4
360		M	22	27	33	15 May
372		M	22	27	20	14 May
<u>Microtis ochrogaster</u>	367	F	22	26	5	11 May
	380	F	22	26	3	15 May
	381	M		"		"
	382	M		"		"
	383	F		"		"
	384	M		"		"
	486	F	21	27	4	17 Oct.
	487	M		"		"
	488	F		"		"
<u>Microtis pennsylvanicus</u>	479	M	22	26	3	16 Oct.
	480	F		"		"
	481	M		"		"
	482	M		"		"

Appendix I. (cont'd)

Species	UNO #	SEX	LOCATION			DATE COLLECTED (1982)
			T #	N, R #	W, S	
<u>Reithrodontomys megalotis</u>	352	F	22	26	10	26 May
	364	M	22	26	2	13 May
	365	F		"		"
	369	M	22	26	21	12 May
	476	F	22	26	3	16 Oct.
<u>Reithrodontomys montanus</u>	359	F	22	27	3	15 May
	483	M	21	27	4	17 Oct.
<u>Perognathus hispidus</u>	374	F	22	26	16	12 May
<u>Perognathus flavescens</u>	356	M	22	27	24	19 May
	358	M	22	26	7	"
	366	M	22	26	5	11 May
	370	M	22	26	20	12 May
<u>Dipodomys ordii</u>	373	F	22	26	16	12 May
	385	M	22	26	3	27 May
<u>Scalopus aquaticus</u>	363	M	22	26	2	17 May
	489	M	21	27	4	17 Oct.
<u>Geomys bursarius</u>	376	F	22	26	16	2 June
<u>Lasiurus borealis</u>	490	M	22	26	21	16 Oct.
	491	M*		"		"

* Skull only