NORTH DAKOTA GAME AND FISH DEPARTMENT

FINAL REPORT

Comparative Evaluation and Inventory of Small Mammal and Herptile Communities in Southwestern North Dakota

Project T-10-R

July 1, 2005 – June 30, 2007

Terry Steinwand
Director

Submitted by
Michael G. McKenna
Chief, Conservation and Communications Division

2007

CLIMATE CHANGE AND LAND USE EFFECTS ON SMALL MAMMAL COMMUNITIES IN A NORTHERN GREAT PLAINS LANDSCAPE

John T. Leonhart and Dr. Rick A. Sweitzer, Department of Biology
University of North Dakota, Grand Forks, North Dakota, 58202
Phone: 701-777-4676, FAX: 701-777-2623, john.leonhart@und.nodak.edu,
richard_sweitzer@und.nodak.edu

PROJECT SUMMARY

Concerns over increasing levels of atmospheric CO2, as well as changing global climate has resonated among the scientific community for several decades. Recent data and climate models suggest that global temperatures have already increased and will continue to do so into the future. These models and data further suggest that extensive disruptions to ecological communities may be overwhelming for many plants and animals, which could lead to local or regional extinctions. Small mammal communities typically function over relatively small spatial scales, suggesting that they are sensitive to short-term climatic change. Drought cycles and periodic seed production are both known to promote wide variability in small mammal populations. Land use practices that introduce extensive habitat fragmentation may also affect small mammal communities. In this study we hypothesized that regional changes in climate in the northern Great Plains may have altered small mammal communities in western North Dakota over the last 30 years. We have access to a historical dataset from an intensive survey of the distribution of small mammals and many reptiles and amphibians over a large region of western North Dakota in the mid 1970s. Beginning in summer 2004 and continuing through summer 2006 we revisited the original survey locations from work in the 1970s to resample for small mammals. Sampling includes a combination of standardized trapping techniques with live traps, pitfall traps, and snap traps, which will provide quantitative information on species richness and diversity for comparison with the historic data. Beginning in 2005, we included methods that focus directly on the capture of amphibians and reptiles, such as, coverboards, night driving surveys, and randomized walks; thus allowing us to ascertain the most accurate data possible, for the distribution of herpitiles.

Climatological records and data on recent land use are being compiled for eventual integration into a geographic information system to allow us to isolate any distributional shifts or species disappearances that are related more to habitat alteration than potential climate shifts.

RESEARCH DESCRIPTION

Scientists raised concerns over the effect of increasing levels of atmospheric CO2 on the global climate over 30 years ago. Recent empirical data and complex climate models suggest that global temperatures have already increased and the rate of warming will likely hasten over the next 100 years (Houghton et al. 2001). Improved models can now estimate potential changes in climate at the continental and even regional scale, which has raised concern among ecologists and conservation biologists regarding the ability, or inability of different species to adapt to altered microhabitat and forage conditions associated with regional flux in climate (Thomas et al. 2004).

Land use changes most often alter the distribution and structure of small mammal communities by habitat loss and habitat fragmentation. Similar to many other types of organisms, patch size has a major influence on diversity of small mammal communities (Lovett-Doust et al. 2003). Small mammals have relatively low dispersal rates and therefore require a relatively high density to maintain viable populations (Silva 2001). Fragmentation and isolation of critical habitats reduces population size for most species, thereby increasing extinction rates and ultimately reducing community level richness and diversity. Davis and Shaw (2001) argue that species distributions tend to parallel climatic limitations. However, species may respond to changing climate by changing their realized niche (Lavorel 1999) as opposed to physiological adaptation. Davis and Shaw (2001) concluded that genetic constraints on adaptation coupled with changes in land use practices that reduce gene flow likely reduce the rate at which adaptation occurs well below the rate of climatic change.

This study was initiated to reassess the distribution and diversity of small terrestrial vertebrates in southwestern North Dakota to determine the extent to which changes in climate and land use may have altered community structure by range shifts or localized extinctions of individual species. We used a combination of standardized trapping techniques to sample terrestrial vertebrates at or very near the original sampling sites used by Seabloom et al. (1978). Data on relative abundance, species richness, and species diversity are being compared between periods to identify potential long-term changes in small terrestrial vertebrate communities between sampling periods. Historical climate records are being compiled for the region for assessing whether the hypothesis of climate warming or change has been realized. Aerial and satellite photographs and county records on agriculture activities and other forms of development are being used to assess and control for changes in land use in the region.

STUDY AREAS

The study area consists of that portion of North Dakota South and West of the Missouri River plus McLean County, an area of approximately 56,980 km^2 (22,000 mi^2). Southwest North Dakota falls within 2 main physiographic regions, the Missouri slope is a strip of bluffs running the length, and extending west from the banks of the Missouri river. The Great Plains make up the rest of the region consisting of semi-rough topography due to fewer glaciations events. The badlands are an extremely rough, highly eroded landscape within the Great Plains region of southwest North Dakota. The climate of the region is characterized as having large temperature fluctuations across seasons, light to moderate, irregular precipitation, plentiful sunshine and nearly continuous wind (Entz 2003). The average annual temperature is approximately 6°C and annual precipitation ranges from about 34.3 cm to 40.6 cm, decreasing from east to west (Entz 2003). These climatic conditions are extremely continental in nature driven by the geographic location.

Prior to the arrival of European settlers in the 1800s the landscape of southwestern North Dakota was dominated by mixed and shortgrass prairie grasslands. Currently, the Little Missouri National Grasslands (LMNG) and Theodore Roosevelt National Park (TRNP) are large areas of publicly owned and managed land in the region. However, most of the Missouri slope consists of privately owned parcels of land with smaller state owned properties dotting the landscape. Management with respect to extraction of non renewable resources and grazing practices are very different between government agencies. TRNP remains pristine habitat while grazing and oil and gas exploration are allowed in the LMNG.

During the project study period (summers 2004, 2005 and 2006) we visited and systematically sampled, by a variety of trapping methods, a total of 67 research sites in southwestern North Dakota, including all of the original sites sampled during the Regional Environmental Assessment study by Seabloom et al. (1978). Fieldwork was initiated in mid-May of each year and continued through October. As part of preliminary research in summer 2004, 16 sites were sampled with 7 of them being from the original REAP study. During the summer of 2005, 26 additional sites were sampled totaling 42 sites completed (Figure 1). Thirty-three, of these 42 completed sites, were from the original REAP study. Twenty-five of the 26 remaining sites were sampled in the summer of 2006, we were denied access to only one of the original 59 study sites. The study area has been graphically separated into five arbitrary regions (Figure 1) for the purposes of this report.

Based on Seabloom et al. (1978), each of the trapping/sampling sites was located in a ¼ section of land, pre-chosen from one of the original 59 sites. At each site, sampling transects described below were positioned as close to the center of the ¼ section as possible, aided by a USGS, Forest Service 1:126,720 quadrangle map. The principal habitat type at each research site was identified and described using the same habitat categories as Seabloom et al. (1978), and acreage estimates were taken in the same manner as Seabloom et al. (1978).

METHODS

Overview of Sampling Techinques

At each sampling site, we used a combination of six different methods to capture and sample terrestrial vertebrates; live trapping transect lines, pitfall trap arrays, snap trap transects, visual encounter surveys, night driving techniques and sampling with artificial cover boards. Live trapping transect lines are effective for estimating relative abundance of rodents, but can also generate data for estimating species richness and species diversity (Mayfield et al. 2000, Caro 2001, Schmidt-Holmes and Drickamer 2001). Pitfall trap arrays are an effective and reliable method for capturing shrews and amphibians (Scott et al. 1994, Kirtland and Sheppard 1996, Mac Nally et al. 2001), but will also capture many smaller mammals and reptiles (Nichols et al. 1996; not effective for large snakes). Snap traps are a standard method for sampling small mammal populations with the resulting data most useful for estimating species richness based on presence/absence and relative abundance by captures/trap day (Seabloom et al. 1980, Wilson et al. 1996, Kaufman et al. 2000). Visual encounter surveys, night driving, and artificial cover were integrated into the 59 trapping sites in order to specifically target herptiles. These 3 methods, in conjunction with pitfalls equipped with funnel traps, should provide an accurate assessment of species richness and abundance of reptiles and amphibians (Scott et al. 1994, Fellars et al. 1994), as well as their habitat associations.

By virtue of the multiple sampling methods further detailed below, sampling was dispersed across many habitat types. Although habitat diversity did not affect the location of traps, most habitats should have been represented based on the length of live trap lines, as well as the configuration of the trapping regime. In addition to data being generated by the various trapping methods, technicians kept records of all other wild mammals, amphibians and reptiles observed either directly or indirectly (sign such as tracks, audible calls, etc.) during the course of research activities across the research area.

Live Trap Transect Line Design

Live trap transects at all research sites consisted of two, 290 m transect lines, spaced 20 m apart, containing 30 collapsible aluminum or galvanized Sherman small mammal live traps (8 x 9 x 10 cm), with 10 m spacing between traps on a given line (Figure 2). In addition to the Sherman live traps, 15 Havahart mesh traps were placed alongside Sherman live traps at 20 m intervals. The same trap configuration was used at all 59 study sites. Trap locations were pre-baited for one night and set for capture over a periods of three consecutive nights. Sherman live traps were baited with a mixture of birdseed and rolled oats, and Havahart traps were baited with apple slices and unsalted peanuts. Trap lines at all sites were operated for a single, 3-night trapping session only.

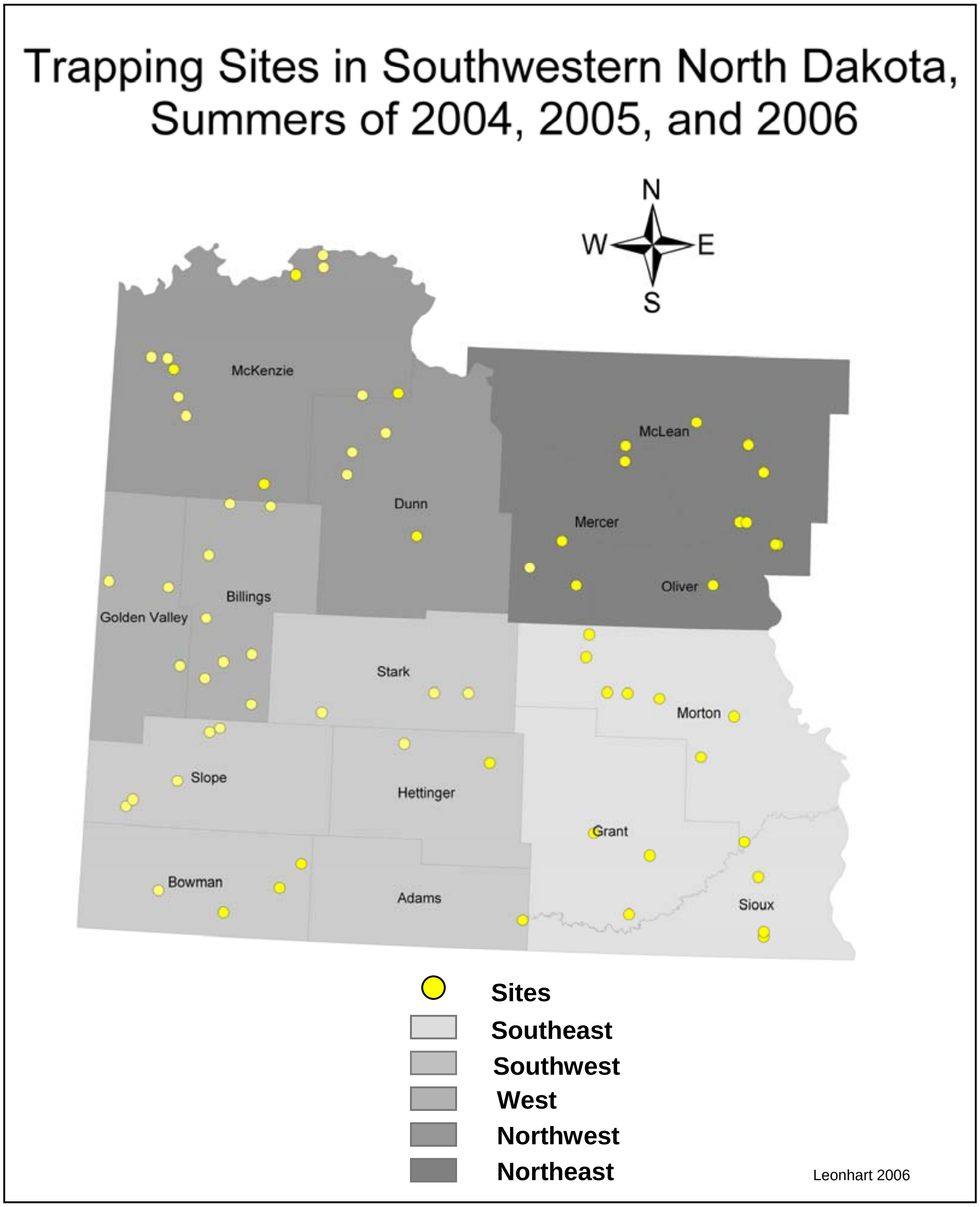

Figure 1. Distribution of all 68 research sites that were trapped for small mammals in the summers of 2004, 2005, and 2006, as well as amphibians and reptiles during the summers of 2005 and 2006. Different shades of gray represent 5 arbitrary regions (Southeast, Southwest, West, Northwest, Northeast). Descriptions and details on each research trapping site are included in Appendix I.

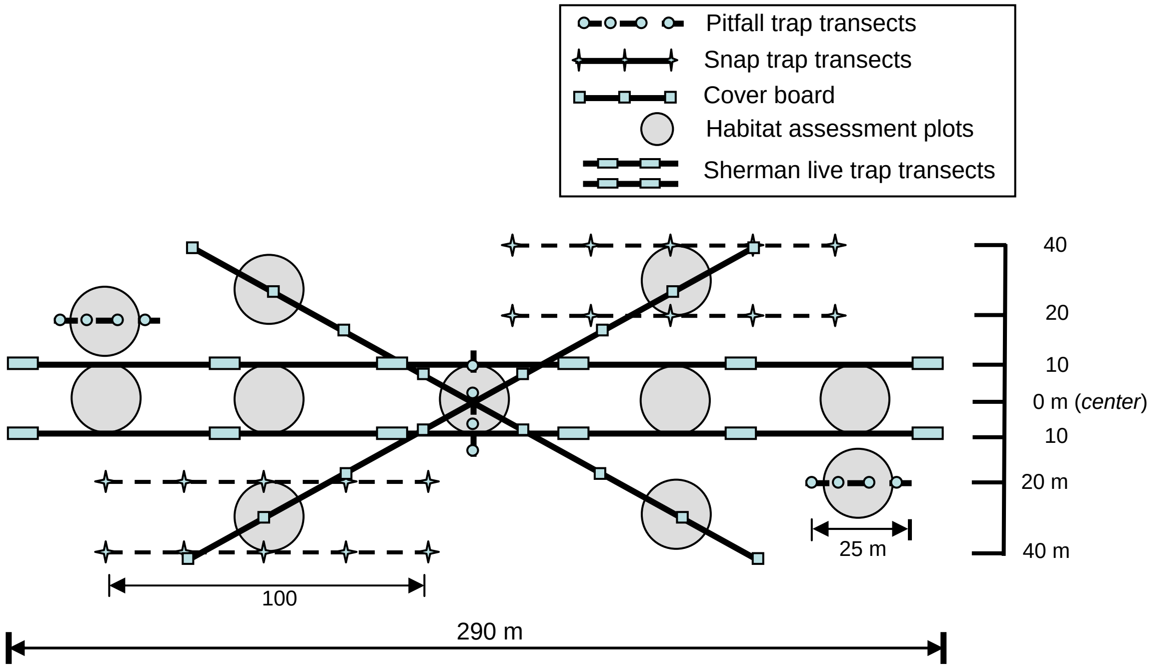

Figure 2. Terrestrial vertebrate trapping configuration of Sherman live traps, pitfall arrays, snap trap transects, cover board transects and habitat assessment plots.

Pitfall Trap Arrays

Pitfall arrays were composed of six 18.3-23.7 L buckets arranged linearly with 5-m spacing between adjacent buckets. Funnel traps were also integrated into the midpoint of the pitfall array for capturing frogs and snakes. Buckets were buried to ground level and connected with a continuous length of 25 cm tall "drift fence" of aluminum or galvanized metal flashing material running over the center of the buckets. At each research site a total of three pitfall trap arrays were used, two pitfall arrays were oriented parallel to the Sherman trap line, and the third pitfall array ran perpendicular to the Sherman transect, intersecting it in the center (Figure 2). The parallel pitfall traps were spaced 20 m from the Sherman live trap transect line (Figure 2). Pitfall trapping arrays operated for three consecutive trap night periods concurrent with when live trapping was underway. During trapping periods pitfall traps were left open during the late afternoon to evening at the beginning of a three day sampling period and checked in the morning and early evening of each day. Pitfall buckets were shaded and a small amount of oatmeal and seed mixture was placed in each bucket to sustain captured animals until they were processed and released.

Snap Trap Sampling Design

Two snap trap transects were established at each of the 67 research sites to ensure adequate sampling of the sites and to provide voucher specimens for the study. Snap trap transects consisted of two semi-parallel 100-m transect separated by 20-m with a total of 42 and 12 museum special/victor mouse traps and Victor rat traps, respectively positioned along them. Each 100-m transect included 21 museum special or Victor mouse traps (1 trap every 5-m) and six Victor rat traps (one every 20-m; Figure 2). Pin flags were used to mark the location of each trap station along the paired 100-m transects. Once they were set up, snap trap transects were baited with a paste mixture of peanut butter, rolled oats, and bird seed and operated for three consecutive days. Traps were checked in mid morning each day and re-baited as needed.

Visual Encounter Surveys & Night Driving

Visual encounter surveys are standard techniques for inventorying and monitoring terrestrial amphibians and reptiles (Heyer et al. 1994). When appropriately performed, data from visual encounter surveys allow for the determination and comparison of herptile species richness and relative abundances among research sites (Scott et al. 1994). As part of this project field crews implemented visual encounter surveys at most of the 67 research sites (visual encounter surveys were added after the 2004 sampling season; therefore, we missed 16 sites) as part of a randomized-walk method. Randomized walks were completed by choosing 50 random, sequential compass azimuths along which 50 random distances of 1 to 50 m were slowly walked while visually searching for reptiles and amphibians. The starting point was determined by dividing the entire site into 4 blocks and randomly selecting 1 block of which the center was the starting point. All amphibians and reptiles encountered within 1 m of each side of the path were captured, identified, marked with a permanent marking pen, and released at capture positions. Survey time required to complete each visual encounter surveys was recorded to estimate catch per unit effort.

Night driving techniques were used to supplement data for estimates of amphibian and reptile species richness and abundance (Fellars et al. 1994). To accomplish this method, a 20 km stretch of road was chosen prior to the arrival at a given study site. The route was determined based on juxtaposition to each of the sampling sites that included as much favorable amphibian and reptile habitat as possible. Favorable habitat was considered to be areas encompassing wetlands, drainages, creeks and rivers. On the first night spent at a particular site, 2 passes were made along road segments at 20 kph. All amphibians and reptiles were processed, marked and released at the point of capture.

Artificial Cover Boards

Amphibians and reptiles typically take cover beneath surface objects, such as vegetation, or rocks that provide refuge from the elements. Therefore, artificial cover objects can provide additional data on terrestrial herptiles (Fellars et al 1994). At each study site, two 200-m lines of cover boards were placed in an X pattern intersecting at the center of the sample plots (Figure 2). Each transect included 41 cover boards of two different sizes (30 x 30 x 2.5 cm, 60 x 60 x 2.5 cm) spaced at 5 m intervals (n = 82 total cover boards at each research site). The different sizes of coverboards were alternated along the length of transects. Cover board rows were checked twice daily (early morning and late evening) for the three concurrent days crews spent sampling each site, and on another occasion approximately 5 days later. We left the cover boards in place when the field crew departed for the next sampling site on the schedule, after which we returned and checked them one final time for retrieval. Observations were made and data recorded on all reptiles and amphibians detected using the cover boards for refuge. The artificial cover board technique was abandoned in the summer of 2006 based on the lack of data being returned, as well as, the overall costs of time and labor. Cover boards were used on a total of 27 sampling sites, out of 67.

Trapping and Animal Handling Procedures

All live-captured rodents were identified to species, sexed, weighed, assigned to one of three age classes (juvenile, sub adult, adult) based on pelage coloration and body weight (Wilson et al. 1996), marked with numbered tags in the left ear (Monel size #1005, National Band and Tag Company, Newport, KY), and released. Live captured shrews were identified to species, weighed, marked with a marker pen, and released. Live captured amphibians and reptiles were identified to species, measured for snout vent length and total body length, weighed and released unmarked. Rodents, shrews and occasional amphibians that were captured in snap traps were identified to species, weighed, measured for head + body length and tail length (snout vent and total body length for amphibians), and retained or discarded depending on condition. Snap trap captured animals that were in relatively good condition are collected for study skin/ skull preparation and long term storage as voucher specimens at the University of North Dakota. Reptiles and amphibians that were observed during the course of research activities were captured, identified and processed as above, and then released at points of observation.

Vegetation Sampling

We used a circular plot technique to quantitatively assess habitat characteristics for the sampling plots at each research site. At the center point of each of 11 different circular plots (Figure 2), a circle with a radius of 10 m was established (circular plot area = 314.16 m^2). Height of herbaceous vegetation, litter depth, canopy cover and substrate type was measured at 5 points within the circular plot, at the ends of the two 2 m x 20 m transects as well as the bisecting point of the 2 transects (the center of the plot). The total number and species type of woody shrubs and trees along the 2 belt transects were also recorded. Diameter at breast height (dbh), species type and total number were recorded for all trees within the quadrats of each of the individual circular plots. We also enumerated all potential cover items (rocks, large tree branches, logs, etc.) within the circular plot, as well as all burrows or gopher mounds along the belt transects bisecting the plots.

Data on habitat features are being used in association with capture data to describe specific habitat features/components typical of each species of terrestrial vertebrate captured. These data will also allow us to identify different “taxonomic assemblages” based on their capture histories and habitat affinities. For those species we have captured, that are identified as a conservation priority, we will further describe and detail critical habitat features for the organisms and use habitat coverage maps developed as part of the North Dakota GAP Analysis project at the Northern Prairie National Wildlife Research Center to identify areas in southwestern North Dakota and elsewhere in the state where those critical habitat features are present. This approach is allowing us to identify areas for targeted sampling where species of conservation priority may occur but have not been recently documented in our state.

Data Analysis

Small mammal and herptile abundance, species richness, and species diversity was estimated and compared for each research site. Abundance was measured as the total individuals captured by the total number of trap nights. Trap nights for live trap transect lines was corrected for undisturbed closed traps with no captures (closed traps) by the following formula; total trap nights (three night trapping period) = 3 X number of traps in line – 0.5 X number of closed traps. This formula assumes that closed traps were open and available for one half of a trap night. No corrections were used for snap traps that were triggered with no captures. Species richness is the number of species captured on each transect over the course of a trapping session. Species diversity is estimated as the exponential form of the Shannon-Weiner function $N = e^{H'}$, with $H' = \sum p_i (\ln p_i)$, where p_i = relative abundance of species i (Krebs 1999). Estimates of abundance, species richness and species diversity were determined for each research site overall with data from all habitat types.

RESULTS

In summer 2004 we sampled small mammal communities at 16 different sites. In the summer of 2005 we sampled small mammals, as well as reptiles and amphibians, at 26 different sites. In the summer of 2006 we again sampled all taxa at 25 different sites, totaling 67 sampling sites for the three summers. A total of 336 individual small mammals were captured in 2004, representing 13 different species (Tables 2 and 3a-e). Twelve total amphibians and reptiles were captured in 2004 representing 5 different species (Table 1). Amphibian and reptile captures from the summer of 2004 were not included in the summary tables because of the extreme differences in trapping regimes between the years. A total of 1049 small mammals were captured in summer 2005 representing 20 different species (Tables 2 and 3a-e). One hundred sixty-five total amphibians and reptiles were caught in 2005 representing 10 different species (Tables 1 and 4a-b). We saw a decline in the numbers of small mammals captured in 2006 (38% reduction), while there was an extreme discrepancy in the total numbers of amphibians and reptiles captured between 2005 and 2006 (80% reduction). A total of 645 individuals of 15 different species of small mammals were captured in 2006, while only 33 amphibians and reptiles of five species were captured. The difference in captures is interesting because a similar number of sites were trapped between the two seasons (26 sites in 2005, 25 sites in 2006). Tables 1 and 2 summarize all species of mammals, reptiles, or amphibians that were observed or captured during the three summers of fieldwork. Table 3a-e summarizes small mammal captures at sampling locations/sites within each of five different general areas of southwestern North Dakota (Southwest, Southeast, West, Northwest, and Northeast) for the three field seasons. Table 4a-b summarizes amphibian and reptile captures for each of those same general areas of southwestern North Dakota during summer 2005 and tables 4c-d shows all reptile and amphibian captures for the summer of 2006.

Preliminary analyses indicate variation in small mammal species richness among regions. Small mammal richness was highest in the west region and lowest in the southwest region (Table 5). The high richness in the west region was expected because the majority of the west region encompasses the badlands where habitats were more diverse. Species diversity was fairly similar across all regions ranging from 4.112 (richness = 11) to 6.855 (richness = 12) in the northeast. The deer mouse (*Peromyscus maniculatis*) was captured 1334 times representing 68% of all small mammals captures in the study area (Table 3a-e). Conversely, the sagebrush vole (*Lemmiscus curtatus*) and the house mouse (*Mus musculus*) were the only mammals captured only once in the study area (Table 3a and 3d).

Table 6 suggests diversity and richness are much more variable in the amphibians and reptiles than small mammals. Species richness measures ranged from three in the southwest region to 9 in the southeast region. This could be explained by generally wetter habitats in the southeast, including several major rivers (e.g. Missouri, Heart, Cannonball), as well as, an increased number of wetlands to the eastern part of the region. However, these results could be biased due to a high number of Woodhouse's toads caught at one site in 2005, and only one smooth green snake (*Opheodrys vernalis*) and one hognose snake (*Heterodon nasicus*) caught in that particular region. The Woodhouses's toad was the most common herptile in the study area; 78 individuals of this species were captured in 2005, and 2006 representing 40% of all herptile captures. The least common herptiles were the western hognose snake and the smooth green snake; single individuals of each species were captured in 2005. Species diversity is also quite variable, ranging from 4.26 in the southwest to 9.43 in the northeast. The high diversity in the northeast could be due, in part, to the northeast region encompassing part of the Missouri coteau, which contains a higher density of wetlands than the other regions of the study area. These results show the extreme variation of small mammal, and reptile and amphibian abundance in southwestern North Dakota. This variation is a product of the wide variety of habitats that are evident across this region of the state.

We were unable to compare data on species richness and species diversity from summers 2004 through 2006 with similar data from the REAP study for this report. Data from the REAP study has just recently been made available to the public and time constraints have made comparisons, between periods, improbable thus far. Until we are able to gain an understanding of the original REAP data, we will avoid making preliminary inferences about potential changes in small mammal communities related to climate change.

Table 1. Species and common names of different reptiles and amphibians captured, or observed during the summers of 2004 and 2005.

Species	*Common name*	*Detection by*
Amphibians		
Ambylostoma tigrinum	Tiger Salamander	Capture
Bufo cognatus	Great Plains Toad	Capture
Bufo hemiosphrys	Canadian Toad	Observation
Bufo woodhouseii	Woodhouse's Toad	Capture
Pseudacris triseriata	Chorus Frog	Capture
Rana pipians	Leopard Frog	Capture
Reptiles		
Coluber constrictor	Racer	Observation
Crotalus viridis	Prairie Rattlesnake	Capture
Heterodon nasicus	Western Hognose Snake	Observation
Opheodrys vernalis	Smooth Green Snake	Capture
Phrynosoma douglassi	Shorthorned Lizard	Observation
Pituophis catenifer	Bullsnake	Capture
Scaphiopus bombifrons	Sagebrush Lizard	Capture
Thamnophis radix	Plains Garter Snake	Observation
Thamnophis sirtalis	Common Garter Snake	Capture

Table 2. Species and common names of different mammals captured, or observed during the summers of 2004 and 2005.

Species	*Common name*	*Detection by*
Large Mammals		
Antilocapra americana	Pronghorn	Observation
Bos bison	American Bison	Observation
Cervus elaphus	Elk	Observation
Odocoileus hemionus	Mule Deer	Observation
Odocoileus virginianus	White-tailed Deer	Observation
Ovis Canadensis	Bighorn sheep	Observation
Carnivores		
Canis latrans	Coyote	Observation
Mephitis mephitis	Striped Skunk	Observation
Mustela frenata	Long-tailed Weasel	Observation
Procyon lotor	Raccoon	Observation
Urocyon cinereoargenteus	Gray Fox	Observation
Vulpes vulpes	Red Fox	Observation
Rodents, Rabbits and Bats		
Chaettodipus hispidus	Hispid Pocket Mouse	Capture
Cynomys ludovicianus	Black-tailed Prairie Dog	Capture
Erethizon Dorsatum	Common Porcupine	Observation
Eptesicus fuscus	Big Brown Bat	Observation
Lepus townsendii	White-tailed Jackrabbit	Observation
Microtus pennsylvanicus	Meadow Vole	Capture
Microtus ochrogaster	Prairie Vole	Capture
Mus musculus	House Mouse	Capture
Neotoma cinerea	Bushy-tailed Woodrat	Capture
Ondatra zibethicus	Muskrat	Observation
Onychomys leucogaster	Northern Grasshopper Mouse	Capture
Perognathus fasciatus	Olive-backed Pocket Mouse	Capture
Peromyscus leucopus	White-footed Mouse	Capture
Peromyscus maniculatus	Deer Mouse	Capture
Reithrodontomys megalotis	Western Harvest Mouse	Capture
Reithrodontomys montanus	Plains Harvest Mouse	Capture
Spermophilus tridecemlineatus	Thirteen-lined Ground Squirrel	Capture
Sylvilagus audobonii	Desert Cottontail	Capture
Sylvilagus floridanus	Eastern Cottontail	Capture
Tamius minimus	Least Chipmunk	Capture
Thomomys talpoides	Northern Pocket Gopher	Capture
Zapus hudsonius	Meadow Jumping Mouse	Capture
Zapus priniceps	Western Jumping Mouse	Capture
Insectivores		
Blarina brevicauda	Short-tailed Shrew	Observation
Sorex Haydeni	Prairie Shrew	Capture

Table 3a. Summary of the numbers of different small mammals captured in the Southwest region of the study area (see text for details) in southwestern North Dakota, for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

	Research Site Number[a]												
Species	**1[d]**	**6[d]**	**7[d]**	**8[c]**	**9[c]**	**20[d]**	**21[c]**	**54[c]**	**55[c]**	**56[c]**	**62[b]**	**68[b]**	**Totals**
Blarina brevicauda	1						2						**3**
Chaettodipus hispidus	8												**8**
Lemmiscus curtatus												1	**1**
Microtus pennsylvanicus		1							2			5	**8**
Onychomys leucogaster	1		1	8	1						1		**12**
Perognathus fasciatus			1	1	1	1							**4**
Peromyscus maniculatus	18	9	4	23	13	16	11	11	12	16	35	22	**190**
Reithrodontomys megalotis			2				2						**4**
Sorex haydeni				1	1		1			1			**4**
Spermophilus tridecemlineatus	4	2					2						**8**
Sylvilagus floridanus									1				**1**
Total Captures	**32**	**12**	**8**	**33**	**16**	**17**	**18**	**11**	**15**	**17**	**36**	**28**	**243**
Species Richness	**5**	**3**	**4**	**4**	**4**	**2**	**5**	**1**	**3**	**2**	**2**	**3**	**11**
Species Diversity	**5.23**	**2.83**	**5.76**	**3.20**	**2.70**	**1.38**	**5.60**	**0**	**2.48**	**1.38**	**1.20**	**2.43**	**4.11**

[a] Detailed location information on each numbered research site is provided in Appendix I
[b] Sampling at this research site was completed in summer 2004
[c] Sampling at this research site was completed in summer 2005
[d] Sampling at this research site was completed in summer 2006

Table 3b. Summary of the numbers of different small mammals captured in the Southeast region of the study area (see text for details) in southwestern North Dakota, for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

	Research Site Number[a]														
Species	**17[d]**	**18[c]**	**19[c]**	**42[c]**	**43[d]**	**44[d]**	**45[c]**	**46[d]**	**47[d]**	**48[c]**	**49[c]**	**51[c]**	**52[c]**	**53[c]**	**Totals**
Blarina brevicauda										4					**4**
Chaettodipus hispidus		1		11	2	15	1		2	4				9	**45**
Microtus pennsylvanicus		7	1	1						4	6	2		6	**27**
Onychomys leucogaster	2	5	8	9	2	6		3						5	**40**
Perognathus fasciatus		2		2			1			9				7	**21**
Peromyscus maniculatus	6	21	17	53	64	20	6	26	38	24	38	12	12	20	**357**
Reithrodontomys megalotis										1					**1**
Sorex haydeni			1					1		6	7		4		**19**
Spermophilus tridecemlineatus								3	1	2	2				**8**
Thomomys talpoides										1					**1**
Total Captures	**8**	**36**	**27**	**76**	**68**	**41**	**8**	**33**	**41**	**55**	**53**	**14**	**16**	**47**	**523**
Species Richness	**2**	**5**	**4**	**5**	**3**	**3**	**3**	**4**	**3**	**9**	**4**	**2**	**2**	**5**	**10**
Species Diversity	**2.25**	**5.39**	**3.64**	**3.86**	**1.47**	**4.23**	**2.89**	**2.87**	**1.56**	**12.27**	**3.54**	**1.81**	**2.25**	**8.27**	**5.61**

[a] Detailed location information on each numbered research site is provided in Appendix I
[b] Sampling at this research site was completed in summer 2004
[c] Sampling at this research site was completed in summer 2005
[d] Sampling at this research site was completed in summer 2006

Table 3c. Summary of the numbers of different small mammals captured in the West region of the study area (see text for details) in southwestern North Dakota, for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

	Research Site Number[a]														
Species	**2[c]**	**3[b]**	**4[c]**	**5[c]**	**14[b]**	**15[b]**	**16[b]**	**57[c]**	**58[c]**	**59[c]**	**60[b]**	**61[b]**	**66[b]**	**67[b]**	**Totals**
Blarina brevicauda								1							**1**
Cynomys ludovicianus												1			**1**
Microtus ochrogaster		5				1									**6**
Microtus pennsylvanicus		7	15	7	12			1	10	7	5	1		15	**80**
Neotoma cinerea	1				1								4		**6**
Perognathus fasciatus	1		1			9				6	1				**18**
Peromyscus leucopus	3														**3**
Peromyscus maniculatus	26	9	66	5	9	23		58	8	54	23	24	12	8	**325**
Reithrodontomys megalotis	1			3				1							**5**
Sorex haydeni	1		2	2				4	5	3	1			1	**19**
Spermophilus tridecemlineatus							5		1		4	1			**11**
Sylvilagus audobonii					1						1				**2**
Sylvilagus floridanus		1													**1**
Tamias minimus			3			1				2			1		**7**
Zapus hudsonius			4												**4**
Total Captures	**33**	**22**	**91**	**17**	**23**	**34**	**5**	**65**	**24**	**72**	**35**	**27**	**17**	**24**	**489**
Species Richness	**6**	**4**	**6**	**4**	**4**	**4**	**1**	**5**	**4**	**5**	**6**	**4**	**3**	**3**	**15**
Species Diversity	**3.31**	**5.71**	**3.74**	**6.37**	**4.11**	**3.28**	**0**	**1.96**	**5.57**	**3.57**	**4.93**	**1.97**	**2.96**	**3.14**	**6.05**

[a] Detailed location information on each numbered research site is provided in Appendix I
[b] Sampling at this research site was completed in summer 2004
[c] Sampling at this research site was completed in summer 2005
[d] Sampling at this research site was completed in summer 2006

Table 3d. Summary of the numbers of different small mammals captured in the Northwest region of the study area (see text for details) in southwestern North Dakota, for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

	Research Site Number[a]															
Species	**10[d]**	**11[c]**	**12[c]**	**13[c]**	**22[d]**	**23[c]**	**24[d]**	**25[b]**	**26[b]**	**27[d]**	**28[b]**	**29[d]**	**63[b]**	**64[b]**	**65[b]**	**Totals**
Cynomys ludovicianus				1												**1**
Microtus ochrogaster	1															**1**
Microtus pennsylvanicus		3	4	4	7	3		3							2	**26**
Mus musculus		1														**1**
Onychomys leucogaster	1	1				1	2			1					1	**7**
Perognathus fasciatus	5		1	1	5		7	4	2				2			**27**
Peromyscus maniculatus	5	19	30	10	15	15	4	17	2	25	13	41	2	7	22	**227**
Reithrodontomys megalotis			1					1								**2**
Sorex haydeni	1				11		2			5		1			1	**21**
Spermophilus tridecemlineatus	1				3			1	1					1		**7**
Sylvilagus floridanus		1														**1**
Tamias minimus												1				**1**
Thomomys talpoides	2															**2**
Zapus hudsonius					1											**1**
Total Captures	**16**	**25**	**36**	**26**	**42**	**19**	**15**	**26**	**5**	**31**	**13**	**43**	**4**	**8**	**26**	**325**
Species Richness	**7**	**5**	**4**	**4**	**6**	**3**	**4**	**5**	**3**	**3**	**1**	**3**	**2**	**2**	**4**	**14**
Species Diversity	**11.29**	**3.40**	**2.36**	**4.15**	**9.33**	**2.49**	**6.03**	**4.65**	**4.58**	**2.31**	**0**	**1.37**	**2.72**	**1.72**	**2.34**	**5.42**

[a] Detailed location information on each numbered research site is provided in Appendix I
[b] Sampling at this research site was completed in summer 2004
[c] Sampling at this research site was completed in summer 2005
[d] Sampling at this research site was completed in summer 2006

Table 3e. Summary of the numbers of different small mammals captured in the Northeast region of the study area (see text for details) in southwestern North Dakota, for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

	Research Site Number[a]												
Species	**30[d]**	**31[d]**	**32[d]**	**33[d]**	**34[d]**	**35[d]**	**37[d]**	**38[d]**	**39[c]**	**40[c]**	**41[d]**	**50[d]**	**Totals**
Blarina brevicauda								1					**1**
Microtus pennsylvanicus	3	6			5		1	13	18			3	**49**
Onychomys leucogaster			3			1	1						**5**
Perognathus fasciatus		1		1				2	3	1		1	**9**
Peromyscus maniculatus	7	25	40	19	8	25	18	11	52	12	14	4	**235**
Reithrodontomys megalotis	6							2					**8**
Sorex haydeni		6	4	3		1	1	1			5	1	**22**
Spermophilus tridecemlineatus		2			6	5		3	6	2	1	9	**34**
Sylvilagus audobonii								1					**1**
Tamias minimus									1				**1**
Thomomys talpoides					2			1	1		2		**6**
Zapus priniceps		1			1	2							**4**
Total Captures	**16**	**41**	**47**	**23**	**22**	**34**	**21**	**35**	**81**	**15**	**22**	**18**	**375**
Species Richness	**3**	**6**	**3**	**3**	**5**	**5**	**4**	**9**	**6**	**3**	**4**	**5**	**12**
Species Diversity	**4.50**	**5.59**	**2.13**	**2.24**	**7.73**	**3.57**	**2.27**	**11.21**	**4.50**	**2.48**	**4.13**	**6.53**	**6.86**

[a] Detailed location information on each numbered research site is provided in Appendix I
[b] Sampling at this research site was completed in summer 2004
[c] Sampling at this research site was completed in summer 2005
[d] Sampling at this research site was completed in summer 2006

Table 4a. Summary of the numbers of different reptiles and amphibians captured at multiple research sites (see text for details) in southwest North Dakota during the summer of 2005. Data are from a combination of pitfall trap arrays, night driving surveys, randomized walks and coverboard transects.

	Research Site Number[a]													
Species	**2[d]**	**4[d]**	**5[d]**	**9[b]**	**11[e]**	**12[e]**	**13[e]**	**18[c]**	**19[c]**	**21[b]**	**23[e]**	**39[f]**	**40[f]**	**Totals**
Ambystoma tigrinum								4						**4**
Bufo cognatus						10	1				1	2		**14**
Bufo woodhouseii	1												6	**7**
Crotalus viridis											1			**1**
Heterodon nasicus									1					**1**
Pseudacris triseriata													9	**9**
Rana pipiens	1			1				1					5	**8**
Scaphiopus bombifrons						1			1		1		3	**6**
Sceloporous graciosus	3													**3**
Total captures	**5**	**0**	**0**	**1**	**0**	**11**	**1**	**5**	**2**	**0**	**3**	**2**	**23**	**53**
Species richness	**3**	**0**	**0**	**1**	**0**	**2**	**1**	**2**	**2**	**0**	**3**	**2**	**4**	**9**
Species Diversity	**3.94**	**0**	**0**	**0**	**0**	**1.55**	**0**	**2.06**	**0**	**0**	**0**	**0**	**6.67**	**16.90**

[a] detailed location information on each numbered research site is provided in Appendix I
[b] site is within the Southwest region of southwestern North Dakota
[c] site is within the Southeast region of southwestern North Dakota
[d] site is within the West region of southwestern North Dakota
[e] site is within the Northwest region of southwestern North Dakota
[f] site is within the Northeast region of southwestern North Dakota

Table 4b. Summary of the numbers of different reptiles and amphibians captured at multiple research sites (see text for details) in southwest North Dakota during the summer of 2005. Data are from a combination of pitfall trap arrays, night driving surveys, randomized walks and coverboard transects.

	Research Site Number[a]												
Species	**42**[c]	**45**[c]	**48**[c]	**49**[c]	**51**[c]	**52**[c]	**53**[c]	**54**[b]	**55**[b]	**56**[b]	**58**[b]	**59**[b]	**Totals**
Bufo cognatus	1	1				2	1						**5**
Bufo woodhouseii	1	1					69						**71**
Crotalus viridis							1						**1**
Opheodrys vernalis			1										**1**
Pseudacris triseriata					8	19							**27**
Rana pipiens			3	1			1				1		**6**
Scaphiopus bombifrons							1						**1**
Total captures	**2**	**2**	**4**	**1**	**8**	**21**	**73**	**0**	**0**	**0**	**1**	**0**	**112**
Species richness	**2**	**2**	**2**	**1**	**1**	**2**	**5**	**0**	**0**	**0**	**1**	**0**	**7**
Species Diversity	**0**	**0**	**2.25**	**0**	**0**	**1.58**	**1.52**	**0**	**0**	**0**	**0**	**0**	**4.57**

[a] detailed location information on each numbered research site is provided in Appendix I
[b] site is within the Southwest region of southwestern North Dakota
[c] site is within the Southeast region of southwestern North Dakota
[d] site is within the West region of southwestern North Dakota
[e] site is within the Northwest region of southwestern North Dakota
[f] site is within the Northeast region of southwestern North Dakota

Table 4c. Summary of the numbers of different reptiles and amphibians captured at multiple research sites (see text for details) in southwest North Dakota during the summer of 2006. Data are from a combination of pitfall trap arrays, night driving surveys, randomized walks and coverboard transects.

	Research Site Number[a]													
Species	**1**[b]	**6**[b]	**7**[b]	**8**[b]	**10**[e]	**17**[c]	**20**[b]	**22**[e]	**24**[e]	**27**[e]	**29**[e]	**30**[f]	**31**[f]	**Totals**
Ambystoma tigrinum	3					2			4					**9**
Bufo cognatus			1					3	2					**6**
Pseudacris triseriata				1										**1**
Rana pipiens	1							1						**2**
Total captures	**4**	**0**	**1**	**1**	**0**	**2**	**0**	**4**	**6**	**0**	**0**	**0**	**0**	**18**
Species richness	**2**	**0**	**1**	**1**	**0**	**1**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**4**
Species Diversity	**2.25**	**0**	**0**	**0**	**0**	**0**	**0**	**2.25**	**2.50**	**0**	**0**	**0**	**0**	**5.01**

[a] detailed location information on each numbered research site is provided in Appendix I
[b] site is within the Southwest region of southwestern North Dakota
[c] site is within the Southeast region of southwestern North Dakota
[d] site is within the West region of southwestern North Dakota
[e] site is within the Northwest region of southwestern North Dakota
[f] site is within the Northeast region of southwestern North Dakota

Table 4d. Summary of the numbers of different reptiles and amphibians captured at multiple research sites (see text for details) in southwest North Dakota during the summer of 2006. Data are from a combination of pitfall trap arrays, night driving surveys, randomized walks and coverboard transects.

	Research Site Number[a]													
Species	**32**[f]	**33**[f]	**34**[f]	**35**[f]	**37**[f]	**38**[f]	**41**[f]	**43**[c]	**44**[c]	**46**[c]	**47**[c]	**50**[f]	**57**[d]	**Totals**
Ambystoma tigrinum			1					1			1		3	**6**
Bufo cognatus									3					**3**
Rana pipiens			5											**5**
Thamnopis sirtalis			1											**1**
Total captures	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**1**	**3**	**0**	**1**	**0**	**3**	**15**
Species richness	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**1**	**0**	**1**	**4**
Species Diversity	**0**	**0**	**3.16**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5.94**

[a] detailed location information on each numbered research site is provided in Appendix I
[b] site is within the Southwest region of southwestern North Dakota
[c] site is within the Southeast region of southwestern North Dakota
[d] site is within the West region of southwestern North Dakota
[e] site is within the Northwest region of southwestern North Dakota
[f] site is within the Northeast region of southwestern North Dakota

Table 5. Summary of the numbers of different small mammals captured in each of five regions (Southwest, Southeast, West, Northwest, and Northeast) of the southwestern North Dakota study area for all years of the sampling effort. Data are from a combination of linear small mammal live trap grids, pitfall trap arrays and snap trap transects.

Species	SW	SE	W	NW	NE	Totals
Blarina brevicauda	3	4	1		1	**9**
Chaettodipus hispidus	8	45				**53**
Cynomys ludovicianus			1	1		**2**
Lemmiscus curtatus	1					**1**
Microtus ochrogaster			6	1		**7**
Microtus pennsylvanicus	8	27	80	26	49	**190**
Mus musculus				1		**1**
Neotoma cinerea			6			**6**
Onychomys leucogaster	12	40		7	5	**64**
Perognathus fasciatus	4	21	18	27	9	**79**
Peromyscus leucopus			3			**3**
Peromyscus maniculatus	190	357	325	227	235	**1334**
Reithrodontomys megalotis	4	1	5	2	8	**20**
Sorex haydeni	4	19	19	21	22	**85**
Spermophilus tridecemlineatus	8	8	11	7	34	**68**
Sylvilagus audobonii			2		1	**3**
Sylvilagus floridanus	1		1	1		**3**
Tamias minimus			7	1	1	**9**
Thomomys talpoides		1		2	6	**9**
Zapus hudsonius			4	1		**5**
Zapus priniceps					4	**4**
Total captures	**243**	**523**	**489**	**325**	**375**	**1955**
Species richness	**11**	**10**	**15**	**14**	**12**	**21**
Species diversity	**4.11**	**5.61**	**6.05**	**5.42**	**6.86**	**7.70**

Table 6. Summary of the numbers of different small mammals captured in each of five regions (Southwest, Southeast, West, Northwest, and Northeast) of the southwestern North Dakota study area during summers of 2005 and 2006. Data are from a combination of pitfall trap arrays, night driving surveys, randomized walks and coverboard transects.

Species	SW	SE	W	NW	NE	Totals
Ambystoma tigrinum	3	8	3	4	1	**19**
Bufo cognatus	1	8		17	2	**28**
Bufo woodhouseii		71	1		6	**78**
Crotalus viridis		1		1		**2**
Heterodon nasicus		1				**1**
Opheodrys vernalis		1				**1**
Pseudacris triseriata		28			9	**37**
Rana pipiens	3	6	1	1	10	**21**
Scaphiopus bombifrons		2		2	3	**7**
Sceloporous graciosus			3			**3**
Total captures	**7**	**126**	**8**	**25**	**31**	**197**
Species richness	**3**	**9**	**4**	**5**	**6**	**10**
Species diversity	**4.26**	**6.85**	**6.12**	**4.32**	**9.43**	**11.71**

DISCUSSION

One of the hypotheses we are assessing in this study is that small mammal community dynamics may be changing due to the impacts of habitat fragmentation and climate change. We do not yet know if there have been changes in small mammal communities in western North Dakota between the mid 1970s and the present. However, data from the summers of 2004 through 2006 indicate some potential range shifts for several species of concern. Recently, the North Dakota Game Fish Department has compiled a "List of Conservation Priority" (Dyke et al. 2004). Three of the terrestrial small mammals on the priority list occur in southwestern North Dakota, including the black-tailed prairie dog (*Cynomys ludovicianus*), the hispid pocket mouse (*Chaettodipus hispidus*) and the sagebrush vole (*lemmiscus curtatus*). Black-tailed prairie dogs were observed across the study area, but were rarely captured (when randomly placed transects crossed portions of prairie dog towns). The sagebrush vole is also a species of conservation priority and the animal appears very rare across the southwestern North Dakota region (Table 3a). Although we captured only a single sagebrush vole in summer 2004, the overall geographic range of the species is centered to the west of North Dakota and we did not anticipate high numbers of captures of this species. The hispid pocket mouse is one species of conservation priority that may be exhibiting some potential range expansion. Comparisons between captures from the 1977 REAP study and data from the current study shows captures of hispid pocket mice in areas north, and west of the previously known historical range.

Several amphibian and reptile species of conservation priority are also found in southwestern North Dakota. The western hognose snake and the smooth green snake are two species that were rarely captured in the study area. Although we anticipated capturing more of these animals, each species was caught only once over the past two years. Three sagebrush lizards (*Sceloperous graciosus*) were captured in 2005, even though sightings were fairly common when in appropriate habitats. The plains spadefoot toad (*Scaphiopus bombifrons*) is another amphibian of conservation concern in North Dakota. Notably, we had captured 7 spadefoot toads after the completion of the sampling effort; captures were well distributed across southwestern North Dakota suggesting the organism remains widespread in this region of our state, with respect to distribution. Terrestrial vertebrate community dynamics will continue to be evaluated as data are analyzed.

PRELIMINARY MANAGEMENT IMPLICATIONS

Data from our ongoing study provide potential indications of changes in terrestrial vertebrate community dynamics. Of the species outlined in the state list of species of conservation priority that inhabit southwestern North Dakota, most appear to be less abundant today than suggestible historical data from the original REAP report. Because terrestrial vertebrates are so closely tied to habitat, management of the species of conservation priority should focus on maintaining habitat. The large tracts of land in southwestern North Dakota provide numerous habitat types, which in turn leads to greater overall richness and diversity. To the extent possible, active management should avoid reducing or altering the landscape in southwest North Dakota. However, this may become more difficult in the future as populations continue to grow and nonrenewable natural resources, such as, oil, natural gas, and coal continue to be exploited in these natural areas.

APPENDIX I

ID Tag	Location (UTM)	County	Region	Sampling Period
1	13 730281 5102900	Adams	SW	2006
2	13 610303 5222764	Billings	W	2005
3	13 611130 5200444	Billings	W	2004
4	13 612247 5179157	Billings	W	2005
5	13 629212 5169157	Billings	W	2005
6	13 651062 5116767	Bowman	SW	2006
7	13 644063 5107757	Bowman	SW	2006
8	13 625003 5097668	Bowman	SW	2006
9	13 601583 5103682	Bowman	SW	2005
10	13 682839 5234907	Dunn	NW	2006
11	13 656668 5254691	Dunn	NW	2005
12	13 657879 5262709	Dunn	NW	2005
13	13 669081 5270256	Dunn	NW	2005
14	13 603112 5183067	Golden Valley	W	2004
15	13 596950 5210256	Golden Valley	W	2004
16	13 575873 5210796	Golden Valley	W	2004
17	14 303617 5105174	Grant	E	2006
18	14 291274 5133670	Grant	E	2005
19	14 312636 5125685	Grant	E	2005
20	13 714575 5157121	Hettinger	SW	2006
21	13 683993 5161685	Hettinger	SW	2005
22	13 672462 5284592	McKenzie	NW	2006
23	13 659883 5282882	McKenzie	NW	2005
24	13 633259 5323347	McKenzie	NW	2006
25	13 642210 5331123	McKenzie	NW	2004
26	13 590505 5290545	McKenzie	NW	2004
27	13 592949 5286885	McKenzie	NW	2006
28	13 595308 5277264	McKenzie	NW	2004
29	13 627796 5249026	McKenzie	NW	2006
30	14 300786 5270120	McLean	E	2006
31	14 327432 5278423	McLean	E	2006
32	14 347315 5272216	McLean	E	2006
33	14 351071 5260828	McLean	E	2006
34	14 356039 5235248	McLean	E	2006
35	14 355223 5325275	McLean	E	2006
36	14 342631 5243290	McLean	E	NA*
37	14 345033 5243162	McLean	E	2006
38	14 302169 5264640	McLean	E	2006
39	13 723352 5226888	Mercer	E	2005
40	14 279961 5326495	Mercer	E	2005
41	14 285040 5221021	Mercer	E	2006
42	14 328975 5160437	Morton	E	2005
43	14 303108 5182988	Morton	E	2006
44	14 344261 5130463	Morton	E	2006
45	14 339044 5174783	Morton	E	2005
46	14 314339 5181056	Morton	E	2006
47	14 295910 5183286	Morton	E	2006
48	14 288505 5195638	Morton	E	2005
49	14 289585 5203650	Morton	E	2005
50	14 333205 5221107	Oliver	E	2006
51	14 351084 5097244	Sioux	E	2005
52	14 351111 5098852	Sioux	E	2005
53	14 349256 5118161	Sioux	E	2005

ID Tag	Location (UTM)	County	Region	Sampling Period
54	13 618560 5161383	Slope	SW	2005
55	13 615382 5160478	Slope	SW	2005
56	13 605305 5142573	Slope	SW	2005
57	13 654205 5170449	Stark	SW	2005
58	13 693162 5180465	Stark	SW	2005
59	13 705251 5181261	Stark	SW	2005
60	13 630728 5241507	Billings	W	2004
61	13 628080 5188882	Billings	W	2004
62	13 587973 5132420	Slope	SW	2004
63	13 642778 5326687	McKenzie	NW	2004
64	13 584746 5290550	McKenzie	NW	2004
65	13 598523 5270866	McKenzie	NW	2004
66	13 616330 5241275	Billings	W	2004
67	13 618334 5185483	Billings	W	2004
68	13 590146 5134835	Slope	SW	2004

* Denied access to site

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