FINAL REPORT

GRANT TITLE: DISTRIBUTION OF SMALL MAMMALS IN GRASSLANDS OF WESTERN MINNESOTA WITH SPECIAL EMPHASIS ON THE PRAIRIE VOLE (*MICROTUS OCHROGASTER*), THE NORTHERN GRASSHOPPER MOUSE (*ONYCHOMYS LEUCOGASTER*), THE PLAINS POCKET MOUSE (*PEROGNATHUS FLAVESCENS*), AND THE WESTERN HARVEST MOUSE (*REITHRODONTOMYS MEGALOTIS*)

CONTRACT NUMBER: NA68

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NOTE

The information in this final report supersedes any information that might have been included in earlier, less complete quarterly reports. While completing this report, we noticed several typographical errors in the earlier quarterly reports and several instances where captures had been miscounted. information in this report is complete and correct to the best of our knowledge.

DMBS

Update: 12 June 1992

The skull in this report which was hoped to be Reithrodontomys megalotis (western harvest mouse) was identified by the Bell Museum as Mus musculus (house mouse). Therefore, no western harvest mice were captured in this study.

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ABSTRACT

During the fall of 1990 and the summer of 1991, a total of 11 grassland study sites in Clay County and 6 sites in Lac Qui Parle County in western Minnesota were live trapped to locate populations of 4 rodent species: prairie voles (Microtus ochrogaster), northern grasshopper mice (Onychomys leucogaster), plains pocket mice (Perognathus flavescens), and western harvest mice (Reithrodontomys megalotis). Sites were generally monitored for small mammals with a 500-m transect of live traps placed at 10-m intervals. Traps were prebaited for 1 day then set open and checked during the 4 following days. A total of 15 prairie voles, 13 northern grasshopper mice, 1 (probable) western harvest mouse, and various nontarget species were captured. Prairie voles were always captured on dry prairie sites, and grasshopper mice were always trapped on sites with gravelly, coarse soils. Gravel and old quarry sites in western Minnesota should be checked further for grasshopper mice and protected in some way if they prove to be adequate habitat sites. We agree with the recommendations of the 1988 small mammal survey of the Minnesota County Biological Survey about burning in a patchwork pattern so as to maintain prairie patches with and without litter buildup to provide habitat for a variety of the target species. It is recommended that all 4 target rodents be considered species of "Special Concern", a label currently given only to the prairie vole. The plains pocket mouse and the western harvest mouse seem to be extremely rare in western Minnesota grasslands and perhaps should even be considered as "Threatened Species".

see update, p.2

INTRODUCTION

The prairie vole, the western harvest mouse, the northern grasshopper mouse, and the plains pocket mouse reach the edge of their northeasternmnost distribution in western Minnesota (Jones and Birney 1988). All species are associated with grassland habitats and all are prey species for a variety of mammalian and avian predators (Jones et al. 1983).

In Minnesota, it is believed that the prairie vole's habitat has been so altered by human activities that it is being displaced by the meadow vole (Hazard 1982). Thomas and Birney (1979) reported that the mating system was basically monogamous and that both parents care for the young which might be relatively rare among microtines. Prairie voles seem to be especially adapted for living in dry prairies (DeCoursey 1957, Getz 1963, Miller 1969).

The northern grasshopper mouse is unusual not only because of its carnivorous feeding habits (Bailey and Sperry 1929, Egoscue 1960, Jahoda 1970) and associated large home range (Blair 1953 as reported by Ruffer 1968), but because it also forms male-female social bonds with both parents contributing to the care of the offspring (Ruffer 1965a). This species also has a complex communication system (Hafner and Hafner 1979), Hildebrand 1961, Ruffer 1966) and is highly aggressive and territorial (Ruffer 1968), characteristics which probably serve to space the species which in turn might make live-trapping more difficult. Grasshopper mice are found in a variety of grassland habitats, often with with sandy, coarse soils (McCarty 1978).

The plains pocket mouse is of special interest because it ranges farther east than any other species of heteromyid in the United States (Hazard 1982) and is especially adapted to arid habitats, e.g., not needing to drink free water (Hibbard and Beer 1960). Specimens taken in Minnesota were found in open and well-drained areas and they seemed to prefer fields of sparse grass or small grain where the surface of the soil was mostly bare so as not to hinder movements (Hibbard and Beer 1960). These animals cache seeds and seem to hibernate, going into torpor when held at temperatures of 5 degrees C (Beer 1961, Hibbard and Beer 1960). Evidence suggests that they wake up periodically during the winter to feed on stored seeds (Hibbard and Beer 1960).

The western harvest mouse seems to be expanding its distribution eastward as land has been cleared (Hazard 1982). Whitaker and Mumford (1972) and Ford (1977) reported its recent appearance in Indiana where it was found in association with the prairie vole and other rodent species. Sex ratios favored males except in the oldest and youngest age classes (Fisler 1971). This species is socially tolerant, and animals in captivity often huddle (Webster and Jones 1982). O'Farrell (1974) reported hibernation in this species in Nevada. Western harvest mice inhabit a wide variety

of grassland habitats including overgrazed pastures, fencerows, and areas bordering agricultural fields. They usually build above-ground nests made of plant material (Webster and Jones 1982).

An extensive literature review indicated that the 4 rodent species mentioned above have been little studied in Minnesota. Shortly after the turn of the century, Perognathus flavescens perniger Osgood, the dusky pocket mouse, and Microtus minor (Merriam), little upland mouse (now called Microtus ochrogaster) were collected in Sherburne County, Minnesota (Bailey 1929). Onychomys leucogaster has been reported in Kittson County (Drickerman and Tester 1957) as well as a number of other counties, including Clay (Heaney and Birney 1975). Allen (1936) and Heaney and Birney (1975) mentioned the distribution of Microtus ochrogaster in Minnesota, but neither Clay nor Lac Qui Parle County were listed. Swanson et al. (1945) listed all 4 species as being found in Minnesota, but again Clay and Lac Qui Parle were not among the counties listed. None of the 4 target species were mentioned from either Itasca County (Cahn 1921) or Itasca Park (Swanson 1943).

In Hazard's (1982) comprehensive and more recent work, however, prairie voles were reported in Clay and grasshopper mice were reported in both Clay and Lac Qui Parle Counties. He stated that the western harvest mouse was found only in southern Minnesota, with specimens taken from Lac Qui Parle and other counties. Most of the information on the plains pocket mouse in Minnesota was from Hibbard and Beer (1960) who stated that it was found only in open and well-drained areas. They mentioned this latter species had been found in Lac Qui Parle, Polk, Sherburne, Anoka, Lincoln, Watonwan, and Dakota Counties.

More recently, snap-trap surveys of Norman, Clay, Wilkin, Traverse, Big Stone, Lac Qui Parle, and Washington Counties in 1988 by the Minnesota County Biological Survey produced no captures of any of the above species except 8 grasshopper mice which were captured in Wilkin (1 capture) and Lac Qui Parle Counties (7 captures) (Birney and Nordquist 1991). It was not known if populations were unusually low due to the drought or if other factor(s) had influenced their capture success.

This study was undertaken to locate populations of the 4 target species in Clay and Lac Qui Parle Counties, Minnesota because so little is known about them in this part of their range. We addressed 2 main objectives:

Objective 1: Develop list of grassland sites in Clay and Lac Qui Parle Counties that are of highest priority for trapping rare small mammals.

Objective 2: Trap selected grassland sites in Clay and Lac Qui Parle Counties to determine the presence of prairie voles, northern grasshopper mice, plains pocket mice, and western harvest mice.

ACKNOWLEDGEMENTS

We would like to thank the Minnesota Department of Natural Resources for their financial assistance through the Nongame Wildlife Tax Checkoff Program. Many students from Moorhead State University, Moorhead, Minnesota also donated countless hours of their time with no financial compensation and we want to extend our thanks to them: Craig Cameron, Mat Goertel, Bobbi Jo Dickerson, Stacy Adolf, Clay Derby, Liz Harper, Todd Mattson, Heidi Olson, Virginia Goertel, Theresa Ebbenga Olson, Bob Sorensen, and Kailey Smith. The Department of Biology at Moorhead State University, Moorhead, Minnesota supplied laboratory space and money for live traps, various kinds of field equipment, laboratory and office supplies, and photographic supplies. Special thanks are extended to the private landowners, The Nature Conservancy, and members of the Minnesota Department of Natural Resources who allowed access to their land or land under their jurisdiction. The cooperation of the museums in giving us information for compiling our list of specimens is gratefully acknowledged; we want to especially thank Dr. Rick Jannett at The Science Museum of Minnesota, Dr. Elmer Birney at the Bell Museum, and Dr. Norman Slade at the University of Kansas. Finally, we extend our thanks to Rich Baker of the Minnesota Department of Natural Resources Nongame Program for his help and suggestions throughout the study.

MATERIALS AND METHODS

Identifying Historical Occurrences of the Target Species. --

A comprehensive literature review was conducted on the 4 target species and a file of over 200 research papers was compiled. All records of captures of the target species in Clay and Lac Qui Parle Counties, Minnesota were recorded as were notes on habitat preferences of the species.

A letter of inquiry was sent and/or phone calls were made to all museums/collections in Minnesota and North Dakota that were likely to have specimens of the target species from Clay and Lac Qui Parle Counties. The Field Museum of Natural History in Chicago, Illinois and the Museum of Natural History at the University of Kansas in Lawrence were also contacted about possible specimens.

A visit was made to the mammal museum at the University of North Dakota in Grand Forks to view the specimens of the target species to aid in field identification. Although we examined all target species, none of the specimens had been captured in Clay or Lac Qui Parle Counties.

The "Minnesota Natural Heritage Program Element Occurrence Records" were examined and a list of the target specimens captured in Clay and Lac Qui Parle Counties was compiled.

The "Checklist of Itasca State Park Mammals" (compiled by A. Sargent [sic] and W. H. Marshall) was consulted to determine if any of the target species were held in the collection at the Biological Station in Itasca State Park.

Identifying Additional Sites That May Be Suitable Habitat For the Target Species. --

The Minnesota Department of Natural Resources/Wildlife Section has compiled a list called the "Natural Communities in Clay and Lac Qui Parle Counties" which is entered in the Minnesota Natural Heritage Program Element Occurrence Records. This list was considered exhaustive by Rich Baker of the Minnesota Department of Natural Resources because the County Biological Survey had been completed in both counties. This list was examined as a source of possible trapping sites.

The principle investigator of this study lives in a farming area near Rollag, Minnesota in Clay County and several farms in the area were examined as possible trapping sites.

"A Guide to Minnesota Prairies" (Wendt 1984) was also examined as a source of possible trapping sites.

Identifying Selected Sites From the 1988 Minnesota County Biological Survey That Are in Need of Further Surveying. --

Gerda E. Nordquist, who conducted most of the field work for the 1988 survey, was contacted. She gave her recommendations on which sites should be trapped again.

Compiling List of Proposed Survey Sites. --

A list of possible trapping sites was forwarded to Rich Baker of the Minnesota Department of Natural Resources, Nongame Wildlife Program. Mr. Baker, in conjunction with Ms. Nordquist and D. Bruns Stockrahm (the principal investigator), finalized the list of survey sites in May 1991 for the 1991 field season.

Live Trapping the Target Species. --

1990 Field Season

All trapping during the 1990 field season was conducted by Moorhead State University students (and the principal investigator) on a volunteer basis because there were not enough funds to pay labor for both field seasons. Therefore, we used this time to train students for the 1991 season as well as to experiment with different kinds of trapping methods, including trap spacing along a transect, transect spacing, effectiveness of prebaiting, timing and number of trap checks, and effectiveness of large (8cm x 9 cm x 23cm) versus small (5cm x 6 cm 16.5cm) Sherman live traps.

The following 2 study sites in Clay County were trapped during September and October 1990:

1) Robert Aakre (Landowner)
T 138N, R 44W, N 1/2 of NW 1/4 S 26
(one trapping transect extended into the very edge of SW 1/4 of S 23)
Clay County, MN (Parke Township)

2) Donna and Jerry Stockrahm (Landowners)
T 138N, R 44W, N 1/2 of NE 1/4 S 26
Clay County, MN (Parke Township)

On the Stockrahm Study Site, 4 transects were laid out, each 50 m apart. Trap stations were placed at 10-m intervals along the transect, with 1 large and 1 small trap per station. Transects 1 and 2 each had 20 stations, and Transects 3 and 4 had 15 stations, for a total of 70 stations with 140 traps. Traps were baited with a mixture of peanutbutter and rolled oats and opened on 27 September 1990 from 15:15h to 16:36h. The traps were then checked in the morning and evening of the next 3 days, i.e., 28-30 September, for a total of 6 trap checks. After the last trap check, traps were either closed or left with their backs open until the following weekend when the site was retrapped. On 5 October from 17:25h to 18:40h, traps were rebaited and set. The traps were checked for the next 3 days just as before with the exception that traps were closed down after the fifth check, i.e., there was no evening check on the third day.

On the Aakre Study Site, 1 transect of 28 stations (at 10-m intervals) was laid out with 1 large and 1 small baited trap per station on 5 October 1990 from 19:00h to 19:35h. However, due to a shortage of large traps, stations 24-28 had 2 small traps each. Traps were checked twice daily for the next 2 days and on the morning of the third day for a total of 5 trap checks just as on the second trapping round on the Stockrahm Study Site. Traps

were closed or left with their backs open until the following weekend when retrapping took place.

Traps on Transect 1 of the Aakre Study Site were rebaited and set open on 13 October 1990, and 2 more transects with 28 stations with 1 small trap per station were also baited and set open from 09:35h to 11:15h. Because the field was 100 acres in size, the transects were quite far apart (up to approximately 1/2 mile). Traps were checked that evening from 17:02h to 19:32h then closed down or left with their back door open. Later in the week, all backs on the small traps on the plot were left open so that small mammals in the area would have access (equivalent of prebaiting). The final trapping of this site took place the following weekend where all small traps only were rebaited and set open (total to 84 traps at 84 stations) on 26 October 1990 from 08:27h to 09:24h. Traps were checked that evening from 16:34h to 20:50h then closed down due to the extremely cold overnight temperatures. Transects 2 and 3 only were set on 27 October (09:35h to 10:15h) and checked that evening (15:12h to 18:00h) at which time all traps were removed from the plot.

For both the 1990 and the 1991 field seasons, the following information was recorded on each captured animal: location of capture, trap size, species, sex, age, weight, tail length, and reproductive condition (Appendix A: Field Forms). Each animal was toe-clipped for individual recognition and released at the capture location.

1991 Field Season

During the 1991 field season, all field methods were standardized so that data from all study sites would be comparable.

A total of 15 study sites were trapped between 15 July through 20 August 1991 (9 sites in Clay County and 6 in Lac Qui Parle County). At each trap site, 50 traps were placed 10 m apart along a transect. The configuration of Sites 3, 12, and 15 did not permit 1 long transect; therefore, on Sites 12 and 15, 3 and 2 transects, respectively, were placed side by side, 30 m apart. On Site 3, the transect took on the configuration of an "L" , with the transect making a 90-degree turn. On Sites 10 and 11, the transect slightly angled away from a straight line due to the topography.

Traps were prebaited with a mixture of rolled oats and peanutbutter and locked open for 1 day before the actual trapping began so as to acquaint the rodents with the traps and to increase trapping success. The day following prebaiting, traps were set in the morning and checked that evening, then checked during the morning, midday, and evening of the next 2 days, with a final check during the morning of the following day when traps were picked up. Therefore, traps on each site were checked a

total of 8 times spanning 4 days (Table 1). There were several occasions when traps were only checked twice during the day due to time constraints and/or weather conditions.

Only live traps were used for this study. Larger traps (8 cm x 9 cm x 23 cm) were set alternately with smaller traps (5 cm x 6 cm x 16.5 cm). The only exception to this occurred on Sites 1, 2, and 3, where 1 small trap was alternated with 2 large traps, i.e., every third trap was a small trap.

Species Identification. --

A number of field guides and books were used for plant and animal identification: mammals (Whitaker 1988, Burt and Grossenheider 1976, Glass 1981, and several nonpublished mammal keys for skin and skull identification from The Ohio State University and The University of North Dakota); amphibians (Behler and King 1979); insects (Borror and White 1970); and plants (Wernert 1982, Peterson and McKenny 1968, and the Great Plains Flora Association 1986). Plant names were taken out of the latter source unless listed otherwise.

Habitat Information and Species Associations. --

At each study site, descriptive habitat information was recorded, including plant community and land use data (Appendix A: Field Forms). In addition, the microhabitat was described at each trap station where a capture occurred.

RESULTS

Identifying Historical Occurrences of the Target Species. --

Very few captures of the target species were recorded in the literature, and when they were, usually only the county was given (most of which is included in the introduction of this report). The literature search was still very valuable because much information was available on the habitat preferences, ecology, and behavior of the target species as well as on trapping/capture techniques and sampling designs. This information was invaluable to the people who conducted the trapping in the field.

Most capture records were obtained from the Minnesota Natural Heritage Program Element Occurrence Records and from the Minnesota County Biological Survey: 1988 Small Mammal Survey (Birney and Nordquist 1991). These capture records are summarized in Appendix B: Capture Records.

The letters (sample letter included in Appendix B: Capture Records) and phone calls to the museums requesting information on the capture sites of the target species from Clay or Lac Qui Parle Counties indicated that very few specimens exist other than those already listed in the Minnesota Natural Heritage Program Element Occurrence Records or on Dr. Elmer C. Birney's list from the Bell Museum (Table 2; Appendix B: Capture Records). Correspondence and phone conversations with Dr. Rick Jannett from the Science Museum of Minnesota indicated that a number of prairie voles and 1 northern grasshopper mouse had been taken on the Felton Prairie in Clay County (Appendix B: Capture Records).

None of the target species were on the "Checklist of Itasca State Park Mammals". However, no date was printed on the list, so it was unknown if the list was up-to-date.

All of our sources indicated that Clay County (especially Felton Prairie) seemed to be a good site to locate M. ochrogaster and various locations in Lac Qui Parle county seemed the best to locate O. leucogaster. The other 2 target species were seldom captured in either county, but were more often captured in Lac Qui Parle County than in Clay.

Identifying Additional Sites That May be Suitable Habitat for the Target Species. --

The "Natural Communities in Clay and Lac Qui Parle Counties" database from the "Minnesota Natural Heritage Program Element Occurrence Records" listed over 300 sites. The information on the prairies described in Wendt (1984) was largely gathered from the above source and so complemented its information. Because we already had many potential trapping sites from the specimen records from the Natural Heritage Program, the information from the above 2 sources was mainly used as supplemental information.

After examining areas around the Rollag area in Clay County, we think this area might hold some potential habitat sites for the target species. Much of this area is rolling hills and has been placed in the CRP program where it is planted to grasses. Although the areas that were examined seem to have less than desirable species diversity in the ground cover, we believe they are areas that perhaps should be trapped during future studies.

In Clay County, the area immediately surrounding Moorhead probably has little potential for habitat sites for the target species. Much of this area is planted to sugar beets and is plowed to the very edges of forests and roadsides during all seasons of the year. Relatively little area is left as grassland.

Identifying Selected Sites From the 1988 Minnesota County Biological Survey That Are in Need of Further Surveying and Compiling List of Proposed Trapping Sites. --

A list of potential trapping sites was sent to Rich Baker (Appendix C: Potential Trapping Sites). From this list, 9 Clay and 6 Lac Qui Parle County sites were chosen as final trapping sites for the 1991 field season (Table 3).

Live Trapping the Four Target Species . --

1990 Field Season (Including Habitat Associations)

On the Stockrahm and Aakre study sites, the meadow vole (Microtus pennsylvanicus) was the species captured most often (Table 4). Nearly all of the meadow vole captures were in areas characterized by dense grass and much grass litter cover. Both sites also had a number of rolling hills, and damp areas with lush vegetation often were found in the lower areas.

Originally, it was believed that some prairie voles were also captured and several skulls were collected, cleaned, and examined under a microscope in the laboratory. Unfortunately, none of the collected skulls were from prairie voles. Therefore, all of the voles on these 2 study sites were recorded here as meadow voles. It should be mentioned, however, that not every skull originally thought to be a prairie vole was collected, only several representative specimens. The possibility exists that some of the released "possible prairie voles" were, in fact, prairie voles, but it is unlikely based on the specimens we did collect.

A number of deer mice (Peromyscus maniculatus), shorttail shrews (Blarina brevicauda, and masked shrews (Sorex cinereus) were captured, especially at the Stockrahm site. Many of these captures were from a transect that ran near a woodlot along 1 edge of the study site or near a few scattered trees along other edges of the study site.

It is noteworthy that 1 arctic shrew (Sorex arcticus) and 1 least weasel (Mustela nivalis) were captured on the Aakre site. The skin and skull of the former was collected and identified in the lab, and photographs were taken of the latter which indicate no black tip on the tail. However, specimens and pictures should be verified by the Bell Museum or others. The shrew was captured at the bottom of a hill and the area was quite moist. Nearby was a low spot that held shallow standing water for much of the year and a few trees, mainly oak (Quercus sp.). The single boreal redback vole (Clethrionomys gapperi) was captured in the transect that ran along the woodlot at the Stockrahm site.

The sex ratios in meadow voles were greatly skewed in favor of females on both study sites (total of 60 males/91 females) (Table 4). A chi-square test for goodness of fit indicated a sex ratio significantly different from a 1:1 on the Aakre Study Site (X^2 = 4.881, d.f. = 1, n = 118, P < 0.05) and on the Stockrahm/Aakre Study Sites combined (X^2 = 6.364, d.f. = 1, n = 151, P < 0.05). Even though the ratios were also skewed on the Stockrahm Study Site, the difference was not significant (X^2 = 1.485, d.f. = 1, n = 33, P > 0.05). The sex ratios of the shrews could not be determined because it was usually impossible to determine the sex of the captured animals.

Because we were using a combination of large and small traps, we wanted to determine if animals were more likely to be trapped in 1 size of trap over the other. When both a large and a small trap were used at a trapping station, it was very rare for both traps to have captures. On the Stockrahm site where 1 large and 1 small live trap were placed at each station, there were no cases out of 770 possible cases where both traps had captures at the same time (70 stations with 2 traps per station with 11 trap checks = 770 possible cases). On the Aakre site in Transect 1 where 1 of each size trap was placed at a station, there were only 7 cases occurring out of a 138 possible cases or 5.1% (i.e, 23 stations with 2 traps per station with 6 trap checks = 138 possible cases). Apparently, 2 captures per station is more common when the populations are higher as they were on this site as compared with the Stockrahm site.

On the Aakre site in Transect 1 where 1 large and 1 small trap was used at each station, meadow voles seemed to have no size preference in traps. When the original capture of each animal was considered, 53.3% of the adults were captured in large traps and 46.7% in small ones (n = 15). In immature meadow voles, 47.1% were caught in large traps and 52.9% in small ones (n = 17). On the Stockrahm site, the same trend was true for all species except meadow voles or shorttail shrews which had a very small sample size: masked shrews had 46.2% in large and 53.8% in small traps (n = 13), shorttail shrews had 25.0% in large and 75% in small ones (n = 4), and deer mice had 60.0% in large and 40.0% in small (n = 5). The meadow voles seemed to be caught more readily in the small traps: adults had 33.3% in large and 66.7% in small (n = 18) and immatures had 23.1% in large and 76.9% in small (n = 13). In several cases, the size of the trap that did the capturing was not recorded and could not be included in the analysis. When each of the above proportions was tested for a 50:50 ratio of large traps to small traps using a chi-square test for goodness of fit, none of them were significantly different from a 50:50 ratio (P > 0.05). However, when adults and immature meadow voles were combined on the Stockrahm Study Site, the sample size was large enough to detect a significant difference with voles favoring small traps (X^2 = 5.452, d.f. = 1, n = 31, P < 0.05).

We thought that perhaps the capture of a shrew in a trap might influence other non-shrew species not to enter the trap (because shrews are insectivorous/carnivorous). On the Stockrahm site where many shrews were captured, there was only 1 case of a meadow vole being captured in a small trap after a shorttail shrew had been there, and 1 case of a deer mouse being captured after a masked shrew in a small trap. There was 1 additional case where a meadow vole might have been captured after a masked shrew in a large trap, but the meadow vole trap size was not recorded. However, the recorded location of the trap indicated that it probably was the same trap.

1991 Field Season Including Habitat Associations

Trapping data from the summer of 1991 indicated that all of the target species except the plains pocket mouse were captured (Tables 5, 6). Of the target species, prairie voles and northern grasshopper mice were captured most often. Several skins and skulls of the target species were preserved and should be verified by the Bell Museum. Because grasshopper mice were so readily identifiable in the field, no specimens were collected. Instead, photographs were taken which are included with this report.

A variety of nontarget species were also captured, including several species of shrews, deer mice, and meadow voles (Tables 5, 6). Some of the captured deer mice were infected with botfly larvae, especially those captured on Site 2. Many thirteen-lined ground squirrels (Spermophilus tridecemlineatus) were captured which precluded the target species from getting into the occupied traps. On sites where many ground squirrels were captured, there was often also a high rate of sprung traps which could have affected the capture rates of other species. These squirrels were too large to toe-clip, and, therefore, original captures could not be distinguished from recaptures. Subsequently, only the total number of captures is known, not the number of different individuals.

Unusual captures included 2 Great Plains toads (Bufo cognatus) on Site 10 and 1 American toad (Bufo americanus) on Site 2. Both of these sites also had many insects visiting the traps to eat the peanutbutter which might have attracted the toads. One northern leopard frog (Rana pipiens) was seen on Site 1, but it was not captured. This latter siting was very unusual because this was a very dry site.

The sex ratios were fairly even for all species except in the meadow voles where more females were captured (Table 5, 6) just as on the Stockrahm and Aakre Sites (Table 4). A ch-square test for goodness of fit indicated a sex ratio significantly different

from 50:50 when the 1991 data was combined for the 15 sites (X^2 = 5.333, d.f. = 1, n = 12, P < 0.05). Of the target species, immature grasshopper mice were seldom captured, while immature prairie voles were more common (Table 7).

Captured animals were caught in nearly equal numbers in large and small traps, again indicating no preference in trap size. When all original captures of small mammals for the 1991 season were considered (excluding thirteen-lined ground squirrels because they could easily fit only into the large traps), 45.5% were caught in large traps and 54.5% in small traps (X^2 = 1.273, d.f. = 1, n = 154, P > 0.05). When only the target species were considered, 55.2% of the original captures were caught in large traps and 44.8% in small ones (X^2 = 0.310, d.f. = 1, n = 29, P > 0.05).

The habitat at each study site was described (Appendix D: Habitat Descriptions). All of the 1991 study sites were on protected land, so "landuse" was essentially a meaningless term. However, the landuse of the area surrounding the study plots was recorded. Some of the more common plant species were identified and recorded, but the list is by no means comprehensive (Appendix E: Plant List). Maps for the study sites are given in Appendix F: Maps.

Prairie voles were found on Sites 1, 4, 6, and 10 (Table 7). The first 3 sites were typical native prairie characterized by native grasses and forbs. Most prairie voles were caught on Site 1 (Bicentennial Prairie), and all 9 of these voles were taken in grassy areas. Site 10 (Yellow Bank Hills) was very hilly and gravelly, but it had native prairie species (Appendix D: Habitat Descriptions). Of the 4 prairie voles caught at this site, 3 were from habitat classified as "sparse grass hilltop" and 1 from "low grass hillside". It is interesting to note that, of all the sites where prairie voles were captured, meadow voles were found only on Site 1 (Tables 5, 6). However, all of these 4 study sites were relatively dry prairie. On Site 1, meadow voles and prairie voles did not seem to be noticeably segregated. In fact, there was 1 instance where both species were captured at the same trap station during the 4-day trapping period.

Northern grasshopper mice were captured on Sites 6, 10, 14, and 15 (Table 7). Each of these sites was characterized by gravel pits or gravelly hills. Vegetation was often sparse. Grasshopper mice were often caught in localized areas, i.e., they were not spread evenly throughout the study site. Most captures of this species occurred on Site 10 (6 mice) and all of them were along the same hill within a 50-m continuous stretch of trap stations. All 6 captures were in grass or weeds (usually sparse) along the hilltop or hill side, and all captures were very near burrows which were seen to be used by the mice. On this same site, there were 2 instances were a female was caught

in a trap first, then a male was caught in the same trap at a later date. It was also noted that deer mice were caught in the same traps that had formerly caught grasshopper mice, indicating that the deer mice did not avoid the smell of the latter. Sites 6 and 10 were the only ones where more than 1 of the target species were captured, with captures of both the prairie vole and the northern grasshopper mouse at each site (Table 7).

The lone western harvest mouse was captured at Site 11 in a grassy/weedy area on a hilltop. An identical specimen was taken and preserved from near Site 7 (exact location is T117N, R46W, SE 1/4 of the SW 1/4 of S1). This specimen is still awaiting verification by the Bell Museum. Its front incisors appeared to have the longitudinal groove characteristic of this species, but the skin was nearly identical with the more common house mouse (Mus musculus). In any event, this species seemed to be exceeding rare or nonexistent on our study sites.

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Of the nontarget species, deer mice and thirteen-lined ground squirrels were the most widely distributed, being trapped on 12 and 13, respectively, of the 15 sites. Surprisingly, meadow voles were captured on only 4 of the 15 sites (Tables 5, 6).

On Site 5 (Bluestem Prairie), there were no captures of any type of mammal. This seemed unusual because the habitat seemed to be suitable for voles and perhaps even prairie voles. Examination of this site while traps were being set or checked, however, revealed little sign of voles (e.g., runways, clippings). It was noted that there seemed to be a large number of insects which frequented the traps and also ate the bait. Those insects which seemed very abundant included field crickets (Gryllus sp.), camel crickets (Ceuthophilus sp.), red ants (Family: Formicidae), and millipede (Class: Diplopoda). Some drizzling rain occurred while this site was trapped, but generally it was fairly dry and foul weather was not believed to be a factor in the poor trapping success.

DISCUSSION

The initial trapping on the Stockrahm and Aakre Study Sites during the fall of 1990 helped us plan the most efficient trapping methods to use for the summer 1991 field season. A distance of 10 m between traps worked quite well; each transect could then cover a long distance, yet traps were close enough to detect movement in the small mammals between trap stations. Peanutbutter and rolled oats worked very well as a bait for herbivorous mammals (e.g., voles, mice) as well as carnivorous/insectivorous ones (e.g., shrews). Two traps per station did not seem necessary because it was relatively rare for 2 small mammals to be captured at the same trap station at the

same time even when 2 traps were used. This was true whether the live traps were large or small.

Generally, there appeared to be no preference in small mammals for either large or small traps. The main exception was in meadow voles on the Stockrahm Study Site where they seemed to prefer the small traps. It is not known why this would occur on only 1 study site and not any of the others. One possibility is that voles were avoiding those traps that had previously caught shrews. Seventeen shrews were also caught on this plot of which 7 were captured in large traps. Shrews are predaceous/insectivorous and perhaps voles avoided them or their smell left in the traps. Even though there were 2 documented cases (1 meadow vole, 1 deer mouse) where non-shrew species entered a trap after it had captured a shrew, the data were inclusive.

It is unknown why more female meadow voles than males were captured in our study, but females have higher survival rates than males in some habitats (Getz et al. 1979) and this could directly affect sex ratios. Other possible factors could include differences in trappability, differences in curiosity or cautiousness toward traps, or females' greater need for high caloric food such as peanutbutter.

The habitat associations in which we captured our target species as well as our nontarget species closely agreed with the published literature. All prairie voles were captured in areas of relatively dry prairie. Most meadow voles were captured on the Stockrahm and Aakre Study Sites, both of which had very dense ground covers mainly of grass and also low damp or wet areas. When DeCoursey (1957) trapped both vole species in the same area in Ohio, he found that meadow voles were more numerous in moist situations while prairie voles were in relatively dry areas. Likewise, Miller (1969) found that meadow voles preferred moister areas with dense vegetation while prairie voles were usually found in drier areas with less dense cover. He also did behavioral studies with the 2 species and he believed that ecological as well as behavioral factors might serve to separate them in natural habitats. He found that when the more aggressive meadow vole was absent, the prairie vole might range into the wetter and vegetatively denser areas. Getz (1962), however, found that interspecific aggression between meadow voles and prairie voles was less than intraspecific aggression in meadow voles. Even though prairie voles seemed to be less aggressive generally, they seemed to be dominant over meadow voles. Getz (1963) believed that the different physiologies of meadow and prairie voles might influence their choice of habitat rather than aggression. His water metabolism studies indicated that prairie voles were better adapted to dry habitats than were meadow voles.

Getz et al. (1979) compared meadow vole and prairie vole densities is 3 different kinds of habitat: alfalfa, bluegrass, and tall grass prairie in Illinois. The densities for prairie voles in order of greatest to least density for each habitat was: alfalfa, bluegrass, and tall grass prairie, while the corresponding order for meadow voles was bluegrass, tall grass prairie, and alfalfa. It is interesting to note that neither species reached its peak density in tall grass prairie, the only natural habitat. Zimmerman (1965) found that meadow voles occurred in fields containing at least 50% grasses and abundant cover, while prairie voles were trapped in areas with less grass and cover.

On Site 1, our only site where both species of voles were captured, the species did not seem to be occupying noticeably different habitats. One trap station had captures of both species over the 4-day trapping period. It is possible that densities of the voles were not great enough to influence habitat associations and/or the habitat was relatively homogeneous.

All captures of grasshopper mice in our study were at sites that were relatively dry with areas of gravel and often sparse plant growth. Soils were usually sandy and somewhat coarse. Northern grasshopper mice have been recorded in areas with sandy soil in Kansas (Kaufman and Fleharty 1974, Kaufman et al. 1990), short-grass prairie in Colorado (Flake 1973), grasslands in Oklahoma, semi-stabilized sand dunes in Utah (Egoscue 1960), desert grassland in New Mexico (Rebar and Conley 1983), and sagebrush desert in Nevada (O'Farrell 1974). McCarty (1978) also gave a good summary on this species and some of this information was taken from this source. Our capture data suggests that the vegetation on the surface of the soil is not as important as the soil type. It seemed that a variety of different kinds of vegetation could be on the surface as long as it was sparse and as long as the soil was sandy/gravelly.

Egoscue (1960) and Bailey and Sperry (1929) believed that grasshopper mice required soils that permitted frequent dust bathing or their pelage became oily and unkempt. Egoscue (1960) also mentioned that the grasshopper mice he studied in Utah avoided marshy areas, extremely rocky areas, precipitous hillsides, shadscale (Atriplex confertifolia) flats with their alkaline soils, and pickleweed (Allenrolfia occidentalis) hummocks (salt-tolerant vegetation).

Egoscue (1960) suggested that adult grasshopper mice lived as isolated pairs or bisexual pairs. On Site 10, however, we found 6 grasshopper mice trapped within a 50-m transect along 1 gravelly hill. It was possible that some of these animals were offspring who not yet dispersed. Two of the males appeared to have testes that were in the process of descending (or had just done so), and thus were only reaching sexual maturity at the time

of capture. The 2 cases of adult males entering traps where adult females had formerly been captured might indicate some sort of sexual attachment, but the scant data were inconclusive.

We were a little surprised that we captured deer mice in the same traps in which grasshopper mice had been formerly captured because grasshopper mice have been known to kill a variety of other rodents (Ruffer 1968). Horner et al. (1964 or 1965 - both years were printed on the original paper), however, noted that in a laboratory test, the southern grasshopper mouse (O. torridus longicaudus) did not kill a Peromyscus maniculatus. They attributed this to the agility and speed of the latter species. The odor left in the traps by our grasshopper mice was very characteristic and very strong. Bailey and Sperry (1929) also reported a very strong odor, "almost skunklike", and believed it was from their feces and the nature of their diet.

Most of the shrews captured in our study were from the Stockrahm Study Site which had quite a few trees in the vicinity and also some damp or wet areas. Although we captured shrews all over the study site, more captures occurred near the trees than on the hotter and dryer areas of the site. The masked shrew is often found in moist areas in forests as well as open or brushy areas and the shorttail shrew is not restricted in habitat according to Burt and Grossenheider (1976), so the Stockrahm habitat was not uncharacteristic for either species. The sole arctic shrew was captured in a low, wet area very close to an area with standing water and trees. Although Burt and Grossenheider (1976) mention that its habitat is tamarack and spruce swamps, neither of these trees seemed to be in the vicinity. Many of the trees in the area were oak (Quercus sp.). Because this species is relatively rare in Minnesota, this capture was of special interest.

Thirteen-lined ground squirrels and deer mice seemed to be fairly common on many of our study sites (Tables 5, 6). This was not surprising because both are known to be fairly common species in grasslands habitats (Burt and Grossenheider 1976). The ground squirrels were especially abundant on Site 7 which was a wildlife management area, a portion of which appeared to have been disturbed.

Site 5 (Bluestem Prairie) was the only site with no captures. The great number of insects in the traps eating the bait was believed to be a factor in the poor trapping success, although the lack of vole sign on this site indicated that populations might have been low to begin with. The Bluestem Prairie was also trapped during the 1988 Minnesota County Biological Small Mammal Survey (Birney and Nordquist 1991), and neither meadow voles nor prairie voles were captured at that time. Predator densities in this area are not known, but perhaps this is also a factor.

The plains pocket mouse was not c.ptured on any of the study plots during this study even though we trapped a variety of grassland habitats. Perhaps this species is more rare in Minnesota than formerly believed.

CONCLUDING REMARKS AND RECOMMENDATIONS

Prairie voles were found in a number of dry grassland prairie sites, northern grasshopper mice were found in several gravelly, sandy areas, 1 western harvest mouse was believed to have been found on a single site, and no plains pocket mice were captured. Based on these trapping records, perhaps all 4 species should be put on the "Special Concern" list, especially the 2 latter species. Currently, only the prairie vole is on this list.

see update p.2

The grasshopper mice were always associated with gravelly areas. This type of area, including old and current quarry sites, should be investigated further around the state and perhaps protected in some way if this habitat proves to be critical. Perhaps native prairie is not necessary for this species, but only sites with gravel/sand.

Birney and Nordquist (1991) discuss the impact of burning on the habitats of these species. In our study, Site 2 (Felton Prairie) was obviously burned very recently as evidenced by black ash and a complete lack of litter, a site which only had captures of deer mice (Table 5) (which seemed to be heavily infected with botfly larvae). Site 2 was also quite wet and harbored many mosquitos. Site 4 appeared to have also recently been burned because no litter was obvious. Again, deer mice were the most abundant species and only 1 prairie vole was captured (Table 5). Site 14 (Buffalo River State Park) was burned in 1990 and grasshopper and deer mice were captured there in 1991. The recommendations that Birney and Nordquist (1991) make about burning small patches of prairie on a rotational basis seem to be valid. Managing this mosaic of habitats would eliminate litter on some plots to provide a more open habitat for the plains pocket mouse and allow litter to build up on other plots to provide habitat more suitable for prairie voles and western harvest mice. The effect of burning on the habitat of the grasshopper mouse is unknown. However, because they usually live in underground burrows (Ruffer 1965b) and seem to have little dependence on litter cover, it is not unreasonable to suspect that the effect is minimal.

Another habitat that should perhaps be looked at more closely is the land under the CRP program. These areas could be potential new habitats for the target species, especially after the land has been out of agricultural production for a number of years and the species plant diversity increases, providing a more optimal habitat.

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Table 1. Timing of prebaiting, setting, and checking small mammal traps in Clay and Lac Qui Parle Counties during summer 1991.

TIMES	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Morning	-	Set Traps	Check 2	Check 5	Check 8; Pick Up Traps
Afternoon	Set Up Transect; Prebait Traps & Lock Open	-	Check 3	Check 6	-
Evening	-	Check 1	Check 4	Check 7	-

Table 2. List of museums or collections to which letters of inquiry were sent or calls made regarding specimens and their capture locations of 4 target species (prairie vole, northern grasshopper mouse, plains pocket mouse, and western harvest mouse) from Clay and Lac Qui Parle Counties, Minnesota. Letters were sent or calls made in November 1990 and December 1991.

LETTER MAILED TO / CALL MADE TO	REPLY
North Dakota State University (Fargo, ND)	No Specimens
Concordia College (Moorhead, MN)	No Specimens
University of North Dakota (Grand Forks, ND)	No Specimens
Bemidji State University (Bemidji, MN)	No Specimens
University of Minnesota & Bell Museum of Natural History (Minneapolis, MN)	[a, b] *M. ochrogaster* (2 in Clay) *O. leucogaster* (2 in Clay) (8 in Lac Qui Parle) *P. flavescens* (1 in Clay) (3 in Lac Qui Parle) *R. megalotis* (4 in Lac Qui Parle)
University of Kansas (Lawrence, KS)	No Specimens
Field Museum of Natural History (Chicago, IL)	No Specimens
St. Cloud State University (St. Cloud, MN)	No Specimens
The Science Museum of Minnesota (St. Paul, MN)	[b] *M. ochrogaster* *O. leucogaster* (Clay)
University of Minnesota-Duluth (Duluth, MN)	No Reply
Southwest State University (Marshall, MN)	No Reply

[a] Most of these 20 captures were also listed in the Natural Heritage Database to which I already had access.

[b] More detailed capture information is included in Appendix B.

Table 3. Final list of trapping sites for small mammal study during summer 1991.

STUDY SITE NUMBER	COUNTY	TOWNSHIP	RANGE	SECTION
1	Clay	141	45	5
2	Clay	142	46	36
3	Clay	142	45	36
4	Clay	139	46	22
5	Clay	139	46	15
6	Clay	139	46	23
7	Lac Qui Parle	117	46	1
8	Lac Qui Parle	117	46	5
9	Lac Qui Parle	117	46	8
10	Lac Qui Parle	118	46	4
11	Lac Qui Parle	120	46	2
12	Lac Qui Parle	119	46	35
13	Clay	139	46	11
14	Clay	139	46	14
15	Clay	139	46	14

Table 4. Sex and age distribution of captured small mammals on Stockrahm and Aakre Study Sites in Clay County, Minnesota during fall 1990. Includes only original captures, i.e., recaptures are not included. Data are combined for all trapping sessions. Some specimens were originally believed to be M. ochrogaster, but examination of several skulls revealed they were M. pennsylvanicus; therefore, all captured voles are listed as the latter species. A = adults, I = immatures, M = males, F = females.

SPECIES	STUDY SITES									
	Aakre Farm				Stockrahm Farm				Totals	
	Males		Females		Males		Females		M	F
	A	I	A	I	A	I	A	I		
INSECTIVORA[a]										
Blarina brevicauda	.	.	1	.	.	.	4	.	.	5
Sorex cinereus	.	.	.	.	.	.	13	.	.	13
Sorex arcticus	.	.	1	.	.	.	.	.	.	1
RODENTIA										
Clethrionomys gapperi	.	.	.	.	.	.	.	1	.	1
Microtus pennsylvanicus	9	38	34	37	6	7	12	8	60	91
Peromyscus maniculatus	.	.	.	.	.	2	3	.	2	3
CARNIVORA										
Mustela nivalis	1	.	.	.	.	.	.	.	.	1

[a] It was generally not possible to determine the sex of the captured shrews with the exception of 3 female adult Sorex cinereus on the Stockrahm site. For simplicity, all shrews are listed under the female column.

Table 5. Summary of small mammal captured in Clay County during summer 1991. Thirteen-lined ground squirrels were too large to be toe-clipped for individual recognition; therefore, original captures could not be distinguished from recaptures. The numbers listed here for this species represent all captures of both sexes combined, i.e., all original and subsequent captures. M = male, F = female, T = totals.

SPECIES	STUDY SITE NUMBER									
	1 M-F	2 M-F	3 M-F	4 M-F	5 M-F	6 M-F	13 M-F	14 M-F	15 M-F	Total M-F
INSECTIVORA										
Sorex cinereus	.[a]	.	1	.	.	.	1	.	2	4
RODENTIA										
Microtus pennsylvanicus	0-3[b]	.	1-5[c]	.	.	.	1-1	.	.	2-9
Microtus ochrogaster	OCC #13 4-5	.	.	OCC #38 0-1	.	OCC #39 1-0	.	.	.	5-6
Onychomys leucogaster	.	.	.	.	.	OCC #30 0-1	.	OCC #28 1-2	OCC #29 2-1	3-4
Peromyscus maniculatus	3-1	7-9[d]	1-0	4-2[c]	.	3-5	.	3-2	.	21-19
Spermophilus tridecemlineatus	2	.	2	3	.	1	1	1	5	15

[a] It was not possible to determine the sex of the captured *Sorex cinereus*.

[b] 1 additional *Microtus* sp. was captured, but it was too young to be identified as either a prairie vole or a meadow vole.

[c] 1 additional animal of unknown sex was also captured.

[d] 2 additional animals of unknown sex were also captured.

Table 6. Summary of small mammals captured in Lac Qui Parle, Minnesota during summer 1991. Thirteen-lined ground squirrels were too large to toe-clip for individual recognition; therefore, original captures could not be distinguished from recaptures. The numbers listed here for this species represent all captures of both sexes combined, i.e., all original and subsequent captures. M = male, F = female, U = unknown sex, T = totals.

SPECIES	STUDY SITE NUMBER						
	7 M-F-U	8 M-F	9 M-F	10 M-F	11 M-F	12 M-F-U	T M-F-U
INSECTIVORA							
Sorex cinereus	.	.	.	.	.	0-1-1	0-1-1
Blarina brevicauda	2-1-5	.	.	.	.	0-1-12	2-2-17
RODENTIA							
Clethrionomys gapperi	0-1	.	.	.	.	.	0-1
Microtus pennsylvanicus	.	.	0-1	.	.	.	0-1
Microtus ochrogaster	.	.	.	occ #40 0-4	.	.	0-4
Onychomys leucogaster	.	.	.	occ #31 3-3	.	.	3-3
Peromyscus maniculatus	2-2	3-0	0-2	14-10	6-2	2-3	27-19
Mus musculus ~~Reithrodontomys megalotis~~	[a]	.	.	.	? 1-0 needs to be added.	.	1-0
Spermophilus tridecemlineatus	42	2	1	13	7	4	69

[a] A skull and skin of this same species was collected at a nearby site and has tentatively been identified as Reithrodontomys megalotis. It is awaiting verification by the Bell Museum.

I examined this specimen and found it had been misidentified. It was actually a House mouse (Mus musculus) —Gaida Madgwick—

Table 7. Sex and age distributior of target species captured in Clay and Lac Qui Parle Counties, Minnesota during summer 1991.

SPECIES	STUDY SITE NUMBER													
	1		4		6		10		11		14		15	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Microtus ochrogaster														
Adults	.	4	.	1	1	.	.	2	.	.	.	.	.	.
Immatures	4	1	.	.	.	.	.	2	.	.	.	.	.	.
Onychomys leucogaster														
Adults	.	.	.	.	.	1	3	2	.	.	1	2	2	1
Immatures	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Reithrodontomys megalotis[a]														
Adults	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Immatures	.	.	.	.	.	.	.	.	.	.	.	.	.	.

[a] A skull and skin of this same species was collected at a nearby site and has tentatively been identified as Reithrodontomys megalotis. It is awaiting verification by the Bell Museum.

See note on p. 2