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Small mammal demographics in North Dakota conservation reserve program plantings

Larry A. Lysne

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SMALL MAMMAL DEMOGRAPHICS IN NORTH DAKOTA
CONSERVATION RESERVE PROGRAM PLANTINGS

by

Larry A. Lysne
Bachelor of Science
Minot State University, 1985

A Thesis
Submitted to the Graduate Faculty
of the
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Science

Grand Forks, North Dakota
August 1991
This thesis, submitted by Larry A. Lysne in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

(Chairperson)

Richard D. Crawford

William Nolen

This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Harvey Knuff
Dean of the Graduate School

7-15-91
PERMISSION

Title: Small Mammal Demographics in North Dakota Conservation Reserve Plantings

Department: Biology

Degree: Master of Science

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Signature: Larry A. Lyne
Date: July 9, 1991
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</tbody>
</table>
ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. Robert Seabloom, for his encouragement and guidance during my time as a graduate student. I also wish to thank Dr. Richard Crawford and Dr. William Wrenn for serving on my committee and engaging in many thought-provoking conversations. Thanks also go to my fellow graduate students for sharing ideas and good times.

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Finally, I want to thank my neighbor and good friend, John Benson, and his son, Mike, for donating hours of their time to help with field work. Thanks also goes to my children, Maggi and Colby, for their encouragement and support, before and during my graduate studies. It has also been a grand experience to have my daughter as a fellow
student at the University of North Dakota during the last two years.
During the summers of 1989 and 1990, capture-recapture methods were used to determine small mammal demographics and population dynamics in Conservation Reserve Program (CRP) plantings in north central North Dakota. Four age classes (1-4 years) of CRP plantings were sampled. Small mammal species diversity was low ($H' = 0.057-0.374$). Eight species of small mammals were captured on CRP tracts, with deer mice (*Peromyscus maniculatus*) comprising 92% of all small mammals recorded. Largest deer mouse populations (64/ha and 51/ha) occurred in late August and early September, 1990. Peak densities in 1990 were over twice as high as those of 1989.

Home range sizes of male and female deer mice were not significantly different, although mean home range of males (0.18 ha) was larger than that of females (0.14 ha). Total number of male deer mice was not significantly different than females.

Based on other studies and sampling of vegetation and small mammals in later successional plantings, a change in vegetation and small mammal species composition can be expected in CRP plantings over time. Substantial populations of deer mice in early growth give way to
potentially substantial populations of meadow voles
(Microtus pennsylvanicus) if plantings are not manipulated
(burned, grazed or mowed). This change in species
composition may influence the occurrence of avian predators
in these areas and may furnish desirable alternate prey to
avian and mammalian predators of ground nesting birds.
INTRODUCTION

The Conservation Reserve Program (CRP) was initiated by the United States Department of Agriculture in 1986 as a component of the 1985 Farm Bill. The goal of the program is to retire highly erodible crop acres and seed them to cover. CRP plantings consist of tame grasses and legumes, native grasses and forbs, trees and shrubs. Out of 13.7 million ha enrolled nationwide, 8.7 million ha have been seeded to tame grasses and legumes. In North Dakota, 1.17 million ha have been enrolled, with 1.16 million ha having been planted to tame grasses and legumes (Jerry Kraus, pers. comm., North Dakota Soil Conservation Service).

Ongoing studies involving CRP plantings deal with vegetative structure and suitability as wildlife habitat and use by breeding birds. However, no investigations of small mammal populations in CRP plantings have been reported. Such studies may provide insight into small mammal population characteristics in early stages of secondary succession, and may also have management implications regarding the changing alternate prey base.

The major objective of this study was to determine small mammal species composition and diversity, population densities, population structure and home range sizes of
dominant species and to identify any relationship to the age and vegetative characteristics of CRP plantings. Other objectives were to determine numbers and species of small mammals colonizing a CRP planting during its first season of growth and to predict vegetative and small mammal succession on CRP plantings, based on characteristics of similar plantings which are in later stages of succession.
STUDY AREAS

This study was conducted in Benson County, which is located in the north central part of North Dakota (Fig. 1). Benson County is in the Central Lowland Province and lies along the eastern edge of the Williston Basin. It is in the physiographic region known as the drift prairie and in the drainage basin of the Red River of the North and of the closed basin of the Devils Lake chain (Strum et al. 1979).

The area lies within the mixed-grass prairie. Native vegetation has been described as the Wheatgrass-Bluestem-Needlegrass type by Barker and Whitman (1989).

Most soils of the area formed in glacial till, glacial outwash or glacial lake sediment. The major part of the area is gently rolling glacial till plains. The sandy and gravelly outwash sediment is associated with Martin, Heimdal, McHenry and North Viking end moraines, which are mainly undulating to hilly glacial till (Strum et al. 1979).

At Leeds, in the northern part of the county, the average winter temperature is -13.3°C, and the average daily minimum is -18.8°C. The average summer temperature is 18.8°C, and the average daily maximum is 26.6°C (Jensen 1974).
Figure 1. Location of study areas.
Total annual precipitation is 45.7 cm, of which 72% usually falls during the period from April through September. In two out of 10 years, the April to September rainfall is less than 27.9 cm. About 25 thunderstorms occur each year, 20 of which are in summer. Average seasonal snowfall is 94 cm. The greatest snow depth at any one time was 83.8 cm (Jensen 1974).

Blizzards (storms of snow and high wind) are common in winter. Hail occurs in scattered areas during summer thunderstorms.

About 74% of Benson County (261,433 ha) is cropland; 17% (59,085 ha) is rangeland and pasture; and the remaining 9% (30,352 ha) is woodland, federal non-crop land, and other land (Strum et al. 1979).

Small mammal populations were investigated on two CRP tracts. Tract 1 (3.2 ha.; SE1/4, Sec#8, T151N, R68W) had been previously cropped with wheat, barley, flax and sunflowers. Tract 1 was seeded to a mix of slender, western and crested wheatgrass (Agropyron spp.), yellow sweetclover (Melilotus occidentalis) and alfalfa (Medicago sativa) on May 19, 1989. Oats (Avena sativa) was interseeded as a cover crop (Floyd Dressen, pers. comm., Benson County Soil Conservation Service).

Tract 2 (64 ha.; SW1/4, Sec#22, T153N, R69W) previously grew wheat, barley, flax and sunflowers. Tract 2 was seeded to a mix of intermediate wheatgrass (Agropyron sp.), smooth
brome grass (*Bromus inermis*) and yellow sweetclover (*Melilotus occidentalis*) on May 20, 1987 (Floyd Dressen, pers. comm., Benson County Soil Conservation Service).
METHODS

LIVE-TRAPPING METHODS

Capture-recapture methods, using Sherman live traps (7.6x23.2x9 cm), were used during the summers of 1989 and 1990 to investigate species composition, species diversity, population densities, colonization, home ranges and age/sex ratios of small mammals on the two CRP tracts.

One-hundred traps were placed at 10-m intervals on square 1 ha grids. ("Grid" refers to actual area trapped, whereas "tract" refers to the entire CRP field.) Grid 1 was located within Tract 1, while Grid 2 was located within Tract 2. Grids were trapped for 5 consecutive nights according to criteria suggested by Otis et al. (1978). Traps were baited with peanut butter and rolled oats and were removed from the grids between trapping periods. Cotton was placed in the traps to insulate animals from the cold. Toe clipping was used to assign a number to each individual. All traps were inspected by 1000 hours each morning. Information collected for each capture included species, animal number, location of capture, weight of the animal, age, breeding condition and date of capture. Moon phase and weather conditions were also recorded.

Small mammals were trapped on one grid within each
tract, with the exception of Tract 1, when an additional grid, adjacent to Grid 1 was sampled concurrently in 1989. Data from the additional grid on Tract 1 were used only in determining sex/age ratios, home range areas and population densities of *Peromyscus maniculatus*, where density per grid was reported as the mean of the 2 grids. Data from Grid 1 only were used in determining species composition and diversity.

Grids 1 and 2 were trapped during 3 five-day trapping periods each summer of the study. Grid 1 was trapped from 29 June through 3 July, 3 August through 7 August and 3 September through 7 September in 1989 and from 26 June through 30 June, 30 July through 3 August and 30 August through 3 September in 1990. Grid 2 was trapped from 21 June through 26 June, 24 July through 28 July and 31 August through 4 September in 1989 and from 12 June through 16 June, 15 July through 19 July and 30 August through 3 September in 1990.

**COLONIZATION**

Rate of colonization of newly planted CRP tracts by small mammals living in adjacent habitats was investigated by trapping and marking individuals in a native grassland habitat bordering Grid 1 before vegetation on the grid emerged in 1989. Animals captured on Grid 1, which had
previously been caught in the adjacent grassland, were recorded.

**SPECIES DIVERSITY**

Indices of small mammal species diversity were calculated for each grid during each field season, using a transformation of the Shannon equation (Zar 1974):

\[
H' = n \log n - \frac{\sum f \log f}{n}
\]

where \( H' \) was the index of species diversity, \( f \) was the frequency of each species and \( n \) was the total frequency of all species. Indices were based on the number of individuals and number of species captured during a field season on a grid.

**POPULATION DENSITIES**

Population density estimates for the dominant species were based on minimum number of animals known to be alive on the grids (Hilborn et al. 1976). Program CAPTURE (White et al. 1978) was also used to estimate population densities. This computer program chooses the most suitable of several models to furnish an estimate of population density. Population estimates yielded by program CAPTURE were compared with minimum numbers of animals known to be alive on both CRP grids during each trapping period.
A chi-square test (Sokal and Rohlf 1981) was used to compare population densities between successive trapping periods on each grid in 1989 and 1990, and between years on each grid during each trapping period. Population densities were also compared between corresponding trapping periods on Grids 1 and 2.

HOME RANGE

Home range areas of individual deer mice were determined using program McPAAL, 1.2 (see Stuwe and Blohowiak 1986). Capture locations for each animal were recorded as X and Y coordinates on the trapping grid. Only animals captured at 4 or more coordinates were used to determine home-range areas. A minimum convex polygon method was used to determine home range areas. Sizes of home ranges of males were compared with those of females using one-way ANOVA (Sokal and Rohlf 1981).

SEX AND AGE RATIOS

Sex composition of the grids was recorded and a chi-square test (Sokal and Rohlf 1981) was used to test for any significant difference between the numbers of males and females. A chi-square test (Sokal and Rohlf 1981) was also used to identify trapping periods with a changing age composition.
VEGETATION SAMPLING

One-meter square quadrats were used at each trap site to sample vegetation. Presence of each plant species within each quadrat was recorded. Frequency of occurrence per 100 quadrats on each grid were recorded to describe the vegetation on each grid during each field season. Plant identification and nomenclature was according to the Great Plains Flora Association (1977).
RESULTS

VEGETATION

Vegetation on Grid 1, in 1989, was characterized by invading annual forbs (Kochia scoparia and Chenopodium album) and grasses (Setaria viridis), and perennial thistle (Cirsium arvense), along with an even stand of oats (Avena sativa), which was planted as a cover crop (Table 1). In 1990, Grid 1 was dominated by planted species (Melilotus officinalis and Medicago sativa) along with invading annual forbs (Kochia scoparia).

Grid 2 was dominated by wheatgrasses (Agropyron spp.) in both 1989 and 1990 along with invading annual forbs (Chenopodium album) and planted alfalfa (Medicago sativa) in 1989 and invading annual forbs (Chenopodium album) and grasses (Setaria viridis) in 1990.

SPECIES COMPOSITION

During the study, 265 deer mice (Peromyscus maniculatus) were captured and represented 92% of all small mammals trapped (Table 2). Other small mammals captured included 9 thirteen-lined ground squirrels (Spermophilus tridecemlineatus), 1 Richardson's ground squirrel (Spermophilus richardsonii), 5 house mice (Mus musculus), 13...
Table 1. Vegetation on CRP Grids 1 and 2, 1989 and 1990. Numbers denote frequency of occurrence of the plant species per 100 quadrats sampled.

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>CRP Grid 1</th>
<th></th>
<th>CRP Grid 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agropyron sp. a</td>
<td>-</td>
<td>-</td>
<td>83</td>
<td>95</td>
</tr>
<tr>
<td>Avena sativa a</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Melilotus officinalis a</td>
<td>6</td>
<td>92</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Medicago sativa a</td>
<td>-</td>
<td>80</td>
<td>21</td>
<td>-</td>
</tr>
<tr>
<td>Kochia scoparia</td>
<td>39</td>
<td>92</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Chenopodium album</td>
<td>48</td>
<td>-</td>
<td>86</td>
<td>21</td>
</tr>
<tr>
<td>Setaria viridis</td>
<td>54</td>
<td>-</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Cirsium arvense</td>
<td>41</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sonchus arvensis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Artemisia absinthium</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
</tbody>
</table>

a - planted species
Table 2. Small mammal species composition, species richness, and indices of diversity on CRP Grids 1 and 2, 1989 and 1990 (based on number of individuals of each species captured each season on each grid).

<table>
<thead>
<tr>
<th>Species</th>
<th>1989 Grid 1</th>
<th>1989 Grid 2</th>
<th>1990 Grid 1</th>
<th>1990 Grid 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. maniculatus</td>
<td>37</td>
<td>34</td>
<td>93</td>
<td>72</td>
</tr>
<tr>
<td>S. tridecemlineatus</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>S. richardsonii</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>M. pennsylvanicus</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>M. ochrogaster</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>M. musculus</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>O. leucogaster</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>S. cinereus</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total individuals</td>
<td>48</td>
<td>35</td>
<td>100</td>
<td>83</td>
</tr>
<tr>
<td>Number of species</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Species diversity</td>
<td>0.374</td>
<td>0.057</td>
<td>0.131</td>
<td>0.235</td>
</tr>
</tbody>
</table>
6 meadow voles (*Microtus pennsylvanicus*), 1 prairie vole (*Microtus ochrogaster*), 6 grasshopper mice (*Onychomys leucogaster*) and 2 masked shrews (*Sorex cinereus*).

**SPECIES DIVERSITY**

The transformation of Shannon's index of small mammal species diversity on Grid 1 was 0.374 during the 1989 trapping season and 0.131 during the 1990 season. Indices of diversity on Grid 2 for 1989 and 1990 were 0.057 and 0.235, respectively (Table 2).

**POPULATION DENSITIES**

Deer mouse population densities (based on minimum of number of individuals known to be alive) ranged from 1 individual per grid on Grid 1 during the first trapping period in 1989 to 64 per grid on Grid 1 during the third trapping period in 1990 (Table 3).

Population densities during trapping periods 2 and 3 were higher than in the previous period in both 1989 and 1990 (Table 3). Significant differences in population density on Grid 1 were between periods 1 and 2 in 1989 (chi-square=16.2, d.f.=1, P<0.001) and between periods 2 and 3 in 1990 (chi-square=9.9, d.f.=1, P<0.01). There was a significant difference on Grid 2 between periods 2 and 3 in 1990 (chi-square=10.6, d.f.=1, P<0.01).
Table 3. Deer mouse population densities on CRP Grids 1 and 2, 1989 and 1990 (animals/ha).

<table>
<thead>
<tr>
<th></th>
<th>1989 Trapping period</th>
<th>1990 Trapping period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Grid 1:</td>
<td>1 19\textsuperscript{a} 24</td>
<td>27 33 64\textsuperscript{a}</td>
</tr>
<tr>
<td>Grid 2:</td>
<td>6 11 26</td>
<td>20 23 51\textsuperscript{a}</td>
</tr>
</tbody>
</table>

\textsuperscript{a} - significantly higher than previous trapping period

\( P<0.05 \)
Differences in population densities between the two grids during corresponding trapping periods in 1989 and 1990 were not significant (Table 3). Population densities on each grid were significantly higher in 1990 than in 1989 during each trapping period (Table 4).

Program CAPTURE (White et al. 1978) did not furnish population estimates for all trapping periods because of an insufficient number of captures. Estimates furnished by program CAPTURE, along with number of individuals known to be alive on each grid, during each period, are listed in Appendix I.

**COLONIZATION**

Nine deer mice were captured and marked in native grassland adjacent to Grid 1. Two were victims of trap mortality before vegetation was established on the grid, leaving 7 potential dispersers to the newly emerging habitat of the grid. Two marked adult males and a marked juvenile male were each captured 2 or more times on Grid 1 in 1989. Small sample size precluded statistical analysis.

**HOME RANGE**

Home ranges of 18 male deer mice captured on 4 or more coordinates ranged from 0.04 ha to 0.56 ha with a mean of 0.18 ha, while those of 13 female deer mice ranged from 0.01 ha to 0.29 ha with a mean of 0.14 ha. ANOVA did not
Table 4. Deer mouse population densities during each trapping period on CRP Grids 1 and 2, 1989 and 1990 (animals/ha).

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1990</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid 1, Period 1</td>
<td>1</td>
<td>27</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Grid 1, Period 2</td>
<td>19</td>
<td>33</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Grid 1, Period 3</td>
<td>24</td>
<td>64</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Grid 2, Period 1</td>
<td>6</td>
<td>20</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Grid 2, Period 2</td>
<td>11</td>
<td>23</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td>Grid 2, Period 3</td>
<td>26</td>
<td>51</td>
<td>P&lt;0.01</td>
</tr>
</tbody>
</table>
detect a significant difference between the home range areas of males and of females (F=0.87, d.f.=1,29, P=0.36). Mean home range areas of males and females on Grids 1 and 2 during both seasons are shown in Table 5.

SEX AND AGE RATIOS

Although the total number of male deer mice (n=143) captured in the study was higher than the number of females (n=122), the difference was not significant (chi-square=1.66, P=0.19) (Table 6). Differences between numbers of males and females during each trapping period on each grid were also not significant.

The number of juvenile deer mice was significantly different than the number of adult females during Period 2, on Grid 1, in 1989 (chi-square=19.6, d.f.=1, P<0.001), and during Period 3, in 1990, on Grids 1 (chi-square=12.52, d.f.=1, P<0.001) and 2 (chi-square=4.12, d.f.=1, P<0.05) (Table 7). Sample size precluded analysis of sex/age ratios of other species.

SURVIVAL

One adult male and three adult female deer mice that had been captured in 1989 were captured on Grid 1 in 1990. Four adult males and 3 adult females that had been captured in 1989 were captured on Grid 2 in 1990. No animals of other species were recaptured the second year.
Table 5. Mean home range areas, expressed in hectares, of male and female deer mice on CRP Grids 1 and 2, 1989 and 1990.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Error</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grid 1, 1989</td>
<td>0.15</td>
<td>0.060</td>
<td>5</td>
</tr>
<tr>
<td>Grid 2, 1989</td>
<td>0.18</td>
<td>0.053</td>
<td>5</td>
</tr>
<tr>
<td>Grid 1, 1990</td>
<td>0.15</td>
<td>0.026</td>
<td>5</td>
</tr>
<tr>
<td>Grid 2, 1990</td>
<td>0.32</td>
<td>0.133</td>
<td>3</td>
</tr>
<tr>
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<tr>
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a - significant at P<0.05
b - significant at P<0.001
DISCUSSION

Small mammal species diversity on the CRP tracts was relatively low ($H'$=0.057-0.374). Nellermoe (1983) reported much higher diversities on grasslands in the Red River Valley in North Dakota ($H'$=1.24-2.19). Species diversity indices on CRP grids were also lower than those reported for northern midgrass prairies in Stark County, North Dakota ($H'=0.76$) and for northern tallgrass prairies in Isanti County, Minnesota ($H'=0.84$) (Grant and Birney 1979). Species diversity of crested wheatgrass plantings in Idaho was also higher ($H'=0.85$) than on the CRP grids (Reynolds 1980).

Species diversity was low during the earlier stages of secondary succession, but increased with time until it stabilized (Smith 1966). CRP plantings, being in the earliest stages of succession and consisting of monotypic habitats, may be expected to exhibit low plant and animal species diversity.

Deer mice dominated CRP plantings because preferred habitats were offered. Lack of accumulations of dead plant material and presence of forbs and seeds are critical variables affecting the occurrence of deer mice. Such conditions are characteristic of early growth of CRP
plantings. Pioneer successional stages favor prairie deer mice (*P. m. bairdi*) (Baker 1968). Beckworth (1954), in a southern Michigan study, found prairie deer mice common in the annual-biennial stages of succession but greatly reduced in the perennial grass stage where the meadow vole (*Microtus pennsylvanicus*) abounds. Preference for forbs by deer mice was shown by Reynolds (1980, p. 560), when he found that his control area, consisting of a diverse plant community dominated by sagebrush, as opposed to homogeneous plantings of wheatgrass, was "a diverse community, heavily dominated by deermice". The most important food items in the diet of an Indiana population of deer mice were lepidopteran larvae, grain, and weed seeds (Whitaker 1966). All are available in early growth CRP plantings.

Deer mice prefer bare ground situations over accumulations of dead plant material (Kaufman et al. 1988), a condition which exists in early growth CRP plantings. Determinants of habitat selection by deer mice can be attributed to availability of seeds and openness of the soil surface (Peterson et al. 1985). However, seed availability was not found by Houtcooper (1971) to be an influence on population densities of deer mice.

Deer mouse population densities reported in many other studies cannot be compared with those of the CRP tracts because the studies used trapping methods which revealed only relative densities. Peak deer mouse population
densities in CRP tracts (64/ha on Grid 1 and 51/ha on Grid 2) were higher than those reported by Wiedmeier (1960) (45/ha), by Greij (1962) (18/ha), and by Nellermoe (1983) (23.7/ha) in the Red River Valley in North Dakota. But Horner (1955) found densities as high as 72/ha in eastern North Dakota shelterbelts. Seabloom et al. (1978) recorded densities of 2-30/ha in McLean County, North Dakota. Blair (1940) found deer mouse populations that were much lower than those found on CRP grids. Mean populations in his southern Michigan study were only 10/ha in fall when populations were at their peak.

Metzgar (1980), in a Montana study, found significant population increases between each trapping period in June, July and August. My data from the tracts agree with this population increase over the summer. But, Howard (1949) reported that the majority of deer mice in his southern Michigan study were born in September and October with peak population levels attained during these months. Therefore, population densities during the last trapping period in CRP tracts may not have yet peaked.

Since CRP plantings in North Dakota are a reclamation of former cropland, a comparison between deer mouse populations on CRP plantings and cropped fields should be made. Small mammal population dynamics of fields seeded to several crops in the midwest were reported by Schulz (1965) in North Dakota. Highest deer mouse population densities in
corn, soybean, alfalfa, wheat and oat fields (16/ha) were much lower than those found in CRP tracts. Johnson (1987) found deer mice occurring in low to moderate numbers (1-34/100 trap days) in winter wheat fields in the Palouse region of Idaho. According to Janulewicz (1971), high population densities have been found in wheat fields, but probably represent a response to the availability to the presence of waste grain and are not supported through winter on the fields.

Higher deer mouse population densities on CRP grids in 1990 than in 1989 may have been attributed to an increased amount of precipitation in 1990. Drought conditions in 1988 and 1989 may have influenced population levels preceding this study. Harris (1971), in a precis of small mammal studies in the grassland biome states that there appears to be a direct relationship between average summer rodent biomass and mean annual precipitation. Higher population densities in 1990 may also have resulted from increased colonization of the area over the previous year.

Population densities during second and third trapping periods may have been influenced by trap mortality during previous trapping periods. Minimal trap mortality occurred with the exception of the last day of Trapping Period 2 on Grid 1 in 1989, when early morning temperatures fell and a heavy dew was present. Loss of animals due to trap mortality did not affect population density data, as victims
of trap mortality were counted as animals known to be alive on the grid at the time.

No significant difference between the sex ratios of prairie deer mice was found on the CRP tracts studied. This agrees with studies by Blair (1940), Howard (1949), Linduska (1942) and Metzgar (1979). But, Terman and Sassaman (1966) found significantly greater production of males than females in a large laboratory colony of *P. m. bairdi*.

Age ratio data (Table 7) indicate a low ratio of juveniles to adult females during most trapping periods, with fewer juveniles than adult females during Period 2 on Grid 1 in 1990. Low age ratios may be due to a lapse in reproduction during summer. Reproduction is generally reduced during summer months with an increased rate again occurring in fall (Fairbairn 1977). Therefore, the observed increases in population densities over the summer may have been influenced more by immigration than by reproduction.

Differential rates of capture for adults and juveniles, if they occur, may also explain low age ratios. Boonstra and Krebs (1978) found that live traps tend to sample larger individuals in populations of *Microtus*. If this tendency is shared by deer mice, a preponderance of adult captures may have existed.

Another explanation for low age ratios may be error in age determination. Age of animals was determined by pelage color. The post-juvenal molt of *P. maniculatus* has been
observed to begin at 4 weeks (Collins 1923) to 5 weeks (McCabe and Blanchard 1950). Subadult pelage, although being brown in color, is duller than the brown coat of a full adult (King 1968). Animals identified as adults may have actually been subadults (young of the year). Breeding condition as a means to distinguish young of the year is also not a reliable criterion, as females become sexually mature at 4 to 7 weeks of age with males taking slightly longer (Blair 1940, Howard 1949, Jameson 1953). With the first litters produced in late March to early April (Burt 1940, Golley et al. 1975), young of the year may have been sexually mature by the first trapping period.

The ability to distinguish cohorts of the population may have been better achieved by autopsy of those females thought to be full adults which had produced litters. But, when using live-trapping techniques, autopsy was not possible. Therefore, identification of subadults as adults may have influenced the ratio of juveniles to adult females.

Large variances in home range sizes of male and female deer mice may have been due to insufficient numbers of captures of individuals used to determine home range areas. Only animals captured at 4 or more coordinates were used to determine home range size. However, Krohne (1986) found that home range size estimates in a population of P. leucopus changed as a function of sample size, reaching an asymptote at 9 captures. Blair (1940) found that the
trap-revealed size of the home ranges of adult male
P. m. gracilis increased little, if any, beyond 19 captures.

Mean home range of male deer mice in this study (0.15-0.32 ha) was found to be larger than that of females (0.09-0.32 ha), although the difference was not significant, probably due to large variances in both male and female home range estimates. Dice and Clark (1953) showed male home ranges of P. m. bairdi to be larger than those of females. Mean adult home range of male deer mice in Montana was higher than that of females, but the difference was not statistically significant (Metzgar 1979). McCann (1977) recorded mean home ranges of deer mice in eastern Montana that fall within the range of those of this study (0.21 ha for males and 0.17 ha for females). Blair (1940) determined that home ranges of P. m. bairdi ranged from 0.03 ha to 0.9 ha in a stand of bluegrass in Michigan and Howard (1949) found home ranges of up to 2.4 ha in Michigan. Small sample size did not permit a statistical comparison of home range areas between grids and between years. However, mean home ranges of deer mice on Grid 2, which was dominated by grasses, were larger than those of deer mice on Grid 1 in both 1989 and 1990. Male and female home range data from both years were pooled to increase sample size and reduce variance.

Population characteristics reported in this study are based only on data from two seasons. Other studies of small
mammal population characteristics on CRP plantings have not been done, so data are not available for comparison. Small mammal populations have been found to fluctuate from year to year, so data presented here may not apply to CRP plantings in other areas and/or in other years.
MANAGEMENT IMPLICATIONS

Habitats offered by later successional stages in CRP plantings may be expected to support populations of small mammals dominated by meadow voles in lieu of deer mice, which dominate early successional habitats. Deer mice have been found to prefer forb and weed dominated habitats with areas of open ground, whereas meadow voles require a dense mat of litter composed of dead vegetation. M'Closkey and Fieldwick (1975) found that prairie habitats in southern Ontario which supported exclusive populations of meadow voles had a mean litter mat depth of 4.9 cm, and that when population overlaps of *Microtus* and *Peromyscus* occurred, it was often associated with mid-successional stages. In the prairie pothole region of North Dakota, Ladd (1972, unpubl. report) found significant populations of meadow voles in unmanipulated 7-year-old plantings which were similar to those on CRP tracts. But he recorded very few voles in 4-year-old plantings. Largest deer mouse populations were documented in 4-year-old plantings. The number of meadow voles trapped in 7-year-old plantings was significantly greater than that in native prairie burned the previous year, 2 and 4-year-old plantings, or heavily grazed
native prairie. A full year's growing season was required after fire before any voles were caught on an area.

The CRP plantings in this study were in early stages of succession, furnishing the forbs and the open ground preferred by deer mice. Predominance of deer mice on these tracts reaffirms their preference for these habitats.

A tract lying 2.4 km from CRP Tract 2 was seeded to a similar seed mix as Tract 2 in 1979, when it was enrolled in the USDA Waterbank Program. The waterbank tract was inspected and was found to have been invaded by smooth brome (*Bromus inermis*) and quackgrass (*Agropyron repens*), which had become the dominant plant species. The tract had not been manipulated (burned, grazed or hayed) and, as a result, a dense mat of dead vegetation covered the ground. Small mammals trapped on the waterbank tract were characterized mainly by meadow voles.

Based on known habitat preferences of the 2 species and trapping results on the waterbank tract, it may be predicted that, over time, populations of deer mice might be replaced by meadow voles in CRP plantings. Deer mice prefer early successional vegetation and bare ground situations offered by CRP plantings during early growth, whereas, meadow voles require a dense mat of accumulated dead plant material which will be offered by CRP plantings in later stages of succession.
Mihok et al. (1985) found meadow vole populations ranging from 2 to nearly 200 per hectare in late old-field succession habitats in Manitoba. Higgins and Barker (1982), in a study of changes in vegetation structure in seeded dense nesting cover (a mixture of tame grasses and legumes similar to that planted on CRP tracts), noted areas where grazing by voles was intense enough to significantly decrease Robel readings (measures of vertical visual obstruction by vegetation) in 1979 in the prairie pothole region of North Dakota. Evidence from other studies, along with samples from the nearby waterbank tract, suggests a potential for substantial vole populations in older CRP plantings.

This shift in small mammal species composition may have implications on the management of CRP tracts. Meadow voles are preferred food sources of predators, both avian and mammalian. The occurrence of one avian predator, the Northern Harrier (Circus cyaneus hudsonius), has been found to be directly related to the presence of voles. Large fluctuations of local harrier populations are attributed to the availability of prey, especially meadow voles (Hammerstrom 1979). Sutherland (1987) noted that meadow voles and ground squirrels were especially important prey items in the earlier stages of the harrier's nesting cycle. Clark (1972) reported a density of about 3 nesting pairs of Northern Harriers on approximately 800 ha of prairie
pothole region habitat in Manitoba during a year when meadow voles were scarce, and at least 15 occupied nests on the same area the next year when meadow voles were abundant.

The meadow vole is also a highly palatable species to some mammalian predators, and may serve as alternate prey in lieu of ground-nesting birds. Food habit studies have shown that deer mice are not a very palatable species in the diet of the red fox (MacDonald 1977), but that meadow voles have a high priority as a food source (Errington 1935, Scott 1947, Scott and Klimstra 1955, Korschgen 1959, Knable 1973, MacDonald 1977). In Iowa, Byers (1974) found a high positive correlation between small mammal population densities and nest success of blue-winged teal, a ground-nesting bird. Small mammals found on his study area were predominantly meadow voles. Darrow (1945), in New York, found an inverse relationship between buffer species abundance and red fox foraging activity. He also found a positive relationship between ruffed grouse nest mortality and fox foraging activity. In North Dakota, Sargeant (1972) observed that an abnormally high population of meadow voles was heavily used by foxes and may have buffered red fox utilization of waterfowl. Goszcynski (1977) found foxes to compensate for lack of field rodents during low populations by catching other prey more frequently.

It is probable that the presence of a desirable prey base offered by CRP plantings in later successional stages
may decrease predation on upland nesting birds and nests. In areas having vast areas of CRP plantings, with the potential for supporting substantial populations of meadow voles, a dilution effect may decrease predation on upland nesting birds and eggs. Implications of a new and larger prey base are not currently understood. It is not known to what extent this added prey base will affect predation on ground nesting birds. The added prey base may, in fact, attract more predators.

If the presence of this new prey base serves to enhance breeding opportunities for Northern Harriers and decreases predation on upland nesting birds, the possible consequences of present management techniques to release and rejuvenate stands of DNC should be considered.

The indirect effects of manipulating older stands of CRP by burning, grazing and haying should be investigated. Crowner and Barret (1979) found that burned sites were suitable only to deer mice in the year following a prairie burn. Deer mice respond positively to conditions created by prairie fires, whereas others, including meadow voles, respond negatively to the same conditions (Kaufman et al. 1983, Schramm 1970, Tester 1965, Vacanti and Geluso 1985). The presence of litter and dead vegetation may discourage use of an area by deer mice. Kaufman et al. (1988, p. 226) stated that "Low numbers of deer mice prior to the burn was probably due to unfavorable litter and standing dead
vegetation conditions that had developed since the previous fire" (4 years earlier). Peterson et al. (1985) attributed the preference for recently burned habitats by deer mice to the increased availability of seeds and increased openness of the soil surface due to litter removal by fire.

Lemen and Clausen (1984), in eastern Nebraska, determined that mowing, like burning, greatly reduced the use of an area by voles and increased the density of deer mice until the grass grew back. If mowed every year, vole populations cannot be maintained at high densities.

Grazing may also cause a shift in small mammal species occupying a grassland. Pugh (1980) found that meadow voles were the dominant species on ungrazed grassland in northern Minnesota and that deer mice were the dominant species on grazed grassland. Tester and Marshall (1961) and Birney et al. (1976) found that voles responded negatively to grazing.

Considering the potential value of meadow voles as a buffer species (alternate prey) and the availability of preferred habitat of voles offered by unmanipulated older CRP plantings, we may want to consider the effects of burning, haying or grazing treatments to rejuvenate or release stands on older CRP plantings on their potential for holding populations of meadow voles. During most years, meadow vole populations may not be large enough to inhibit predation on upland nests, but the potential for vole population eruptions may substantially boost production of
upland nesting birds during the years of high densities.

The emphasis of management of CRP tracts, as well as dense nesting cover plantings, has been on the rejuvenation of vegetative stands for nesting cover, with little or no consideration given to the consequences of such manipulation to the existing alternate prey base. "Prey management", or the management of an area to preserve its alternate prey base, should be emphasizes as well.

Plans to use fire, grazing or haying to revitalize CRP stands in their later years to enhance nesting cover should be scrutinized. If large meadow vole populations act as a buffer to predation on upland nesting birds and their nests, the adverse effects of burning, grazing or haying on vole habitat should be considered.

Management of CRP plantings (or any dense nesting cover) to enhance vole populations should involve the preservation of a litter mat with a mean depth of at least 5 cm, based on habitat requirements found by M'Cloesky and Fieldwick (1975). Optimum vole habitat may not be achieved until the 7th year of growth on CRP plantings, based on the findings of Ladd (1972, unpubl. report).

CRP tracts, as well as any tracts which have been seeded to dense nesting cover, should be managed to allow for the existence of a prey base to support populations of avian and mammalian predators. If stands are to be manipulated for the purpose of rejuvenation, manipulation
should not occur simultaneously over large areas. Rather, areas should be managed to furnish a mosaic of prey habitats, among them those with sufficient plant density and litter accumulation to support potentially large populations of voles. To allow for these conditions to exist, manipulation should occur on a 7-8 year rotation, rather than every 4-5 years, which is commonly practiced.

Some wildlife biologists suspect possible delayed use or colonization by mammalian predators of upland nesting birds, or "predator lag", in newly planted stands of nesting cover (Arnold Kruse, Robert Hays, Alan Sargeant, pers. comm., U. S. Fish and Wildlife Service). If a "predator lag" exists, it may be caused, not by the absence of a prey base, but rather, by the absence of a desirable prey base. Research which will support or refute this theory is needed. Delayed predator activity in new stands may depend on the availability of older, vole-dominated stands.

The amount of time required to achieve optimum vole habitat on new or manipulated plantings may vary with species of vegetation. Research is needed to establish criteria for the management of an adequate alternate prey base in specific vegetation types under specific local conditions.

Unmanipulated older stands of CRP, although not providing desirable nesting cover, may hold a valuable "lure crop" of prey species. Scattered, unmanipulated stands may
serve to concentrate predator activity in these areas. Investigations of the relationships between alternate prey availability in unaltered habitat patches and predator foraging trends may yield a better understanding of the importance of alternate prey to the welfare of ground nesting birds.
APPENDIX I
Table 8. Comparison between "minimum number of deer mice known to be alive" and population estimates of Program CAPTURE.

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LITERATURE CITED


