Small Mammal Component Report

Canadian Forces Base Suffield National Wildlife Area

Wildlife Inventory

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

SMALL MAMMAL COMPONENT REPORT

CANADIAN FORCES BASE SUFFIELD NATIONAL WILDLIFE AREA

WILDLIFE INVENTORY

Canadian Wildlife Service
Environment Canada
Prairie and Northern Region
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ABSTRACT

Small mammals contribute to the diversity of mixedgrass prairie and are important prey for terrestrial and avian predators. Also, small mammals can directly or indirectly influence the availability of resources for other species by modifying habitat conditions. The main objective of this project was to determine the occurrence, distribution, and abundance of small mammals as part of the wildlife inventory of the proposed Canadian Forces Base (CFB) Suffield National Wildlife Area (SNWA) from June 1994 to September 1996. The SNWA is a large (459 km^2) contiguous block of native prairie grassland within the much larger military training base of CFB Suffield (2,690 km^2). The SNWA is possibly the finest example of mixedgrass prairie, sand dune, and riverbreak/ravine complexes in Canada. This wildlife area is important as a refuge for the preservation and long-term survival of many grassland-endemic species. The need to ensure permanent protection of this significant prairie ecosystem is of paramount importance.

Snap trapping, the standard for cost-effective small mammal bioinventories, was used for the main survey while incidental observations accounted for species not trapped. A trapline grid was established which consisted of 36 snap traps set for 3 consecutive nights, yielding a total of 108 trap nights per sample plot. Snap trap data were used to map species distributions for prairie shrews (*Sorex haydeni*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), olive-backed pocket mice (*Perognathus fasciatus*), Ord's kangaroo rats (*Dipodomys ordii*), western harvest mice (*Reithrodontomys megalotis*), deer mice (*Peromyscus maniculatus*), northern grasshopper mice (*Onychomys leucogaster*), meadow voles (*Microtus pennsylvanicus*), sagebrush voles (*Lagurus curtatus*), and house mice (*Mus musculus*). Only incidental observations were used to map species distributions for Nuttall's cottontails (*Sylvilagus nuttallii*), white-tailed jack rabbits (*Lepus townsendii*), Richardson's ground squirrels (*Spermophilus richardsonii*), beavers (*Castor canadensis*), muskrats (*Ondatra zibethicus*), and porcupines (*Erethizon dorsatum*), the 6 species that were not snap-trapped. Northern pocket gophers (*Thomomys talpoides*) were surveyed by counting mounds in a 400 m^2 area of coverage at each plot. In addition to incidental observations, pellet transect counts were used to inventory the 2 species of lagomorphs (hares and rabbits), Nuttall's cottontails and white-tailed jack rabbits, for relative abundance and distribution.

A classification system describing 3 vegetation zones and 5 topographic habitats was created to compare small mammal catch results. The mean catch effort (CE) values for each small mammal species were calculated, graphed, tabulated, and compared among vegetation zones and topographic habitats. Catch effort is a calculated expression of the number of small mammals caught relative to the trapping effort which measures trap success based on 100 trap nights of effort.

Snap traps were used to sample 384 plots of the total of 836 identified on 55 transect lines in 1994 and 1995. The overall trapping coverage was 45.9% of the established sites and represented 72 ecosites of the total of 103 identified. Seven additional plots in 1994, 3 duplicate plots in 1995, and 48 repeat plots in 1996 were sampled using snap traps for a total of 442. This yielded 19,324 trap nights in 1994, 23,208 trap nights in 1995, and 6,046 trap nights in 1996 for a 3-year total of 48,578 trap nights of effort. In the SNWA, 12 species of small mammals were

snap-trapped, 6 species of bats were trapped using mist nets, and 6 additional species were observed but not caught. This resulted in a total of 24 different species of small mammals in 4 orders and 10 families. The largest group was rodents, with 7 families and 15 species represented.

In 1994, 1,374 small mammals of 10 different species were snap-trapped. Species composition of the catch ranged from a high of 81.6% deer mice to a low of 0.1% sagebrush voles. In 1995, 450 small mammals of 10 species were snap-trapped. The species composition ranged from a high of 83.1% deer mice to a low of 0.2% for both northern grasshopper mice and house mice. The mean CE for total species in 1994 was 7.94 while the mean CE in 1995 was 2.21. This represented an overall decrease of 72.2% or about a 3.5 fold decrease between years. Based on the results of 48 plots and 8 replications, the mean CE for total species was 4.26 in 1996. This showed nearly a two-fold increase from 1995 and a value that was slightly more than half the 1994 mean.

Deer mice exceeded 81% of the total catch in all 3 years. Western harvest mice were the second highest species group caught by snap trapping during the study. Meadow voles were third, thirteen-lined ground squirrels were fourth, prairie shrews were fifth, and Ord's kangaroo rats were sixth. The olive-backed pocket mouse and the northern grasshopper mouse were tied for seventh followed by the sagebrush vole which had only 3 individuals caught, and the house mouse, which had only 1 caught.

Of the 6 species of bats caught, the western small-footed bat (*Myotis ciliolabrum*) comprised 50% of the catch at 43 captures while the long-eared bat (*Myotis evotis*) was second at 28 captures for 33% of the catch. The big brown bat (*Eptesicus fuscus*) had 6 captures for 7% of the catch, while the little brown bat (*Myotis lucifugus*) and the hoary bat (*Lasiurus cinereus*) each had 4 captures which together represented 9% of the catch, and the long-legged bat (*Myotis volans*) had the least number of captures at 1, for 1% of the catch.

In section 4.0 DISCUSSION, we presented information on the distribution of small mammals in the SNWA relative to known habitat requirements and identified areas that are likely important to those species for their continued survival in the SNWA. Mammal guidebook-type descriptions on general biological information for each species of small mammal trapped and observed in the SNWA are included in Appendix 6.

The SNWA is the largest area of relatively undisturbed mixedgrass prairie remaining in Canada. The importance of the SNWA as a significant refuge for the long-term protection and conservation of several grassland-endemic species of small mammals in the prairie ecosystem has been identified. This area supports a wide spectrum of native prairie flora and fauna which exhibits a high species diversity and richness, possesses a high degree of prairie endemism, and contributes substantially to global biological diversity. In the SNWA, the Ord's kangaroo rat and the olive-backed pocket mouse are at the northern limit of their North American ranges, and as established disjunct populations they have diverged substantially from their southern relatives. The SNWA represents one-third of the Canadian range for Ord's kangaroo rats thereby constituting the most important area for their conservation in Canada. This study also confirmed that the SNWA supports a significantly large population of the western harvest mouse, a rare Canadian species, and it is the northern range limit for this species. The SNWA is also a significant refuge for a few uncommon Canadian prairie small mammal species that occur in low numbers across prairie Canada such as, the olive-backed pocket mouse, the northern grasshopper mouse, and the sagebrush vole. In addition, the SNWA provides refuge to 4 prairie species which are of limited distribution and are possibly declining elsewhere; namely, the prairie shrew, Nuttall's cottontail, Richardson's ground squirrel, and the thirteen-lined ground squirrel. Furthermore, the ravines topographic habitat is important to 2 species of bats, the western small-footed bat and the long-eared bat which are relatively uncommon throughout Alberta, but comprised 83% of the bat fauna in the SNWA. Protection of ravine habitat is essential to maintain roosting sites to ensure survival of 5 species of colonial bats that use this prairie ecosystem.

The following management and research recommendations are presented: continue monitoring surveys of Ord's kangaroo rats, western harvest mice, northern grasshopper mice, and sagebrush voles to determine if there is concern for their long-term survival in relation to current grazing and fire policies; continue monitoring surveys of Ord's kangaroo rats to determine ecological factors that influence habitat by comparing abundance, distribution, and survival in anthropogenic habitats and in native sand dune habitats, and evaluate this in the context of sand dune stabilization and survival of kangaroo rats in human-modified habitats; conduct general ecological studies on the little-known western bat populations and determine the importance of ravine habitat as foraging areas for bats in the SNWA; take advantage of opportunities to learn more about habitat relationships of western bat species especially those dependent on river break complexes in the prairie ecosystem; initiate paleoecological research to identify the ecological disturbance factors that have affected this grassland ecosystem; and install a GPS benchmark base station to provide differential correction of GPS locations in future biological studies.

1.0 INTRODUCTION

1.1 Background

The Canadian Forces Base (CFB) Suffield, a 2,690 km^2 area in the semi-arid grassland ecoregion of southeast Alberta, is one of the largest military training bases in the western world, larger than Luxembourg, or two-thirds the size of the province of Prince Edward Island. The entire CFB Suffield is essentially a wildlife sanctuary since public access and hunting are not permitted. In 1971, the Department of National Defence (DND), with the assistance and advice of the Canadian Wildlife Service (CWS), recognized the eastern side of CFB Suffield as an environmentally sensitive area and had the foresight and fortitude to designate it as out of bounds to military training. This action eventually led to the 11 March 1992 signing of a Memorandum of Understanding by DND and the Department of Environment (DOE) to designate this 459 km^2 area of CFB Suffield as a National Wildlife Area. The CWS of the DOE conducted surveys of the proposed CFB Suffield National Wildlife Area (SNWA) from June 1994 to September 1996 to identify and quantify the occurrence of wildlife species in this area. These interdisciplinary surveys included the collection and interpretation of wildlife and vegetation data describing the biotic and abiotic components of the SNWA landscape.

Usher and Strong (1994) developed a preliminary ecological land classification (ELC) system for the SNWA. The ecosite, the fundamental unit of the ELC, contains a unique combination of vegetation, landforms, soils, and location. The ecosites were mapped at 1:15,000 scale and were used to provide a land classification for the SNWA. The ELC identified 103 ecosites, based on 1 ecoregion, 5 ecodistricts, and 13 ecosections in a four-level hierarchical land classification system (Appendix 1). In addition to being used to produce 12 map sheets of full land classification coverage of the SNWA, the data were provided in digital format using geographic information system (GIS) software (ATLAS GIS, version 3.0, Strategic Mapping Inc., Santa Clara, California). These data were then used as a template for the general wildlife inventory studies that followed (Environment Canada 1994). Additional information on the ELC is available in Adams *et al.* (1997). Data collected in the SNWA for the vegetation, birds, raptors, large mammals, small mammals, amphibians and reptiles, and wetlands components of the ecological inventory will be used to develop a management plan for the SNWA.

Interactions among small mammals and other organisms as well as their physical environment and the role that small mammals play in prairie ecosystems are not well understood (Kaufman and Kaufman 1997). However, small mammals can directly or indirectly influence the availability of resources for other species through their modification, maintenance, and creation of particular habitat conditions (Kaufman and Kaufman 1997). Furthermore, small mammals contribute to the diversity of the mixedgrass prairie: they are important prey for terrestrial and avian predators and are objects of competition among those predators. These roles are often accentuated during periods of high densities.

Through their interrelationships with other organisms and the environment, small mammals affect the rate of transfer of nutrients and energy in the ecosystem. They do this by interacting with soils and vegetation structure and composition in the following ways by: grazing the foliage of grasses and forbs (grazers), consuming seeds of grasses and forbs (seed predators), dispersing seeds from prairie plants for germination (dispersers), disturbing soil surfaces through burrowing and dust bathing (disturbance agents), and providing subterranean habitats for other organisms (Kaufman and Kaufman 1997).

CFB Suffield is one of the few large blocks of unploughed prairie remaining in western Canada. The significance of the need to protect such large blocks of native prairie grasslands and their flora and wildlife from the harmful effects of human activity has been recognized by conservationists and government (World Wildlife Fund Canada 1989). The SNWA, which has been designated as ecologically sensitive since 1971, is now destined to become the second largest National Wildlife Area in Canada. This large contiguous block of native grassland, an area the size of Grasslands National Park in southern Saskatchewan, is possibly the finest example of mixedgrass prairie, sand dune, and riverbreak/ravine complexes in Canada (Cottonwood Consultants Ltd. 1987). The potential of global climate change and the continued modification and destruction of native prairie grasslands by humans, especially through landscape fragmentation, make it imperative that ecologists and conservationists continue to study and develop management strategies for the preservation of small mammals in prairie ecosystems (Kaufman and Kaufman 1997). The need to ensure continued protection of this significant prairie ecosystem, preferably on a permanent basis, is of paramount importance.

1.2 Objectives

The main objective of this project was to determine the occurrence, distribution, and abundance of small mammals as part of the wildlife inventory of the SNWA. A secondary objective was to establish a database of small mammal occurrence, distribution, and abundance in the SNWA that contributes to the entire ecological database for the area and can be used to develop a management plan for the SNWA. This report documents the results of the small mammal inventory surveys conducted during the summers of 1994, 1995, and 1996.

2.0 METHODS

2.1 Study Area

CFB Suffield is located in southeastern Alberta, north of Medicine Hat. The SNWA lies along the eastern side of the military base and consists of 2 units (Figure 1), the North Block and the South Block. This large block of essentially untilled prairie grassland is part of the Dry Mixedgrass Ecoregion (Appendix 1) of the Brown Chernozemic soil zone, as identified by Strong and Leggat (1992). This climatic zone has the lowest summer precipitation (median 156 mm) of any Alberta ecoregion and is one of the most arid areas in the prairie provinces. The landscape of the SNWA is dominated by 3 broad physiographic units: the Eastern Alberta Uplands, the Eastern Alberta Plain, and the South Saskatchewan River Valley (Pettapiece 1986; Strong 1992).

The Eastern Alberta Uplands is the second most common landscape in southern Alberta, with

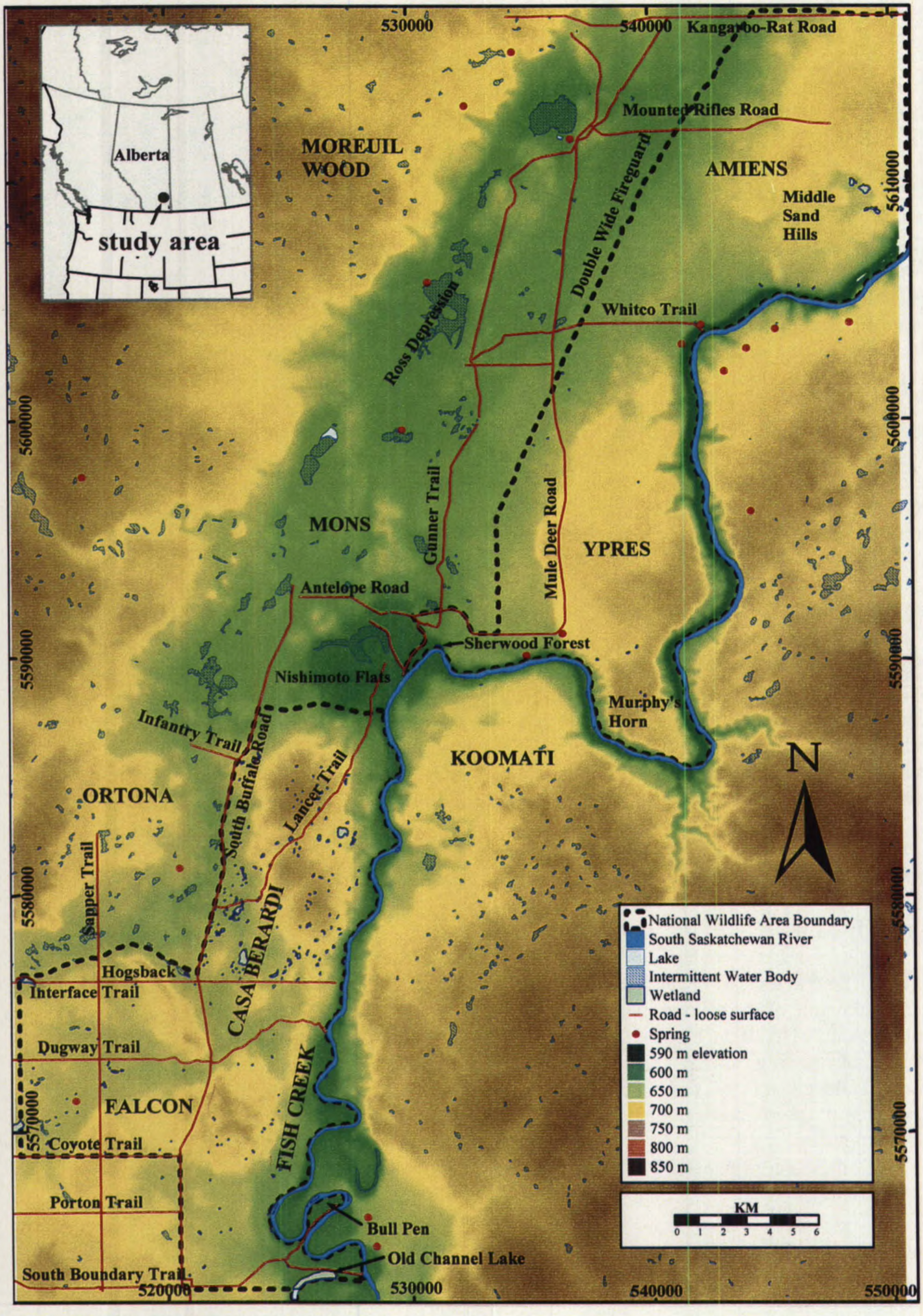

Figure 1. CFB Suffield National Wildlife Area.

hummocky-to-rolling relief of up to 30 m. Included in this physiographic unit within the SNWA are the Middle Sand Hills, a complex of stabilized, partially stabilized, and active sand dunes located in the North Block of the study area (Figure 1). Although these sand dune complexes support shrub and some tree communities, they are highly susceptible to surface disturbances such as fire, grazing, and trampling, owing to the surface aridity, steep slopes, and loose, sandy soil.

The Eastern Alberta Plain has generally level-to-undulating topography and occurs only in the southern 20% of the study area (Adams *et al.* 1997). Included in this physiographic unit, are the rolling hills and undulating plains of the mixedgrass prairie portion of the SNWA. The majority of the South Block of the SNWA is a fenced community pasture for livestock grazing, which is permitted through an agreement signed in 1976 between Agriculture Canada, the Prairie Farm Rehabilitation Administration, and DND.

The South Saskatchewan River Valley (the River Bank complex) of the SNWA consists of precipitous and poorly vegetated valley walls and rugged topography that form open or wooded draws which support riparian plant communities. Wooded and herbaceous riparian communities also occupy the flood plain of the South Saskatchewan River. Relief within this River Bank complex varies from the level of the river to about 150 m elevation (Figure 1).

The zonal soils of the Dry Mixedgrass Ecoregion are moderately to well drained Brown Chernozems that typically develop in semi-arid steppe environments. The zonal and climatic vegetation of this ecoregion that has reached dynamic heterogeneity is a steppe grassland (Coupland 1961), dominated by needle-and-thread (*Stipa comata*) and blue gramma (*Bouteloua gracilis*). The major herbaceous plant species associated with these grasslands are northern and western wheat grass (*Agropyron dasystachyum* and *A. smithii*), June grass (*Koeleria macrantha*), prairie selaginella (*Selaginella densa*), pasture sagewort (*Artemisia frigida*), moss phlox (*Phlox hoodii*), and thread-leaved sedge (*Carex filifolia*) (Coupland 1961).

The flora of the SNWA was classified into 28 vegetation cover types (Adams *et al.* 1997). The North Block has a significantly more woody vegetation cover compared with the South Block, which supports more extensive tracts of herbaceous-dominated vegetation. The woody cover is associated with the occurrence of sandy soils and protected slopes of ravine and sand dune complexes. Grasslands are the dominant cover within the entire SNWA at 38%, followed by grassland-shrubs at 32%, shrub-grasslands at 14%, shrub dominant landscapes at 13%, barren areas at 2%, and wetlands and tree-dominated landscapes comprising less than 1% of the SNWA (Adams *et al.* 1997). The landscape mixtures of shrubs and shrub-grasslands, when combined, comprise the largest cover component of the SNWA at 59%. Additional information on the ecological land classification system, climatic zonation, geomorphology, soils, and vegetation cover types in the SNWA is presented in Adams *et al.* (1997).

2.2 Inventory Techniques

2.2.1 Snap traps

Generally, live traps are not as effective as snap traps for catching small rodents; therefore, the snap trap is more successful and productive (Nagorsen and Peterson 1980), and has become the standard for cost-effective small mammal bioinventories. Other collecting methods exist for small mammals such as shooting and the use of special traps, like the pocket gopher trap or the pitfall trap, which is used for shrews, jumping mice, and microtine rodents (Nagorsen and Peterson 1980). We considered using live traps in the Suffield inventory, but decided against that technique because the size of the study area was too great for an adequate live trap survey to be logistically feasible. Instead, we opted for the more efficient and economical snap trap methodology.

Potential sample plots for snap traps were selected from the available marked plots located every 500 m along the standard 1000 m west-east transect grid lines of the Universal Transverse Mercator (UTM) topographic map projection grid. The sample plots to be snap-trapped were systematically chosen so as to provide proportional coverage of the entire SNWA, based on size of the area represented by ecosites and how often those ecosites occurred within the entire SNWA. Each sample site consisted of a circular plot 200 m in diameter, which was marked at the centre with a fiberglass stake and an identification label (Adams *et al.* 1997). The transects and plots were located by using a hand-held global positioning system (GPS) (±100 m; Trailblazer GPS, Magellan Systems Corp., San Dimas, California). A trap line was established at each sample plot, consisting of 36 Victor snap traps (model M325, Woodstream Corp., Lititz, Pennsylvania) in two sets (north and south) of 9 pairs, with 18 trap sites to the north of the plot centre marker pin and 18 trap sites to the south of the pin (Figure 2). Individual traps were spaced 2 m apart in parallel trap lines with the pairs of traps spaced at 10-m intervals (10 paces apart) along the trap lines, covering a distance of 100 m north of the plot centre and 100 m south of the plot centre.

The 36 traps were checked at approximately the same time each morning. They were baited with a smooth peanut-butter based "Radvanyi" small mammal bait mixture (Appendix 2), and reset and rebaited as required. The traps were kept active for 3 consecutive nights for a total of 108 trap nights per sample plot. Field data forms were designed (Appendix 3) and used to record species, numbers, sex, age, and condition of small mammals caught, as well as the vegetation community type, the number of northern pocket gopher (*Thomomys talpoides*) mounds, the transect number, plot number, trap number, UTM co-ordinates, date, time of day, trap day, and trap line direction for each plot sampled.

The strategy used for field sampling varied between 1994 and 1995. During 1994, small mammal trap sites were systematically chosen from the available plots and transect lines that were designated and marked for sampling. In 1994, every third west-east grid line in the North Block and every second line in the South Block was designated for sampling by the Suffield wildlife inventory team, and all plots on the lines were marked. This ensured that the various teams could maximize coverage of both North and South blocks for later comparisons since

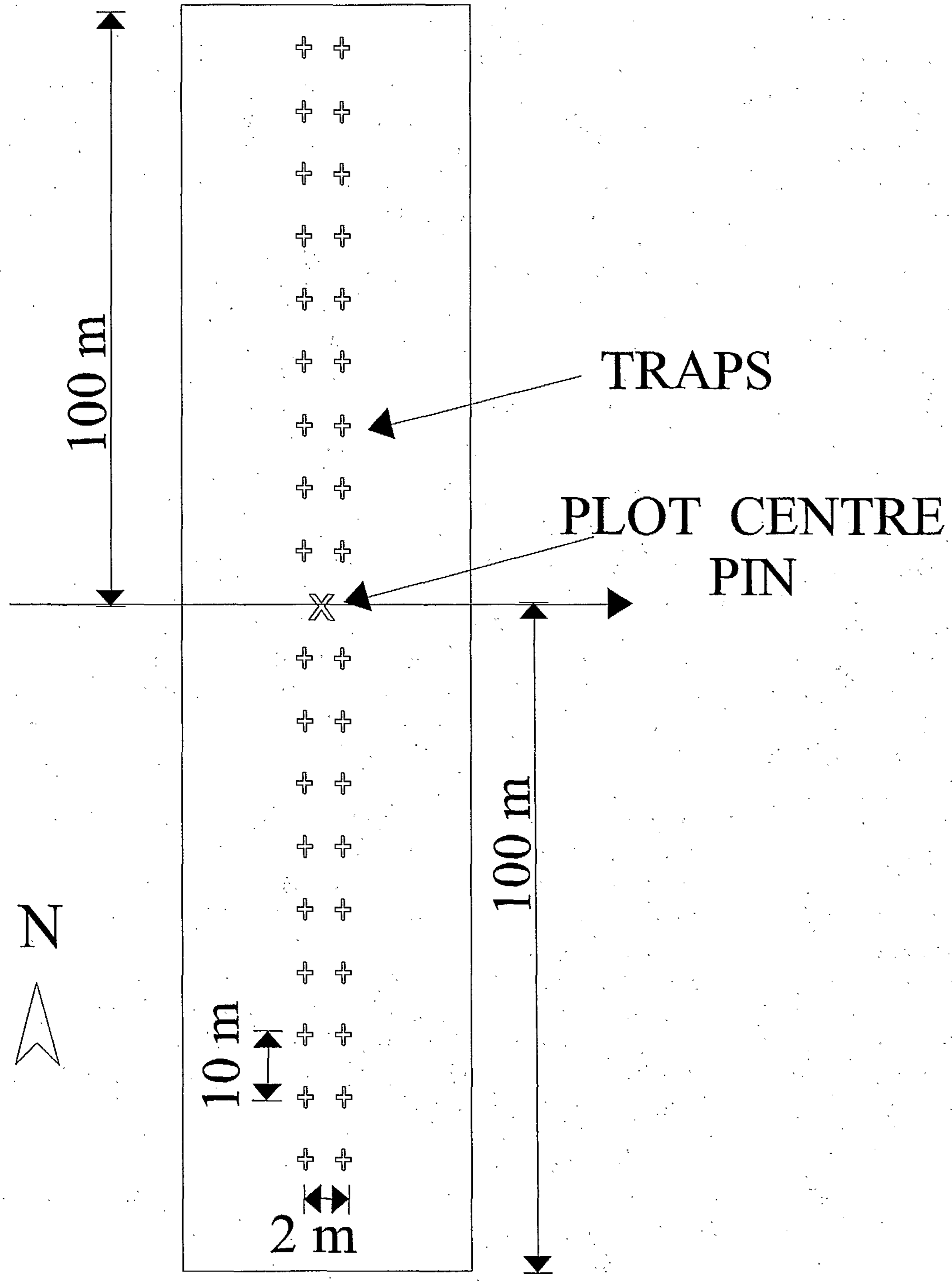

Figure 2. Diagram of the trapline grid of 36 snap traps used in the small mammal survey in the CFB Suffield National Wildlife Area, 1994-1996.

access was more restricted in the North Block because of military activities.

During the 1995 field season, ecosites for sampling were chosen systematically and based proportionately on size and how frequently they occurred within the SNWA, and whether or not they were sampled in 1994. Coverage included as many ecosites as possible that were not sampled in 1994, as well as the smaller and less easily accessed habitat types such as ravines and riparian sites. The same trapping methods used in 1994 were repeated in 1995. During June 1995, inclement weather sprang many set traps; therefore, replacement plots were selected and sampled during August to ensure an adequate sample size.

During the 1996 field season, 48 of the plots trapped in 1994 were resampled to measure small mammal population variation over time. The same trapping methods used in 1994 were repeated, except for replication of 8 of the 48 plots by running west-east trap lines in addition to the north-south lines. This increased the number of trap nights for each of these plots from 108 to 216.

2.2.2 Mound counts for northern pocket gophers

In addition to setting snap traps at each sample plot, northern pocket gophers were surveyed by counting "old" and "fresh" mounds in a 2-m wide transect for a total distance of 200 m (100 m north of the plot centre and 100 m south of the plot centre). This yielded a total of 400 m^2 of area searched at each plot. Northern pocket gopher mound count surveys were done at all plots with snap traps during the 1994 and 1995 field seasons. Additional mound count surveys were conducted in cooperation with the ungulate team from May 3 to 7 and 11 to 17, 1994, for 11 field days, and from April 8 to 12 and 19 to 25, 1995, for 12 field days.

During ungulate pellet plot surveys, a 2-m wide transect for a distance of 100 m to the south of the plot centre marker pin was also checked for northern pocket gopher mounds. The mound counts that were completed in association with pellet plot transects provided a total of 200 m^2 sample coverage at each plot. A "fresh" mound was defined as one that appeared to have been formed within the last 48 hours based upon the wetness or dampness of freshly deposited sand. An "old" mound was defined as one that was created prior to 48 hours, including the previous year's deposits that had vegetation growing up through it, as long as the mound structure was still visible. In this manner, we were able to evaluate the use of snap traps versus mound counts to determine which better reflected northern pocket gopher distribution in the SNWA. There were no other species of animals present in the SNWA that would construct loose mounds of soil.

2.2.3 Pellet transect counts for lagomorphs

Cooperation with the ungulate team during pellet transect counts in 1994 and 1995 (Shandruk *et al.* 1998) resulted in the collection of data on lagomorphs (hares and rabbits). This was used to determine the relative abundance of the Nuttall's cottontail (*Sylvilagus nuttallii*) and the white-tailed jack rabbit (*Lepus townsendii*) at each sample site based on pellet count density. Pellet count transects were conducted by the small mammal team in cooperation with the ungulate team from May 3 to 7 and 11 to 17, 1994, and from April 8 to 12 and 19 to 25, 1995.

2.2.4 Observation blue card system

Locations of small mammals recorded by the small mammal team and other wildlife inventory teams on the observation blue cards were entered into an incidental observations database. The incidental observations from all sources contributed to the main database for the porcupine (*Erethizon dorsatum*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*), and also provided the majority of information collected on the Nuttall's cottontail, white-tailed jack rabbit, and Richardson's ground squirrel (*Spermophilus richardsonii*). Independent inventory surveys for each of these 6 species were not conducted because of budget, personnel, and time constraints. However, during the 1994 and 1995 field seasons, we investigated potential sites for Richardson's ground squirrels in the SNWA and adjacent areas.

2.2.5 Bat survey

During the summer of 1995, an undergraduate student, Mr. Stephen McNalley, under the supervision of Dr. Robert M. Barclay (Department of Biological Sciences, University of Calgary), was contracted to study bats as a subcomponent of the small mammal inventory project. The abundance and distribution of bats in the SNWA was investigated from July 5 to August 15 and a report was submitted (McNalley and Barclay 1995).

Mist nets were set nightly in sample sites selected according to the ecosection classification of the SNWA (Appendix 1). All captured bats were identified to species, age, and sex. Levels of bat activity were also determined at sample sites using a mini bat-detector (QMC-2, Summit Corp., Birmingham, England), and by noting the number of passes and feeding buzzes by bats within a specified time period. Echo-location calls were tape-recorded for 45-minute time periods. Chemiluminescent tags were attached to the ventral side of some of the captured bats. The tagged bats were observed and notes recorded where they flew until they disappeared from sight. This was used to determine foraging behaviour within the ecosection being sampled. Roosting sites were located by searching for bat feces in suitable locations during the day, and by watching for bats to emerge from potential sites at dusk. Additional details of these techniques are described in McNalley and Barclay (1995).

2.2.6 Ord's kangaroo rat research survey

Nightlight surveys along road and trail rights-of-way were used to inventory the Ord's kangaroo rat (*Dipodomys ordii*). In cooperation with a University of Calgary graduate student, Mr. David Gummer, the locations of kangaroo rat observations were recorded. When possible, individuals were captured by hand, ear tagged, and weighed. During 1995, 1996, and 1997, Mr. Gummer was contracted to conduct an independent ecological study on the abundance, distribution, density, reproduction, and habitat use of Ord's kangaroo rat to supplement the ongoing CFB Suffield small mammal inventory. He conducted a Master of Science degree project at the Department of Biological Sciences, University of Calgary, to determine the effects of latitude and long-term isolation on the ecology of the northern Ord's kangaroo rat (Gummer 1997a). The abundance and distribution of Ord's kangaroo rats in the SNWA was studied from 1995 to 1997 and a report was submitted (Gummer 1999).

The Ord's kangaroo rat field surveys were purposely biased toward habitats in which capture success was high and presumably where kangaroo rats were the most abundant. The most productive technique for capturing kangaroo rats, routinely and consistently, proved to be nightlighting whereby a network of 418 km of roads and trails was surveyed regularly. Details of the road survey technique are described in Gummer (1999). Intense nightlighting survey effort was performed during spring and summer, while occasional surveys were conducted during autumn and winter. Habitats that were inaccessible by vehicle, such as active sand dunes, were surveyed on foot using flashlights. Live trapping, which was found to be relatively unproductive, was also used to a lesser extent. Body mass, sex, reproductive status, age-class, and overall condition were collected from each captured animal. Data collected by nightlighting, flashlight investigations of sand dunes, live trapping, systematic small mammal trapping with snap traps, and incidental observations from other wildlife inventory team members contributed to the overall database for Ord's kangaroo rats.

2.3 Data Analysis Techniques

2.3.1 Vegetation zone and topographic habitat classification

We developed a strategy that was designed to combine existing vegetation cover types (structure) and the lowest level land classes of the SNWA, on the basis of underlying similarities, to create simplified vegetation zone and topographic habitat maps. Thus, we described the basic recognizable and biologically meaningful vegetation and topographical features of the landscape. Using the vegetation cover classification described in the Vegetation Component Report (Adams *et al.* 1997), we merged the 28 vegetation cover types into 3 vegetation zones based on the relative abundance of grassland and woody vegetation, and then created a generalized map (Figure 3). Similarly, we merged the 99 ecosites into 5 topographic habitats based on 5 landform themes: sand dunes, plains and terraces (flat uplands), rolling (low relief) sand and morainal areas, ravines, and wetlands. A generalized map was then created (Figure 4). Ecosite assignments were based on the composition of plant communities and their association with landform elements such as, soil texture, slope, and aspect as described in the ELC legend (Adams *et al.* 1997).

The Grasslands vegetation zone (39.4% of the SNWA) includes vegetation cover types dominated by herbaceous plants (Table 1). The essential feature of this zone is the absence of shrubs. It includes 8 of the 20 vegetation cover types that were sampled for small mammals, 4 cover types that were not sampled, and 2 water cover types, Dugouts and Aquatic (Appendix 4).

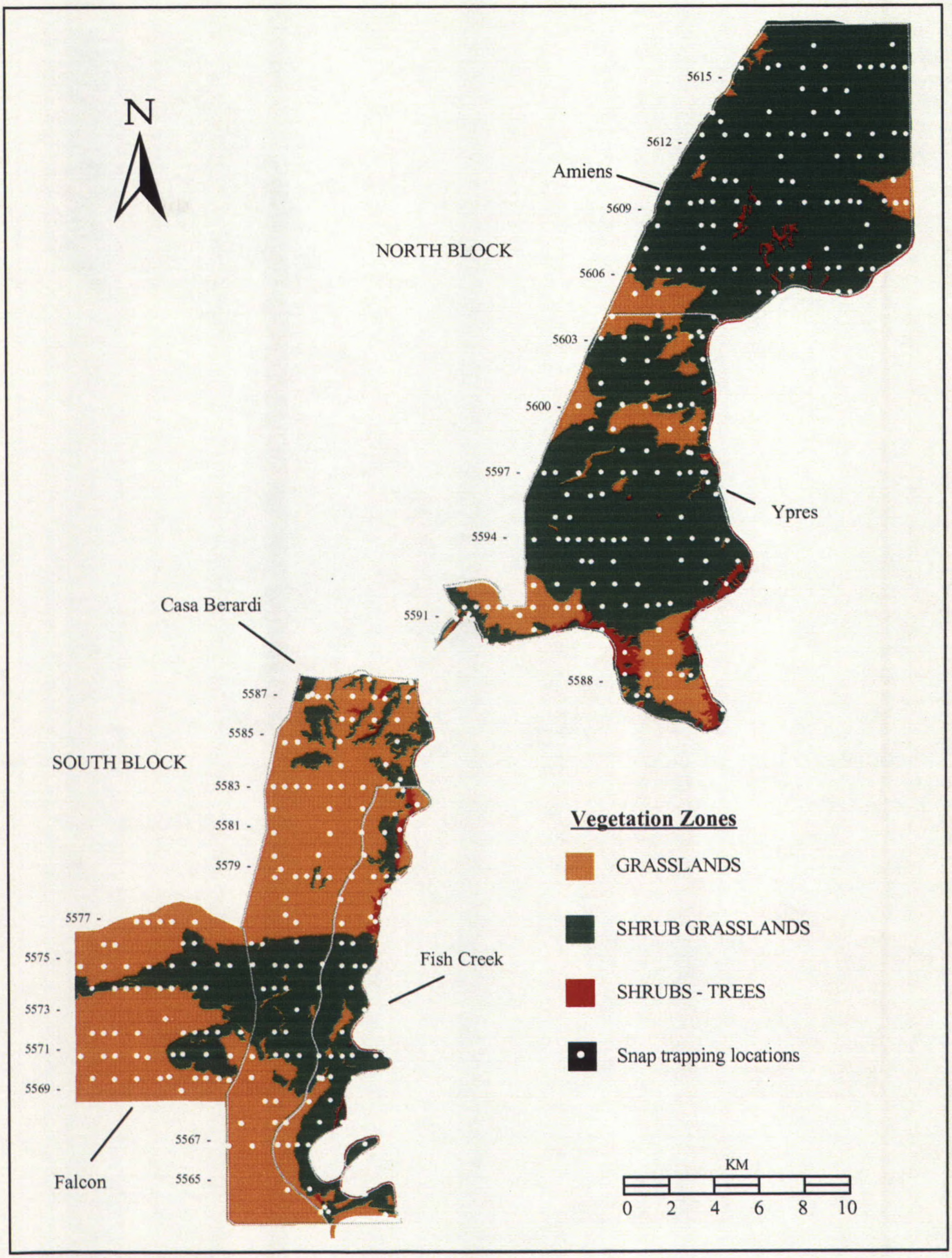

Figure 3. Vegetation zones in the CFB Suffield National Wildlife Area (Based on data from Adams *et al*. 1997).

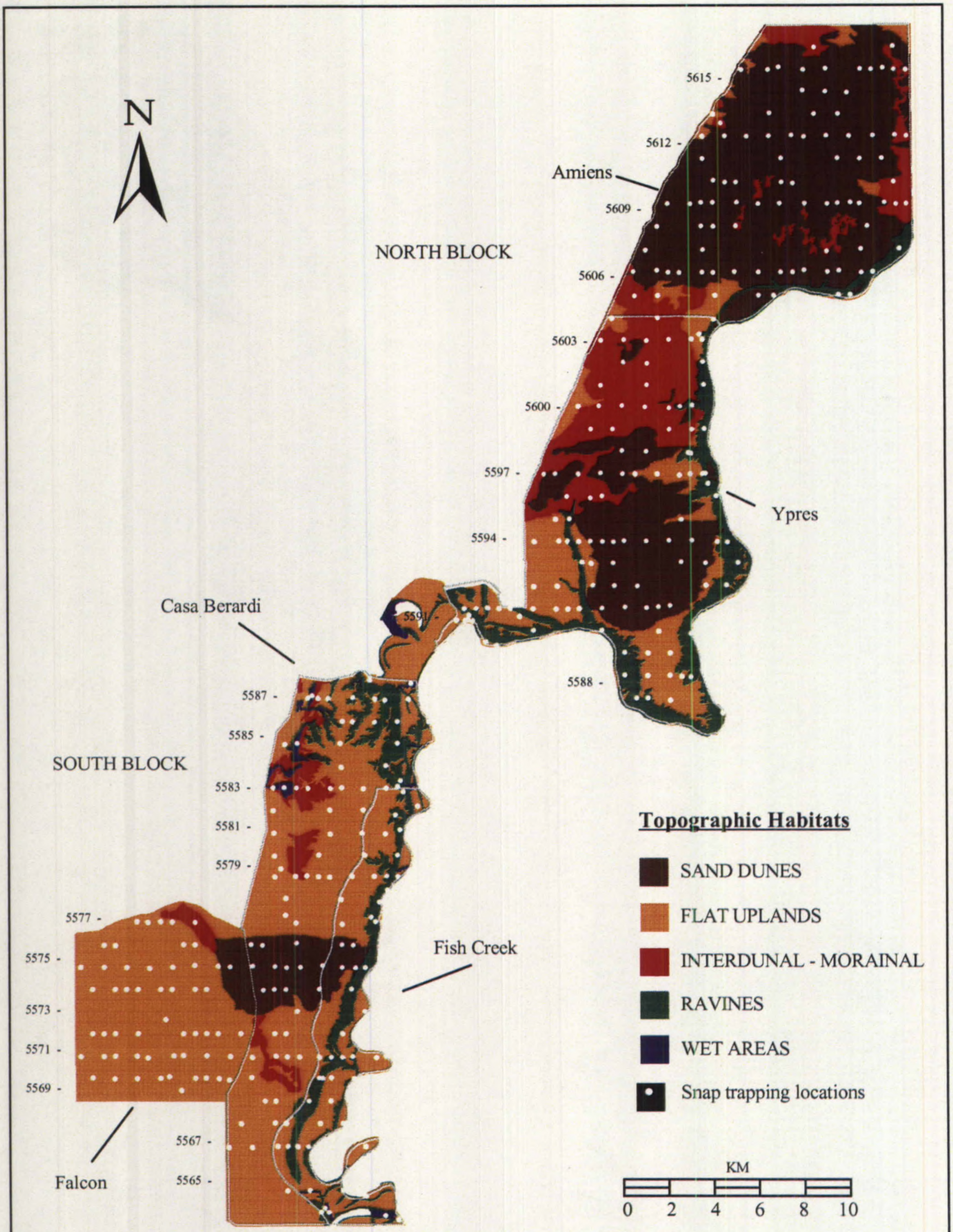

Figure 4. Topographic habitats in the CFB Suffield National Wildlife Area (Based on data from Adams *et al*. 1997).

Table 1. Size and distribution of vegetation zones and topographic habitats, relative to the distribution of small mammal trapping plots and catch effort (CE) results, in the CFB Suffield National Wildlife Area, 1994-1995.

VEGETATION ZONES	Number Polygons	Total Area (ha)	% of Area	Mean Size ha/Polygon	# Plots in Cover Type	# Plots CE=0	# Plots CE>0	% of Plots with CE>0
GRASSLANDS								
Vegetation Cover types								
Upland grassland	162	15091	32.87	93.2	112	30	82	73
Moist grassland	74	1355	2.95	18.3	16	5	11	69
Disturbed grassland	19	1090	2.37	57.4	7	3	4	57
Sedge-forb wetlands	33	174	0.38	5.3	5	1	4	80
Barren-grass	12	145	0.32	12.1	2	0	2	100
Seeded grassland	8	129	0.28	16.2	4	2	2	50
Saline grassland	5	72	0.16	14.4	1	1	0	0
Forb	1	18	0.04	17.8	2	1	1	50
SUBTOTAL	**314**	**18074**	**39.37**	**57.6**	**149**	**43**	**106**	**71**
SHRUB GRASSLANDS								
Vegetation Cover types								
Grassland-mid/low shrubs	161	13718	29.88	85.2	110	17	93	84
Mid/low shrubs-grassland	142	6220	13.55	43.8	49	3	46	94
Shrubs-trees-grassland	68	5435	11.84	79.9	49	4	45	92
Grassland-tall/mid/low shrubs	24	665	1.45	27.7	7	1	6	86
Meadow-low shrubs	18	252	0.55	14.0	2	1	1	50
Tall shrubs-grassland	13	164	0.36	12.6	9	0	9	100
Mid/low shrubs	4	12	0.03	3.0	1	0	1	100
SUBTOTAL	**430**	**26466**	**57.66**	**61.5**	**227**	**26**	**201**	**88**
SHRUBS - TREES								
Vegetation Cover types								
Barren-mid/tall shrubs	55	830	1.81	15.1	10	1	9	90
Tall/mid/low shrubs	16	129	0.28	8.1	1	0	1	100
Trees-tall/mid shrubs	14	63	0.14	4.5	4	0	4	100
Barren	12	40	0.09	3.4	2	0	2	100
Tall trees	3	3	0.01	0.9	1	0	1	100
SUBTOTAL	**100**	**1065**	**2.33**	**10.6**	**18**	**1**	**17**	**94**
8 OTHER COVER TYPES **SUBTOTAL**	**65**	**305**	**0.66**	**4.7**	**0**	**0**	**0**	**0**
GRAND TOTAL	**909**	**45910**	**100.02**	**50.5**	**394**	**70**	**324**	**82**
TOPOGRAPHIC HABITATS								
SAND DUNES	44	15223	32.64	345.9	111	9	102	92
FLAT UPLANDS	177	21363	45.81	120.7	182	42	140	77
INTERDUNAL - MORAINAL	31	5219	11.19	168.4	35	12	23	66
RAVINES	168	4548	9.75	27.1	58	5	53	91
WET AREAS	17	284	0.61	16.7	8	2	6	75
TOTAL	**437**	**46637**	**100.00**	**106.7**	**394**	**70**	**324**	**82**

The Shrub Grasslands vegetation zone (57.7% of the SNWA) includes vegetation cover types that are combinations of shrubs and grass as the dominant or subdominant vegetation type and areas of grasslands that contain trees (Table 1). The essential feature of this zone is the mixture of both grasslands and shrubs and grasslands and trees. This vegetation zone includes 7 of the 20 vegetation cover types that were sampled for small mammals and one cover type that was not sampled (Appendix 4).

The Shrubs–Trees vegetation zone (2.3% of the SNWA) includes the vegetation cover types that are mainly tall and mid shrubs or shrub-tall trees as the dominant or subdominant vegetation cover, but without a grassland component (Table 1). The essential feature of this zone is the absence of grasslands. It includes 5 of the 20 vegetation cover types that were sampled for small mammals and 1 cover type that was not sampled (Appendix 4). The vegetation cover types that are assigned to each of the 3 vegetation zones are listed in Appendix 4 and the generalized map of these 3 zones is shown in Figure 3.

The Sand Dunes topographic habitat (32.6 % of the SNWA) includes topographical areas that are eolian landforms where mainly sand dunes dominate the landscape (Table 1). This topographic habitat includes 7 ecosites, 5 of which are eolian landforms, 1 is a glacio-fluvial landform, and 1 is a morainal landform (Appendix 4).

The Flat Uplands topographic habitat (45.8 % of the SNWA) includes topographical areas that are flat grasslands, upland grasslands, or grasslands that form terraces above the South Saskatchewan River valley throughout the SNWA, where glacio- and postglacio-fluvial terraces dominate the landscape (Table 1). This topographic habitat includes 46 ecosites, of which 32 are glacio-fluvial landforms, 8 are fluvial landforms, and 6 are morainal landforms (Appendix 4).

The Interdunal–Morainal topographic habitat (11.2 % of the SNWA) includes topographical areas that are interdunal eolian flats and gently rolling eolian landscape, as well as rolling and undulating morainal areas where interdunal flats of sand dunes dominate the landscape (Table 1). This topographic habitat includes 10 ecosites, 5 of which are eolian landforms, 3 are glacio-fluvial landforms, and 2 are morainal landforms (Appendix 4).

The Ravines topographic habitat (9.8 % of the SNWA) includes fluvial incised channels with steep side slopes, fluvial landforms associated with the South Saskatchewan River valley, and glacio-fluvial channel banks (Table 1). These 3 landforms are fairly evenly represented in this topographic habitat which includes a total of 25 ecosites, 14 of which are fluvial landforms and 11 are glacio-fluvial landforms (Appendix 4).

The Wet Areas topographic habitat (0.6 % of the SNWA) includes low-lying topographical areas that are intermittent or permanent wetlands of the fluvial and glacio-fluvial landform types (Table 1). This topographic habitat includes 11 ecosites, 7 of which are fluvial landforms in the form of secondary stream channels and 4 are glacio-fluvial landforms, mainly glacio- and postglacio-fluvial terraces (Appendix 4). The ecodistricts and ecosites (Appendix 1) assigned to each of the 5 topographic habitats are listed in Appendix 4, and the generalized map of the 5 topographic habitats is shown in Figure 4.

2.3.2 Snap trap distributions and catch effort analyses

Total numbers of each small mammal species caught were compiled and tabulated from snap trap data. Trapping locations and catch results, based on 4 categories of count data (0 caught [nil]; 1 caught [low]; 2-5 caught [medium]; and >5 caught [high]), were plotted on base maps of the SNWA, along with incidental observations where applicable, to delineate the distribution of individual species or groups of species in the SNWA. A list of the SNWA small mammal species in taxonomic sequence, as classified by order and family, was generated based on the snap trap results and incidental observations from all inventory teams (Appendix 5).

Catch effort (CE) is a calculated expression of the number of small mammals caught relative to the trapping effort (Nelson and Clark 1973; Holroyd and Van Tighem 1983; Sharpe and Millar 1991). Catch effort, which measures trap success based on 100 trap nights of effort as the catch per unit effort, can be considered to be an index of abundance that measures relative density (Fleharty and Navo 1983; Krebs 1994), with a higher CE rate probably relating to a higher density of animals. However, only a rough estimate of abundance is achieved, since the number of animals trapped depends not only on the population density, but also on their activity and movements as well as on the skill of the trapper in placing the traps (Krebs 1994). In the SNWA study, the CE was calculated from the following equation adapted from Nelson and Clark (1973):

$$CE=100A/[N-S/2]$$

where:
- A = the number of animals of each species caught,
- N = the number of trap nights, and
- S = the number of traps sprung for any reason.

This equation corrects the catch effort trap success value by accounting for a decrease in trap efficiency caused by traps being sprung by animals of other species already caught or by rain, wind, debris, or other unexpected incidents (Nelson and Clark 1973). The basic premise of measuring relative abundance is that it depends on the collection of samples that represent some relatively constant but unknown relationship to the total population size (Krebs 1994). Trap success is an expression of the total number of animals caught divided by the total number of trap nights times 100 for any specified trapping period. This is the trap success rate without adjusting for trap closures or effort.

We organized the data from the small mammal trap plots by vegetation zones and topographic habitats for additional analyses. The number of plots sampled, the percentage of plots with a catch effort greater than zero, the total number of animals caught, the mean CE values, the standard deviation CE, and 4 local abundance levels (nil, low, medium, and high) based on maximum mean catch effort rates, were calculated for each small mammal species trapped and tabulated for each of the 3 vegetation zones and 5 topographic habitats. To maintain objectivity, we calculated the local abundance levels by dividing the largest mean CE value from any of the vegetation zones or topographic habitats by the number of categories, in this case 3 (low, medium, and high), to determine a range of values for defining these 3 category levels. The nil category is the same for all species since it represents a zero catch. The mean CE value for each vegetation zone and topographic habitat by species was then assigned to 1 of the 4 local abundance level categories, based on where this value fit into the calculated range of values.

The CE results were compared among the 3 vegetation zones and 5 topographic habitats to help explain and interpret small mammal occurrences and distributional relationships. The mean CE values were used to compare species at the sample plot level among vegetation zones and topographic habitats, and to compare different plots according to the small mammal trap success. The mean CE values and standard errors of the means for each of 10 species of small mammals caught in snap traps for the combined years of 1994 and 1995 were plotted on graphs for each of the 3 vegetation zones and 5 topographic habitats.

Mean catch effort values for each of the 3 vegetation zones and 5 topographic habitats were examined in separate one-way analysis of variance (ANOVA) tests with Bonferroni pairwise comparisons to look for differences among the vegetation zone means and topographic habitat means. ANOVA tests were completed for each of the 10 small mammal species caught in snap traps, northern pocket gopher mean mound counts, and lagomorph mean pellet counts. Significant differences were determined using the 5% significance level.

To confirm the validity of merging the 28 vegetation cover types into 3 vegetation zones, we plotted the percent shrub cover data, as collected by the vegetation inventory team, to determine the relationship of the actual percent shrub cover on the ground relative to the percent composition of shrubs and grass in the 3 vegetation zones as we defined them. The mean percent shrub cover for the Grasslands zone was 0.9%, for the Shrub Grasslands zone it was 7.7%, and for the Shrubs–Trees zone it was 33.6% (Figure 5). This indicated a strong relationship between the actual percent shrub cover on the ground and the percent composition of shrubs in the 3 vegetation zones. This justified merging the 28 vegetation cover types into 3 vegetation zones based on the relative abundance of grassland and woody vegetation.

Three assumptions were made in the snap trap and catch effort data analyses. The first is that snap trapping was assumed to account for animals residing in the area at the time of trapping and transient movements of animals were equally represented across trapping periods and plots. The second assumption is that trap captures were assumed to represent an index of population abundance to a reasonable degree. The third assumption is that important factors, such as moon stage, which affects activities and capture success, weather, seasonality of capture, age-class, sex, diet, home range, reproduction, dispersal movement, and parasites were not accounted for in the analyses of the trap data, but these ecological considerations undoubtedly affect animal activity levels, movements, distribution, and abundance especially those strictly nocturnal species.

2.3.3 Mound counts for northern pocket gophers

At each sample plot, northern pocket gopher mound count densities were expressed as mounds per hectare (mounds/ha). Mound count data were used to assess the relative abundance of northern pocket gophers by calculating the mean number of mounds/ha and the standard

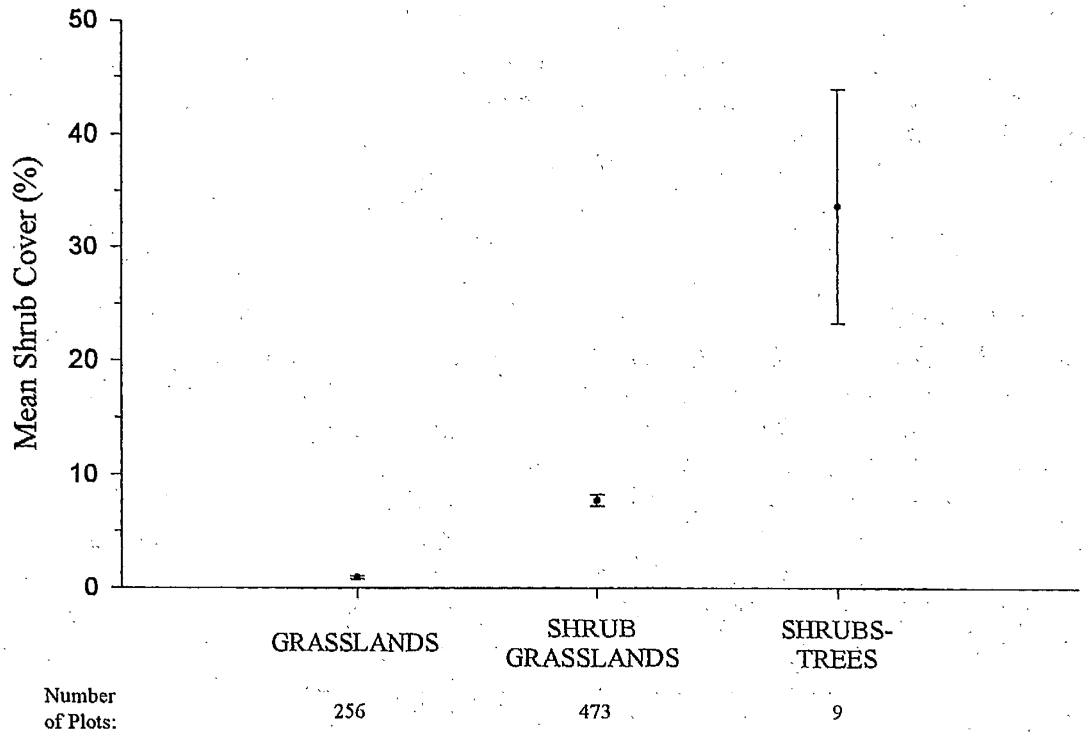

Figure 5. Mean percent shrub cover (Based on data from Adams *et al.* 1997) by vegetation zones in the CFB Suffield National Wildlife Area, 1994-1995. Error bars represent 1 standard error of the mean.

deviations of the means for each of the 3 vegetation zones and 5 topographic habitats for the combined years of 1994 and 1995. These values were then arranged and tabulated in descending order of magnitude. Also, these values were plotted on a graph for each of the 3 vegetation zones and 5 topographic habitats. This analysis was completed for "old" mound counts only. The mounds/ha data from all plots sampled were analyzed by kridging procedures to represent northern pocket gopher density by contours over the entire SNWA (SURFER, version 6.04, Golden Software Inc., Golden, Colorado) to produce a distribution map of mound count densities.

2.3.4 Pellet transect counts for lagomorphs

Species differentiation was not possible from pellet count surveys in the SNWA and, therefore, results apply to both Nuttall's cottontails and white-tailed jack rabbits. At each sample plot, the number of lagomorph pellets per 200 m^2 was expressed as pellets/ha. The mean number of pellets/ha and the standard deviation of the means were calculated and tabulated for the combined years of 1994 and 1995 for each of the 3 vegetation zones and 5 topographic habitats, and used to assess the relative abundance of lagomorphs by habitat types. Also, these values were plotted on a graph for each of the 3 vegetation zones and the 5 topographic habitats. The pellets/ha data from all plots sampled were analyzed as with the northern pocket gopher mound count data to produce a distribution map of lagomorph pellet densities, represented by contours over the entire SNWA.

2.3.5 Observation blue card system

During nightlight surveys for Ord's kangaroo rats, observations of Nuttall's cottontails, white-tailed jack rabbits, porcupines, and other small mammal species that were seen along roads, trails, and transects were recorded on the blue cards. Observations noted on blue cards from all Suffield wildlife inventory teams were added to an incidental observations database for each species. This combined database was analyzed for numbers of sightings by species, location, and date, and was used in conjunction with the snap trap data, where applicable, to plot individual species distribution maps for the SNWA. Only incidental observations were used to plot distribution maps for Nuttall's cottontails, white-tailed jack rabbits, Richardson's ground squirrels, beavers, muskrats, and porcupines because trap data were not collected for these species. One of the shortcomings of the incidental observations was a bias towards main travel routes that were used by observers, and their frequency of travel on those routes. Oftentimes, road locations could be plotted from such incidental observations data owing to this bias.

2.3.6 Bat survey

The distribution of the total number of bat captures within each ecosection type (Appendix 1) was statistically tested against an expected random pattern of captures based on the netting effort within each ecosection type. A one-way ANOVA test was used to determine if there were differences in activity for 3 species of bats among the different ecosections sampled and among the 3 nighttime periods (dusk, night, and dawn). The light-tag observations were tabulated according to 5 category areas, based on physical features within an ecosection, and by the amount of time each tagged individual was observed there. The distribution of the total number of feeding buzzes for each ecosection sample site and for each species of bat was tested for randomness of distribution (McNalley and Barclay 1995).

2.3.7 Ord's kangaroo rat research survey

All the Ord's kangaroo rat data were entered into a relational database management system (Microsoft Access 97, Microsoft Corporation, Redlands, California) for efficient access to records. The spatial data were incorporated into map images for evaluation of relationships, and all maps were created and analyzed at a resolution (pixel size) of 30 m (Gummer 1999). The ecological land classification, vegetation cover classification, and other relevant map data were incorporated into Idrisi for Windows (version 2.01, Clark Labs, Worchester, Massachusetts), and the images were restructured according to the 3 vegetation zones and 5 topographic habitats.

To allow for direct comparisons with the snap trap survey, the kangaroo rat data were organized as catch per unit effort: the total number of individuals caught per 100 searches of 30-m quadrats (Gummer 1999). Only habitats that were sampled by at least 10 different quadrats were included in the statistical analysis (Gummer 1999). Tables were standardized with those of the small mammal survey tabular results. The mean CE values for each of the 3 vegetation zones and 5 topographic habitats were examined in separate one-way ANOVA tests, and mean differences were tested using Bonferroni-corrected pairwise comparisons (Gummer 1999).

2.3.8 Specimen handling and deposition

All small mammals caught in snap traps were collected. In 1994, deer mice (*Peromyscus maniculatus*) were bagged together in plastic bags by plot from each transect line, but during the 1995 and 1996 field seasons, deer mice were bagged individually. All other species were bagged individually during the 3 field seasons. These specimen bags were labelled with transect number, plot number, trap number, date, and trap day. In addition, a separate, waterproof paper tag was labelled with the field information and placed inside each specimen bag. Specimens were frozen and taken to the lab for confirmation of species, age, and sex. Specimens other than deer mice were donated to the Provincial Museum of Alberta for preparation of study skins and inclusion in the museum collection. The deer mice were stored separately and a technician was contracted to take 5 standard taxonomic measurements from each specimen. Samples of deer mice from the 1994 and 1995 field seasons were shipped to the laboratory of Health and Welfare Canada, Ottawa, to test for the presence of hantavirus.

3.0 RESULTS

3.1 Snap Trap Effort and Ecosites Sampled

In 1994, snap trapping was conducted by the small mammal team during 6 different trap periods between 13 June and 6 September for a total of 46 field days. Individual trap periods varied from 3 to 11 days. In 1994, 348 plots on 22 transect lines were identified and field marked for sampling by the Suffield wildlife inventory team. Snap trapping occurred at 172 of those plots for a sample coverage of 49.4% of the available sites. The small mammal team established 4 additional plots in a ravine by the South Saskatchewan River and 3 more at Sherwood Forest for a total of 179 plots in 1994. Of these, 111 were from the North Block with 68 from the South Block along 20 different transect lines, totaling 19,324 trap nights (Table 2).

In 1995, snap trapping was conducted by the small mammal team during 3 different trap periods between 11 June and 31 August for a total of 56 field days. Individual trap periods varied from 17 to 25 days. Between 13 June and 4 July, 26 plots (22 South Block, 4 North Block) had high trap closure rates, varying from 16.7% to 80.6%, which was caused by inclement weather. To supplement these plots, replacement plots were selected from the nearest adjacent plot within the same ecosite and were trapped from 13 to 31 August. In 1995, 488 additional plots were marked for sampling by the Suffield wildlife inventory team (295 in the North Block and 193 in the South Block). Snap trapping occurred at 212 of those plots for a sample coverage of 43.4%.

Table 2. Species, rank, actual catch, percentage of catch, mean catch effort (CE), maximum CE, 95% confidence interval (CI), standard deviation (SD), and coefficient of variation (CV) of small mammals snap-trapped in the CFB Suffield National Wildlife Area, 1994-1996.

1994 (179 Plots Sampled)		**Actual**	**% of**	**MEAN**	**MAX**	**95%**		**CV**
SPECIES	**Rank**	**Catch**	**Catch**	**CE**	**CE**	**CI**	**SD**	**%**
Sorex haydeni- prairie shrew	5	26	1.9	0.15	2.1	(0.09, 0.21)	0.40	1800.0
Spermophilus tridecemlineatus- 13-lined ground squirrel	6	17	1.2	0.10	2.0	(0.04, 0.15)	0.36	360.0
Thomomys talpoides- northern pocket gopher	9	6	0.4	0.04	1.2	(0.01, 0.06)	0.19	475.0
Perognathus fasciatus- olive-backed pocket mouse	8	8	0.6	0.05	1.1	(0.01, 0.08)	0.22	440.0
Dipodomys ordii - Ord's kangaroo rat	4	34	2.5	0.20	9.0	(0.07, 0.33)	0.89	2250.0
Reithrodontomys megalotis- western harvest mouse	2	80	5.8	0.45	6.4	(0.30, 0.60)	1.01	224.4
Peromyscus maniculatus- deer mouse	1	1122	81.6	6.50	30.5	(5.65, 7.35)	5.75	88.5
Onychomys leucogaster- northern grasshopper mouse	7	12	0.9	0.07	3.1	(0.01, 0.12)	0.38	542.9
Microtus pennsylvanicus- meadow vole	3	64	4.6	0.36	5.2	(0.24, 0.49)	0.85	236.1
Lagurus curtatus - sagebrush vole	10	2	0.1	0.01	1.9	(-0.01, 0.03)	0.14	1400.0
Mus musculus- house mouse		0	0.0	0.00	0.0	(0.00, 0.00)	0.00	
Unidentified vole		2	0.1	0.01	1.0	(-0.01, 0.02)	0.07	700.0
Unidentified mouse		1	0.1	0.01	2.0	(-0.01, 0.03)	0.15	1500.0
Total Species		1374	99.8	7.94	33.9	(6.99, 8.88)	6.39	80.5
Total Trap Nights = 19,324 (Trap Success = 7.1%)								

1995 (212 New Plots Sampled + 3 Repeats)		**Actual**	**% of**	**MEAN**	**MAX**	**95%**		**CV**
SPECIES	**Rank**	**Catch**	**Catch**	**CE**	**CE**	**CI**	**SD**	**%**
Sorex haydeni- prairie shrew	2	19	4.2	0.09	3.0	(0.04, 0.14)	0.35	388.9
Spermophilus tridecemlineatus- 13-lined ground squirrel	4	13	2.9	0.07	2.9	(0.03, 0.12)	0.33	471.4
Thomomys talpoides- northern pocket gopher	8	3	0.7	0.01	1.1	(0.00, 0.03)	0.12	1200.0
Perognathus fasciatus- olive-backed pocket mouse	7	5	1.1	0.02	1.1	(0.00, 0.04)	0.15	750.0
Dipodomys ordii - Ord's kangaroo rat	6	7	1.6	0.03	2.0	(0.01, 0.06)	0.20	666.7
Reithrodontomys megalotis- western harvest mouse	3	15	3.3	0.07	4.3	(0.02, 0.12)	0.38	542.9
Peromyscus maniculatus- deer mouse	1	374	83.1	1.84	16.3	(1.49, 2.19)	2.61	141.9
Onychomys leucogaster- northern grasshopper mouse	10	1	0.2	0.004	1.0	(0.00, 0.01)	0.07	1750.0
Microtus pennsylvanicus- meadow vole	5	12	2.7	0.06	3.2	(0.02, 0.10)	0.33	550.0
Lagurus curtatus - sagebrush vole		0	0	0.00	0.0	(0.00, 0.00)	0.00	
Mus musculus- house mouse	9	1	0.2	0.005	1.0	(0.00, 0.01)	0.07	1400.0
Total Species		450	100	2.21	16.3	(1.85, 2.58)	2.69	121.7
Total Trap Nights = 23,208 (Trap Success = 1.9%)								

1996 (48 Plots Sampled)		**Actual**	**% of**	**MEAN**	**MAX**	**95%**		**CV**
SPECIES	**Rank**	**Catch**	**Catch**	**CE**	**CE**	**CI**	**SD**	**%**
Sorex haydeni- prairie shrew		0	0	0.00	0.0	(0.00, 0.00)	0.00	
Spermophilus tridecemlineatus- 13-lined ground squirrel	2	16	7.1	0.36	9.2	(-0.06, 0.78)	1.44	400.0
Thomomys talpoides- northern pocket gopher		0	0	0.00	0.0	(0.00, 0.00)	0.00	
Perognathus fasciatus- olive-backed pocket mouse	4	1	0.4	0.02	1.0	(-0.02, 0.06)	0.14	700.0
Dipodomys ordii - Ord's kangaroo rat	4	1	0.4	0.01	0.5	(-0.01, 0.03)	0.07	700.0
Reithrodontomys megalotis- western harvest mouse		0	0	0.00	0.0	(0.00, 0.00)	0.00	
Peromyscus maniculatus- deer mouse	1	198	87.6	3.68	29.8	(2.19, 5.18)	5.16	140.2
Onychomys leucogaster- northern grasshopper mouse	4	1	0.4	0.01	0.5	(-0.01, 0.03)	0.07	700.0
Microtus pennsylvanicus- meadow vole	3	8	3.5	0.16	2.3	(0.02, 0.31)	0.49	306.3
Lagurus curtatus - sagebrush vole	4	1	0.4	0.01	0.5	(-0.01, 0.03)	0.07	700.0
Mus musculus- house mouse		0	0	0.00	0.0	(0.00, 0.00)	0.00	
Total Species		226	99.8	4.26	29.8	(2.67, 5.85)	5.48	128.6
1996 Total Trap Nights = 6,046 (1996 Trap Success = 3.7%)								
G.T.= Plots (442); Trap Nights (48,578); Trap Success (4.2%)		**2050**						

Three plots were duplicated for a total of 215 plots that were sampled with snap traps, yielding 23,208 trap nights (Table 2).

In 1996, snap trapping was conducted between 21 June and 8 July for a total of 16 field days. Forty-eight plots that were trapped in 1994 (32 plots from the North Block and 16 plots from the South Block) were resampled. In addition to the standard north-south trap lines, 8 of those 48 plots (6 from the North Block and 2 from the South Block) were replicated by running west-east trap lines, increasing the number of trap nights for each of these plots from 108 to 216. During the 1996 field season, an equivalent of 56 plots was sampled using snap traps, yielding 6,046 trap nights (Table 2).

During 1994 and 1995, 384 of the 836 plots identified for sampling by the Suffield wildlife inventory team from 55 transect lines were sampled using snap traps for an overall sample coverage of 45.9% of the established sites. Also, 72 of the 99 ecosites that were classified for the SNWA were sampled: 9 only in 1994, 31 only in 1995, and 32 ecosites in both 1994 and 1995. Twenty-seven of the classified ecosites were never sampled with snap traps. During the 3-year field season, 442 plots were sampled using snap traps, yielding a total of 48,578 trap nights (Table 2).

3.2 Numbers of Species and Composition of the Catch

We caught 10 species of small mammals in snap traps during each of the 1994 and 1995 field seasons, where the sagebrush vole (*Lagurus curtatus*) was taken in 1994 but not in 1995, and the house mouse (*Mus musculus*) was first caught in 1995. During 1996, only 7 species were caught; western harvest mice (*Reithrodontomys megalotis*), prairie shrews (*Sorex haydeni*), northern pocket gophers, and house mice were not represented in the catch. A total of 794 independent incidental observations were recorded on the blue card system, which included 12 species of small mammals. By the end of the fieldwork, 12 species of small mammals were snap-trapped, 6 species were observed but never caught in snap traps, and 6 species of bats were caught by mist netting. Thus, a total of 24 species, representing 4 orders and 10 families, were identified as the small mammal fauna of the SNWA (Appendix 5). The Order Rodentia, with 7 families and 15 species, was the largest group. General biological information on animal descriptions, natural history, food habits, reproductive characteristics, and predators for each small mammal species trapped and observed in the SNWA from 1994 to 1996 is provided in Appendix 6.

In 1994, 1,374 small mammals were caught in snap traps with a success rate of 7.1%; 450 were caught in 1995 with a 1.9% success rate, and 226 were caught in 1996 with a 3.7% success rate (Table 2). The total number of small mammals caught in snap traps within the 3 years was 2,050, with an overall success rate of 4.2%. Species composition of the catch ranged from a high of 81.6% deer mice to a low of 0.1% sagebrush voles in 1994; from a high of 83.1% deer mice to a low of 0.2% for each of the house mouse and the northern grasshopper mouse (*Onychomys leucogaster*) in 1995; and from a high of 87.6% deer mice to a low of 0.4% for 1 capture each of the olive-backed pocket mouse (*Perognathus fasciatus*), the Ord's kangaroo rat, the northern grasshopper mouse, and the sagebrush vole in 1996 (Table 2).

From 1994 to 1995, our trapping effort increased by 16.7%, but the total catch decreased by 67.2% and trap success declined from 7.1% to 1.9%. However from 1995 to 1996, trap success increased from 1.9% to 3.7%, but our trap effort was only 26.8% of the 1994 effort and the total catch was correspondingly low (226).

3.3 Species Distributions and Abundance

3.3.1 Prairie shrew

The prairie shrew was well distributed throughout the SNWA (Figure 6). The plots showing medium-density (2-5 caught) were associated with the Shrub Grasslands zone, especially within the North Block, while the plots of low-density (1 caught) were evenly distributed throughout the Grasslands and Shrub Grasslands zones. The individual plot CE values for prairie shrews were highest in 1995 in the Ravines topographic habitat, attaining a maximum of 3.0 (Table 2). There appeared to be 2 areas of higher catch rates in the northern sand dunes of Amiens in the North Block and in the sandy areas just south of Interface/Trumpeter Trail and north of Coyote Road in the Falcon area of the South Block, but overall, prairie shrews were generally found throughout the SNWA.

The mean CE values for the prairie shrew were consistent across vegetation zones and topographic habitats, except for the Wet Areas topographic habitat which had a small sample size and no catch (Table 3). Prairie shrews were captured in all vegetation zones and topographic habitats sampled in the SNWA except for Wet Areas (Table 3; Figure 7). Within vegetation zones and topographic habitats, the mean CE values were not significantly different ($P > 0.05$), although within vegetation zones, Shrub Grasslands had a larger mean CE as did Sand Dunes within the topographic habitats (Table 3). The Sand Dunes topographic habitat had the overall highest mean CE (0.16) for prairie shrews (Table 3; Figure 7).

Based on the number of plots with a catch, the catch rate for prairie shrews within vegetation zones was highest in the Shrub Grasslands zone, where 10.7% of the plots trapped had a CE > 0. Within topographic habitats, the Sand Dunes was highest, with 12.7% of the plots trapped having a CE > 0 (Table 3). The catch rate within topographic habitats ranged from 9% to 13% of the plots that were trapped having a CE > 0 (Table 3). Overall, 10% of the plots trapped (39/391) had a CE > 0, and a total of 44 prairie shrews were caught in 1994 to1995 (Table 3; Table 2). The overall local abundance level for prairie shrews was medium (Appendix 7). Within vegetation zones, the local abundance level for Shrub Grasslands was high, while within topographic habitats the Sand Dunes, Interdunal–Morainal, and Ravines were high (Table 3).

The proportion of prairie shrews in the total catch increased from 1.9% (fifth rank in 1994) to 4.2% (second rank in 1995); however, none were caught in 1996 (Table 2). Within vegetation zones, 65.9% (29/44) of the prairie shrews were caught in the Shrub Grasslands zone, 31.8% (14/44) were caught in the Grasslands zone, and 2.3% (1/44) were caught in the Shrubs–Trees zone. Within topographic habitats, the proportion of the catch was distributed as follows: the Sand Dunes at 38.6% (17/44), the Flat Uplands at 36.4% (16/44), the Ravines at 15.9% (7/44), the Interdunal–Morainal at 9.1% (4/44), and the Wet Areas at 0%.

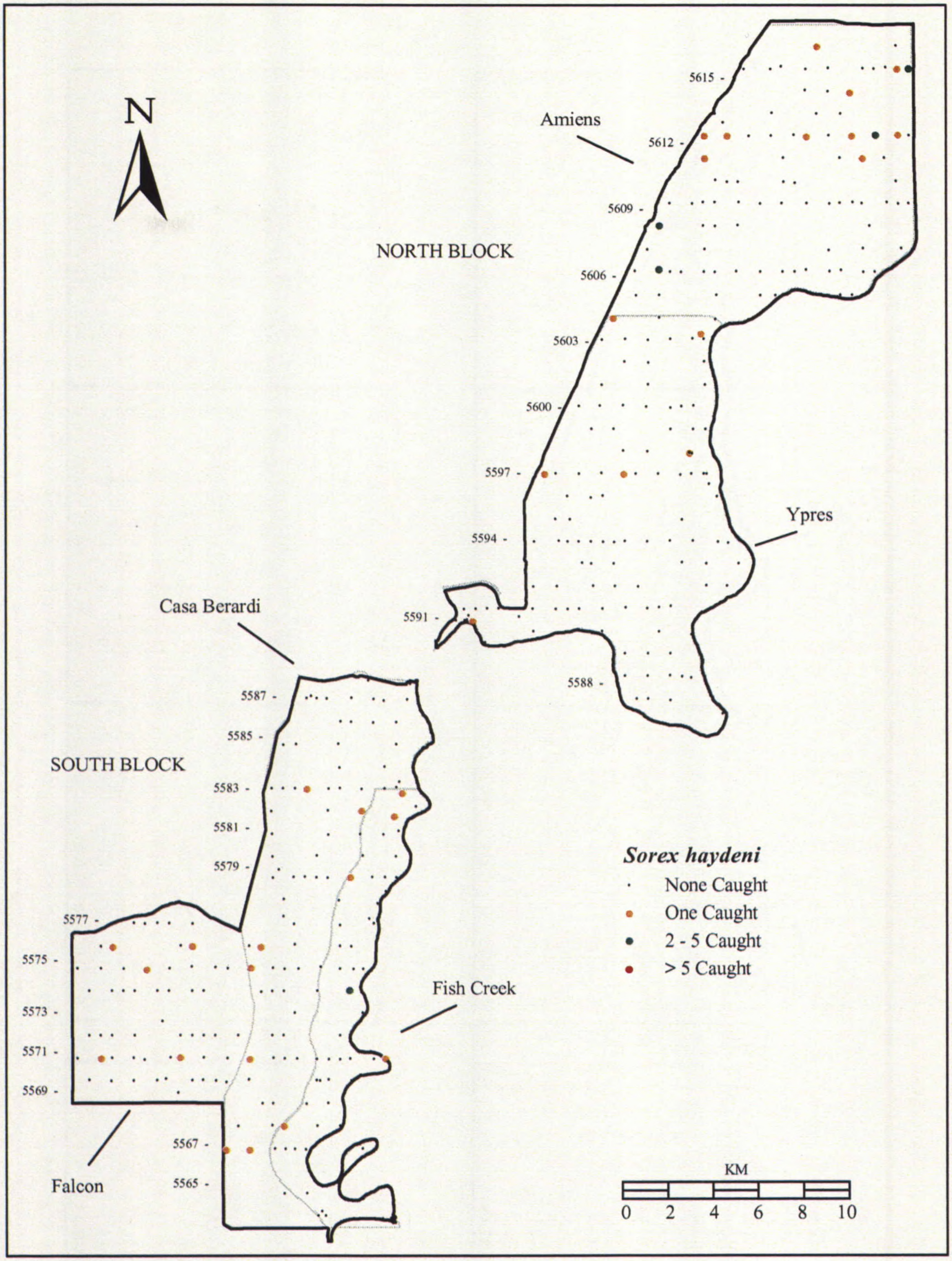

Figure 6. Prairie shrew trapping distribution in the CFB Suffield National Wildlife Area, 1994-1995.

Table 3. Mean catch effort (CE) values for 10 species of small mammals, mean pellet count density for lagomorphs, mean mound count density for northern pocket gophers, and species abundance levels in vegetation zones and topographic habitats within the CFB Suffield National Wildlife Area, 1994-1995.

		PRAIRIE SHREW						THIRTEEN-LINED GROUND SQUIRREL						OLIVED-BACKED POCKET MOUSE					
	n*	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level
VEGETATION ZONES																			
GRASSLANDS	149	14	9.4	14	0.09	0.29	M	13	8.7	16	**0.13**	0.44	H	1	0.7	1	0.01[a]	0.08	L
SHRUB GRASSLANDS	224	24	10.7	29	**0.13**	0.43	H	12	5.4	13	0.06	0.27	M	12	5.4	12	**0.06[a]**	0.24	M
SHRUBS - TREES	18	1	5.6	1	0.06	0.25	M	0	0.0	0	0.00	0.00	-	0	0.0	0	0.00	0.00	-
TOPOGRAPHIC HABITATS																			
SAND DUNES	110	14	12.7	17	**0.16**	0.45	H	7	6.4	8	0.07	0.29	M	11	10.0	11	**0.10[abc]**	0.32	H
FLAT UPLANDS	181	17	9.4	16	0.09	0.29	M	17	9.4	20	**0.13**	0.44	H	2	1.1	2	0.01[a]	0.10	L
INTERDUNAL - MORAINAL	35	3	8.6	4	0.12	0.41	H	1	2.8	1	0.03	0.17	L	0	0.0	0	0.00[b]	0.00	-
RAVINES	57	5	8.8	7	0.12	0.47	H	0	0.0	0	0.00	0.00	-	0	0.0	0	0.00[c]	0.00	-
WET AREAS	8	0	0.0	0	0.00	0.00	-	0	0.0	0	0.00	0.00	-	0	0.0	0	0.00	0.00	-

		ORD'S KANGAROO RAT						WESTERN HARVEST MOUSE						DEER MOUSE					
	n*	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level	n'	% n'	tc	$\bar{X}$ CE**	sd CE	Level
VEGETATION ZONES																			
GRASSLANDS	149	1	0.7	1	0.01[a]	0.09	L	17	11.4	27	0.18	0.56	M	89	59.7	247	1.71[ab]	2.74	L
SHRUB GRASSLANDS	224	21	9.4	40	**0.19[a]**	0.82	H	39	17.4	61	0.28	0.79	H	192	85.7	1144	5.34[a]	5.57	H
SHRUBS - TREES	18	0	0.0	0	0.00	0.00	-	1	5.6	6	**0.36**	1.51	H	17	94.4	98	**5.62[b]**	3.34	H
TOPOGRAPHIC HABITATS																			
SAND DUNES	110	15	13.6	27	**0.25[a]**	0.77	H	12	10.9	20	0.19	0.63	M	97	88.2	647	**6.14[ab]**	6.12	H
FLAT UPLANDS	181	3	1.6	3	0.02[a]	0.14	L	34	18.8	58	**0.32**	0.91	H	122	67.4	458	2.65[ac]	3.77	M
INTERDUNAL - MORAINAL	35	1	2.8	1	0.03	0.17	L	5	14.3	5	0.14	0.35	M	23	65.7	109	3.16[b]	4.66	M
RAVINES	57	3	5.3	10	0.19	1.21	H	6	10.5	11	0.20	0.72	M	51	89.5	264	4.82[c]	4.43	H
WET AREAS	8	0	0.0	0	0.00	0.00	-	0	0.0	0	0.00	0.00	-	5	62.5	11	1.36	1.52	L

Table 3. Continued.

	NORTHERN GRASSHOPPER MOUSE							MEADOW VOLE							SAGEBRUSH VOLE						
	n*	n'	% n'	tc	X̄ CE**	sd CE	Level	n	n'	% n'	tc	X̄ CE**	sd CE	Level	n	n'	% n'	tc	X̄ CE**	sd CE	Level
VEGETATION ZONES																					
GRASSLANDS	149	1	0.7	1	0.01	0.08	L	149	10	6.7	17	0.12	0.49	L	149	1	0.7	2	0.01	0.16	H
SHRUB GRASSLANDS	224	7	3.1	12	**0.05**	0.34	M	224	36	16.1	57	**0.26**	0.73	M	224	0	0.0	0	0.00	0.00	-
SHRUBS - TREES	18	0	0.0	0	0.00	0.00	-	18	1	5.6	2	0.12	0.50	L	18	0	0.0	0	0.00	0.00	-
TOPOGRAPHIC HABITATS																					
SAND DUNES	110	6	5.4	9	**0.08**	0.39	H	110	21	19.1	34	0.32	0.79	M	110	0	0.0	0	0.00	0.00	-
FLAT UPLANDS	181	2	1.1	4	0.02	0.24	L	181	15	8.3	28	0.16	0.63	L	181	1	0.6	2	0.01	0.14	H
INTERDUNAL - MORAINAL	35	0	0.0	0	0.00	0.00	-	35	5	14.3	6	0.18	0.46	M	35	0	0.0	0	0.00	0.00	-
RAVINES	57	0	0.0	0	0.00	0.00	-	57	3	5.3	4	0.07	0.33	L	57	0	0.0	0	0.00	0.00	-
WET AREAS	8	0	0.0	0	0.00	0.00	-	8	3	37.5	4	**0.50**	0.75	H	8	0	0.0	0	0.00	0.00	-

	HOUSE MOUSE							LAGOMORPH PELLETS						NORTHERN POCKET GOPHER MOUNDS					
	n*	n'	% n'	tc	X̄ CE**	sd CE	Level	n	n"	% n"	X̄ p/ha**	sd	Level	n	n'''	% n'''	X̄ m/ha**	sd	Level
VEGETATION ZONES																			
GRASSLANDS	149	1	0.7	1	0.01	0.08	H	211	73	34.6	154.4	566.0	L	216	80	37	197.9[a]	387.0	L
SHRUB GRASSLANDS	224	0	0.0	0	0.00	0.00	-	337	138	40.9	**396.0**	2587.9	M	336	233	69.3	**790.9**[ab]	1058.1	H
SHRUBS - TREES	18	0	0.0	0	0.00	0.00	-	13	1	7.7	11.5	41.6	L	26	6	23.1	108.7[b]	264.5	L
TOPOGRAPHIC HABITATS																			
SAND DUNES	110	0	0.0	0	0.00	0.00	-	208	81	38.9	298.1	2444.9	L	181	165	91.2	**1162.4**[abcd]	1102.1	H
FLAT UPLANDS	181	1	0.6	1	0.01	0.07	H	246	94	38.2	186.1	574.8	L	257	111	43.2	274.5[a]	639.1	L
INTERDUNAL - MORAINAL	35	0	0.0	0	0.00	0.00	-	54	21	38.9	189.4	869.7	L	53	31	58.5	413.7[b]	631.7	M
RAVINES	57	0	0.0	0	0.00	0.00	-	50	15	30	**935.0**	4385.3	H	79	12	15.2	107.0[c]	360.1	L
WET AREAS	8	0	0.0	0	0.00	0.00	-	3	1	33.3	483.3	837.2	M	8	0	0	0.0[d]	0.0	-

* Number of plots sampled (n); number of plots with CE>0 (n'); number of plots with pellets present (n"); number of plots with mounds present (n'''); percent of plots with CE>0 (% n'); percent of plots with pellets present (% n"); percent of plots with mounds present (% n'''); total number of animals caught (tc); mean CE (X̄ CE); mean number of pellets/ha (X̄ p/ha); mean number of mounds/ha (X̄ m/ha); standard deviation CE (sd CE) or standard deviation (sd); and local abundance level (Level) where - =nil, L=low, M=medium, H=high.

** Means followed by the same letter are significantly (P<0.05) different with the ANOVAs for the vegetation zones and the topographic habitats being separate tests.

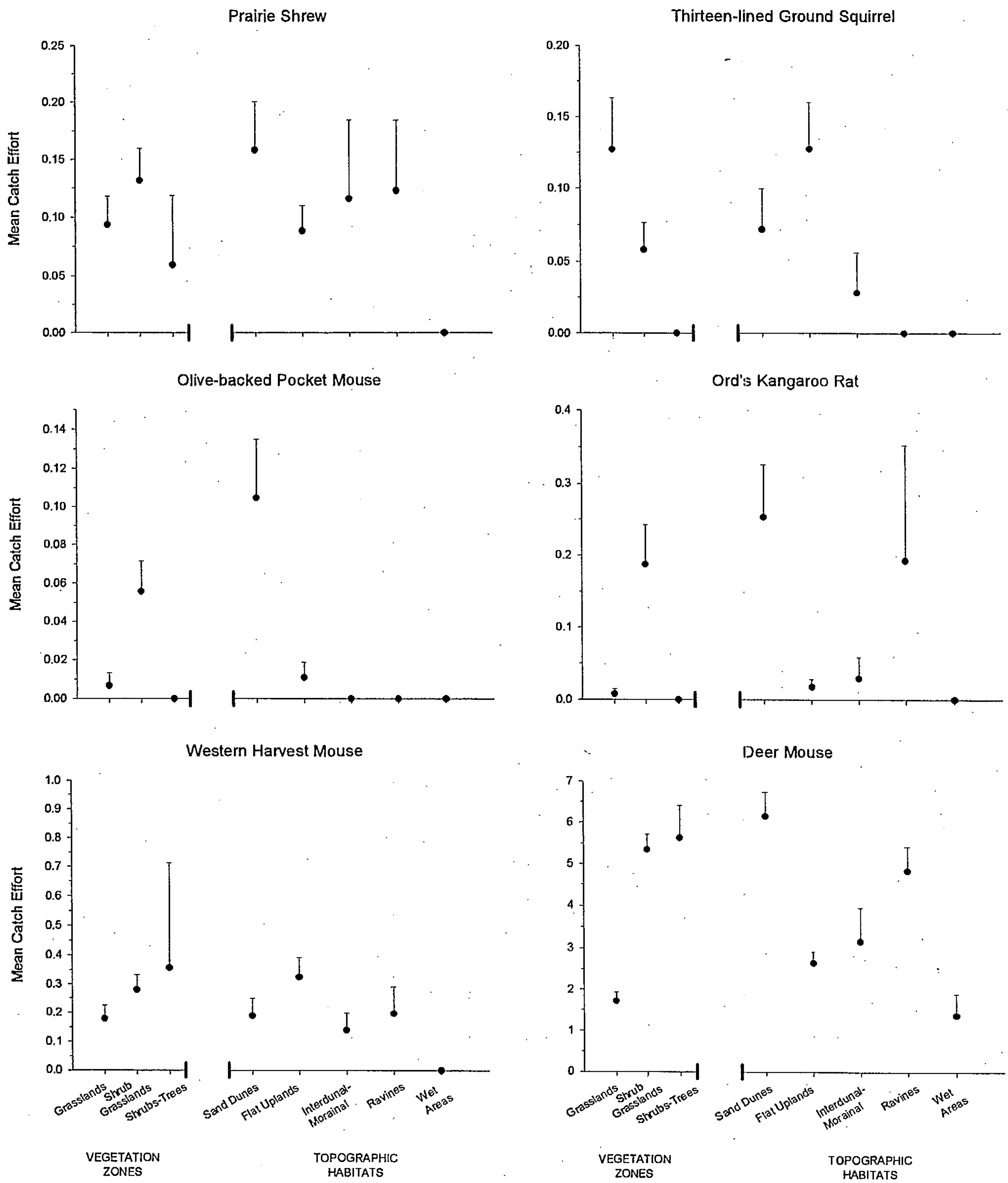

Figure 7. Mean catch effort (CE) values for 10 species of small mammals, mean number of pellets/ha for lagomorphs, and mean number of mounds/ha for northern pocket gophers in vegetation zones and topographic habitats in the CFB Suffield National Wildlife Area, 1994 -1995. Error bars represent 1 standard error of the mean.

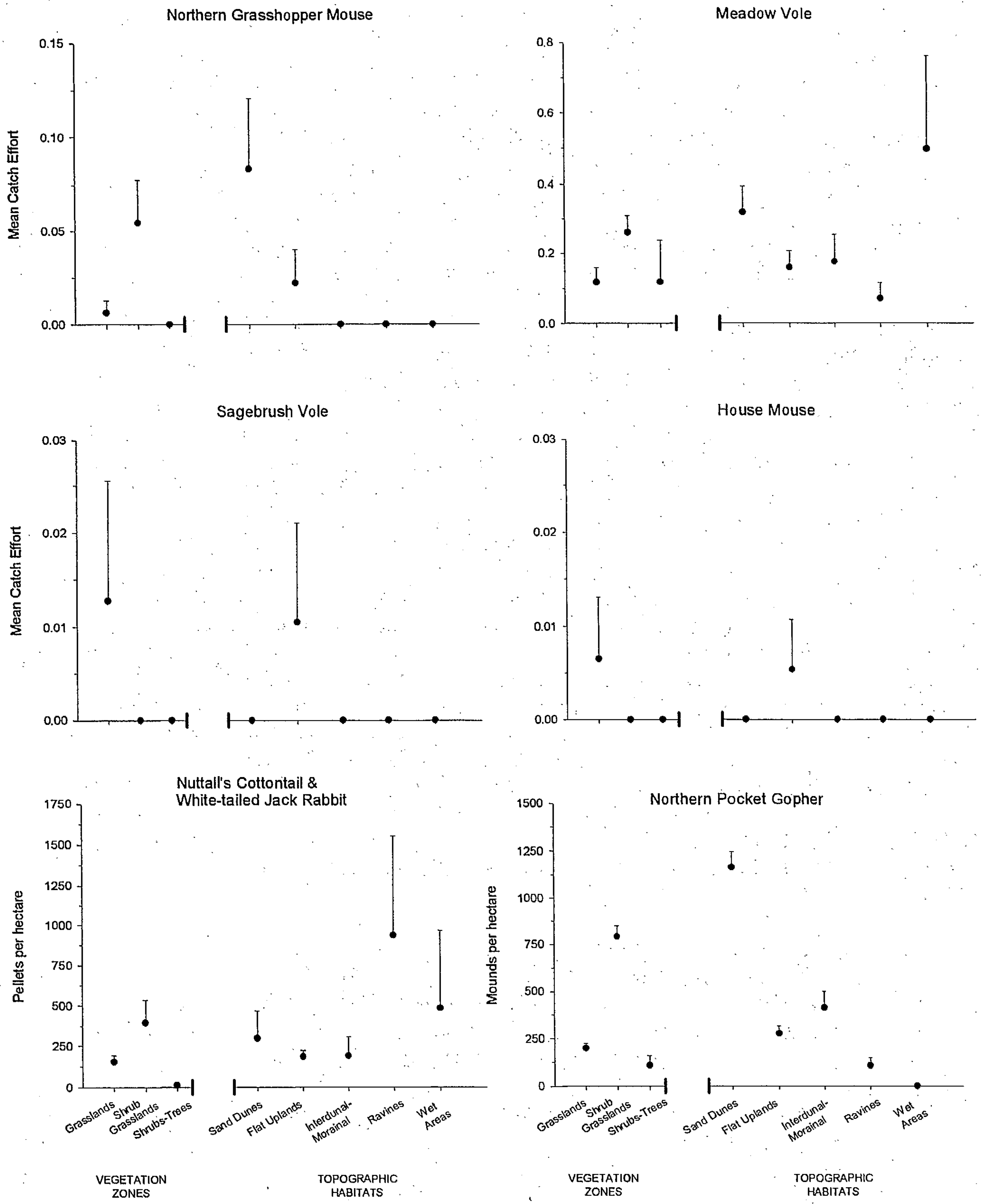

Figure 7. Continued.

3.3.2 Bat Species

Of the 19 bat species occurring in Canada, 6 were recorded in the SNWA: the little brown bat (*Myotis lucifugus*), the long-eared bat (*Myotis evotis*), the long-legged bat (*Myotis volans*), the western small-footed bat (*Myotis ciliolabrum*), the big brown bat (*Eptesicus fuscus*), and the hoary bat (*Lasiurus cinereus*) (McNalley and Barclay 1995). The distribution and abundance of bats in the SNWA was determined from the results of mist netting at 35 different sites in 1995 and from 56 incidental observations (Figure 8). In 1994, there were 9 incidental observations, with 33 incidental observations in 1995 along with mist net trapping at 35 different sites. In 1996, there were 14 incidental observations and mist net trapping at 4 more sites.

Bats were distributed mainly along the South Saskatchewan River valley within 1 km of the river in both the North and South Blocks of the SNWA (Figure 8). The incidental observations showed that bats were also distributed up to 12 km from the South Saskatchewan River along the Double Wide Fireguard in the North Block (Figure 8). However, most of the incidental observations highlighted routes of main roads and trails throughout the North Block, as would be expected since the majority were collected by the kangaroo rat team during nightlight surveys. Within vegetation zones, the plots of high-density (> 3 caught) occurred only in the North Block and were associated mainly with the Shrub Grasslands zone. Only 2 catch plots were associated with the Shrubs–Trees zone. The plots of low-density (1-3 caught) were nearly equally represented in both the North and South Blocks, and were associated with both the Shrub Grasslands and the Shrubs–Trees zones. Within topographic habitats, about 73% of the mist net sites where bats were caught were associated with the Ravines topographic habitat, including 6 of the 8 high-density (> 3 caught) plots. Bats were caught in 2 plots in the Sand Dunes and in 2 plots in the Flat Uplands topographic habitats. Five of the no-catch plots were in the Grasslands zone while 15 no-catch plots were in the Shrub Grasslands zone. All incidental observations of bats occurred in the North Block, where the majority were associated with the Shrub Grasslands vegetation zone and a few were associated with the Shrubs–Trees and Grasslands zones. Overall, there were 15 plot sites where bats were caught and 20 plot sites where mist nets were set, but no bats were caught (Figure 8). The species of bat caught, numbers of bats caught, the date, UTM co-ordinates, location name of the trap site, Figure 8 site number for mist net locations where bats were caught, and the sites where observed bats were identified are provided in Appendix 8.

The most abundant bat caught in the SNWA was the western small-footed bat, representing 50% of the catch (43/86 captures). The second most commonly caught bat was the long-eared bat at 32.6% of the catch (28/86), the third was the big brown bat at 7% of the catch (6/86), and the fourth was shared between the little brown and hoary bats for a total of 9.3% of the catch (4/86 for each species). The least caught bat was the long-legged bat at 1 of 86 captures for 1% of the total catch (McNalley and Barclay 1995). The 4 species of *Myotis* bats accounted for 88% (76/86) of the catch with 2 of those species, the western small-footed bat and the long-eared bat, comprising 82.6% of the catch.

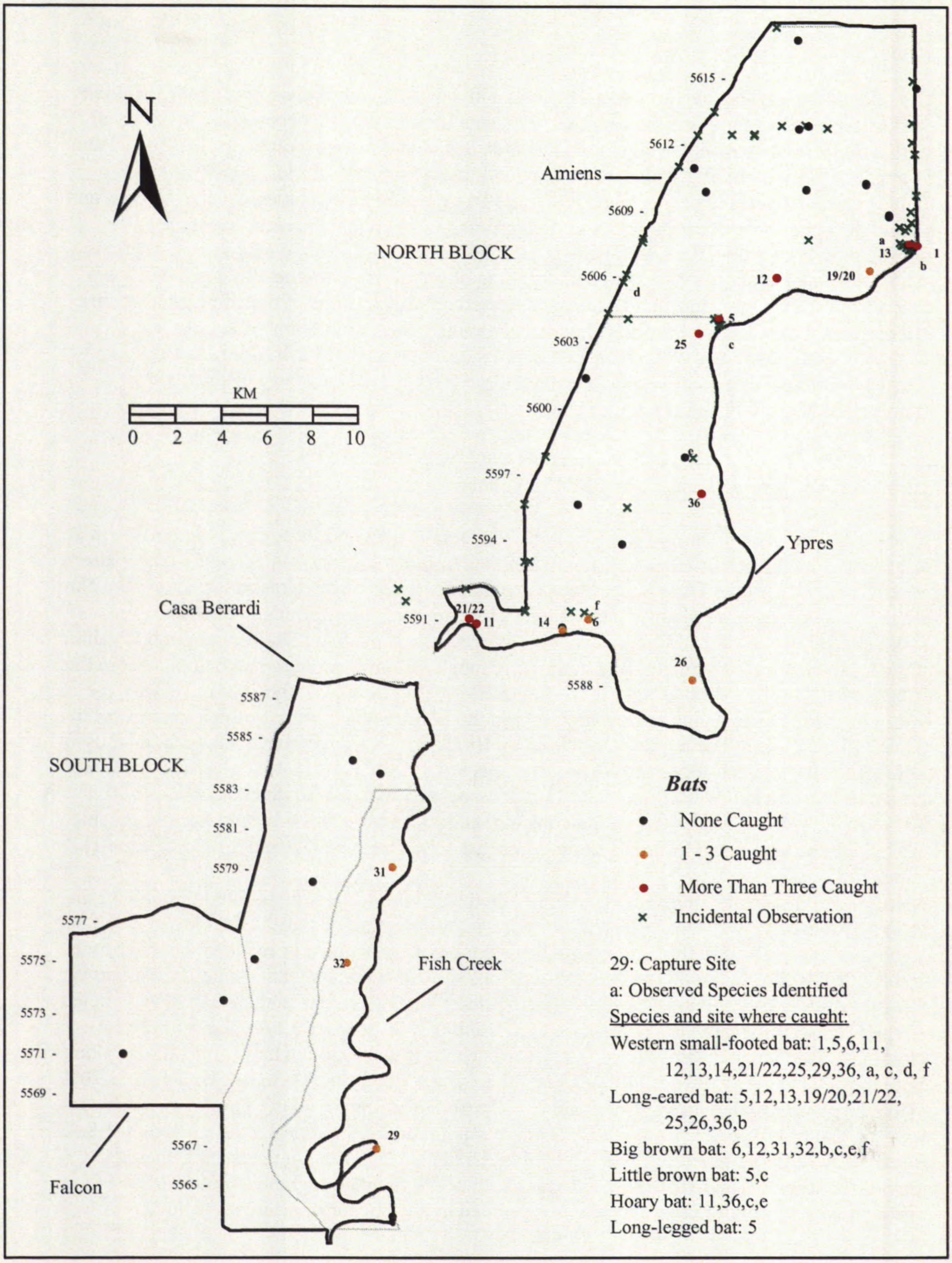

Figure 8. Sampling locations for, capture locations for, and incidental observations of 6 species of bats in the CFB Suffield National Wildlife Area, 1994-1996.

The total number of bat captures was distributed in a non-random pattern among the different ecosections, with the majority of captures (77%) occurring in the "F" ecosection, the Fluvial landforms of ravines, valley wall slopes, terraces, and slump blocks (Appendix 1). The Glacial-fluvial landform, including groves of cottonwood trees (*Populus deltoides*), had the second highest proportion of the captures at 20%. Based on the number of passes, feeding buzzes, and activity levels of bats, the most active ecosection was the Fluvial landform, which was significantly higher than the Glacial-fluvial, the Eolian, and the Ground Moraine ecosections (McNalley and Barclay 1995). Based on light-tag observations, 8 of the 13 tagged bats were observed in the Fluvial landform ecosection. Based on observations of bat emergence at dusk and collection of bat feces from daytime investigations, groves of cottonwood trees and sandstone cliffs in ravines were identified as potential roosting sites (McNalley and Barclay 1995). Additional information on the results of the 1995 bat fauna survey of the SNWA is presented in McNalley and Barclay (1995).

3.3.3 Nuttall's cottontail and white-tailed jack rabbit

Based on 48 incidental observations, Nuttall's cottontails occurred throughout the SNWA in a somewhat scattered distribution (Figure 9). In the North Block, nearly 40% of the observations were within the Shrubs–Trees zone, with the remainder in the Shrub Grasslands zone. The North Block observations were mainly in the Ravines topographic habitat along the South Saskatchewan River. In addition, observations occurred in the Sand Dunes topographic habitat in the northwest part of Amiens, and in the Interdunal–Morainal topographic habitat. More than 60% of the total observations were in the South Block (Figure 9). Of those, about 70% were within the Shrub Grasslands zone, a few were in the Shrubs–Trees zone, with the remainder in the Grasslands zone. The majority of the South Block observations were in the Flat Uplands topographic habitat. However, some observations were in the Ravines topographic habitat and the Sherwood and Dugway cottonwood forests associated with the South Saskatchewan River. A few were in the Sand Dunes topographic habitat, and some were in the Wet Areas topographic habitat and the associated lowlands in the southeast corner near Old Channel Lake (Figure 1).

Based on 360 incidental observations, white-tailed jack rabbits were distributed throughout the SNWA (Figure 9). More than 90% of the observations were in the North Block, with about 80% of those occurring within the Shrub Grasslands zone and the remainder in the Grasslands zone. In the North Block, about 40% of the observations were in the Sand Dunes topographic habitat, 30% were in the Flat Uplands, 25% were in the Interdunal–Morainal, and about 5% were in the Ravines topographic habitat. White-tailed jack rabbits were scattered throughout the North Block, but observations were skewed to west of central in the southern half of this block, along main roads where they were readily visible, especially at night. In the South Block, about 70% of the observations were in the Grasslands zone with the remainder in the Shrub Grasslands zone, a reverse pattern from the North Block. From a topographic habitat perspective within the South Block, 41% of the observations were in the Flat Uplands, 28% were in the Sand Dunes, 21% were in the Ravines, and 10% were in the Interdunal–Morainal topograhic habitat. Most of the white-tailed jack rabbit observations were provided by the kangaroo rat survey team.

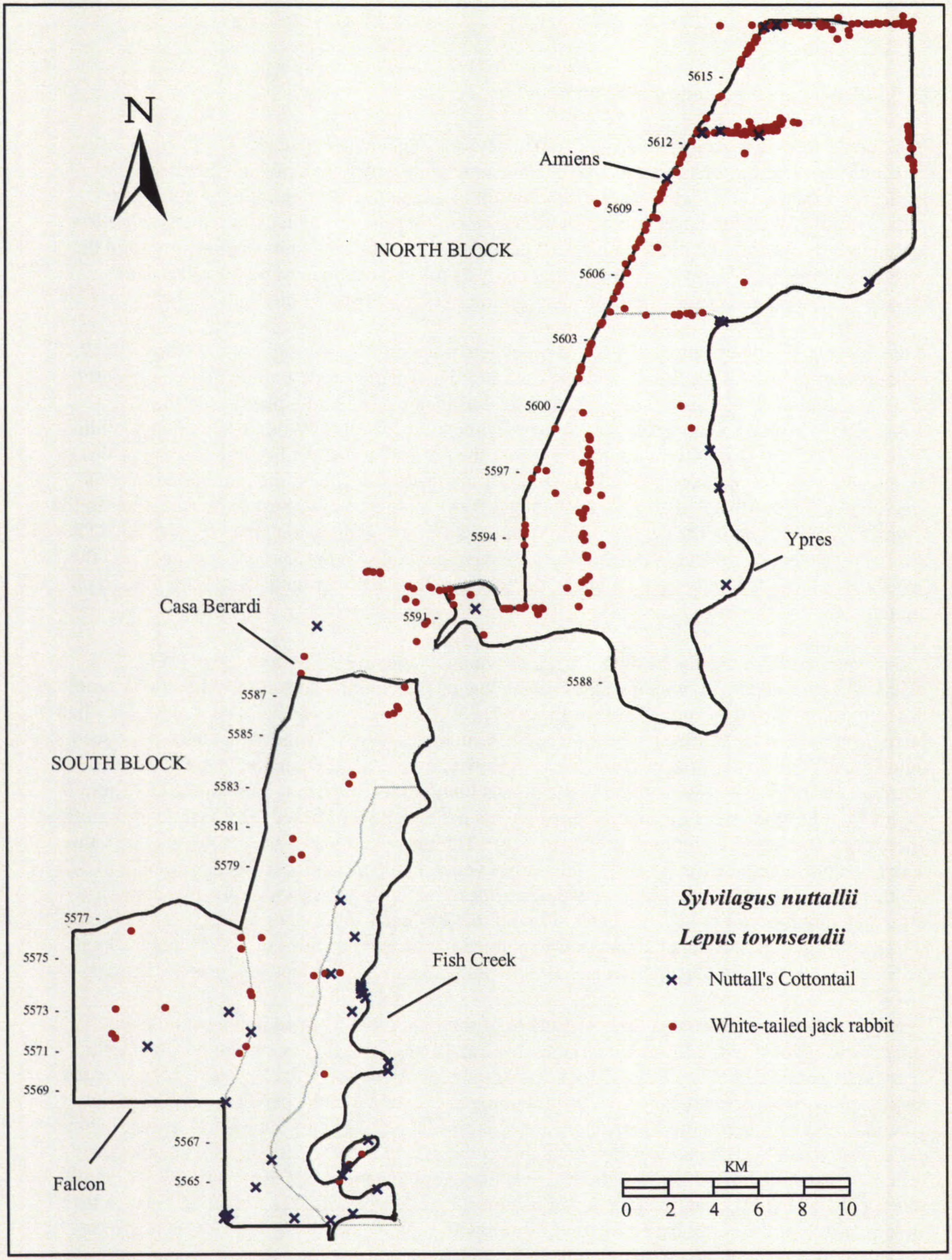

Figure 9. Incidental observations of Nuttall's cottontail and white-tailed jack rabbit in the CFB Suffield National Wildlife Area, 1994-1996.

3.3.3.1 Pellet transect counts for lagomorphs

Pellet count transects occurred during 11 field days in 1994 and 12 field days in 1995. The distribution of lagomorphs (Nuttall's cottontails and white-tailed jack rabbits) based on incidental observations (Figure 9), the distribution based on the mean number of pellets per hectare (Table 3), and the distribution based on the contour map of pellet count density (pellets per hectare) for individual plots (Figure 10) provided 3 independent sources of information that were complementary. However, in the final analysis the contour map of pellet count data provided a more detailed picture of the distribution of lagomorphs within the SNWA.

In the SNWA, the distribution of lagomorph pellets was scattered throughout the North Block, and occurred mainly in the Shrub Grasslands zone. The Ravines topographic habitat along the South Saskatchewan River in the middle of the North Block, the Flat Uplands and the Interdunal–Morainal topographic habitats at the junction of Double Wide Fireguard and Whitco Trail, and the Sand Dunes topographic habitat in the northwest had the highest concentrations of lagomorph pellets in the North Block (Figure 10). In the South Block, the numbers of pellets were highest in the Bull Pen area, in the wetland flats along the South Saskatchewan River in the southwest corner, and in the central portions of Casa Berardi and Falcon areas (Figure 10). The plots of high-density pellets in the South Block were generally in the Shrub Grasslands and the Grasslands zones and in the Flat Uplands, the Ravines, and the Interdunal–Morainal topographic habitats.

Within vegetation zones, the Shrub Grasslands zone had the highest overall mean (396) pellets/ha count (Table 3), which was 2.5 times that of the Grasslands zone and nearly 35 times that of the Shrubs–Trees zone (Table 3; Figure 7). Within topographic habitats, the Ravines had the highest overall mean (935) pellets/ha count, which was nearly 2 times greater than the second highest mean value (483) for the Wet Areas, followed by the Sand Dunes at 298, the Interdunal–Morainal at 189, and the Flat Uplands topographic habitat at 186 pellets/ha (Table 3; Figure 7). The Wet Areas mean number of pellets per hectare was based on a sample of 3 plots where only 1 plot had lagomorph pellets present. The mean number of pellets per hectare values were not significantly different ($P > 0.05$) across vegetation zones nor across topographic habitats (Table 3), although within vegetation zones, the Shrub Grasslands zone had a much larger mean number of pellets per hectare as did the Ravines within topographic habitats (Figure 7). The individual plot pellet count values attained maximum densities of 34,750 pellets/ha in the Sand Dunes topographic habitat and 27,350 pellets/ha in the Ravines topographic habitat.

Based on pellet transect counts, the percentage of sampled plots that had lagomorph pellets present was highest in the Shrub Grasslands zone at 40.9%, with the second highest being the Grasslands zone at 34.6%. Only 7.7% (1/13) of the plots sampled in the Shrubs–Trees zone had lagomorph pellets present (Table 3). Within topographic habitats, the percentage of plots that were sampled with lagomorph pellets present was similar among the 5 habitats. The Sand Dunes and the Interdunal–Morainal topographic habitats were each at 39%, the Flat Uplands was at 38%, the Wet Areas had 33%, and the Ravines topographic habitat had 30% (Table 3). Overall, 37.8% (212/561) of the sampled plots had lagomorph pellets present. The local abundance levels for lagomorph pellet count density varied from low to high, where the Shrub Grasslands zone was medium and the Ravines topographic habitat was high (Table 3).

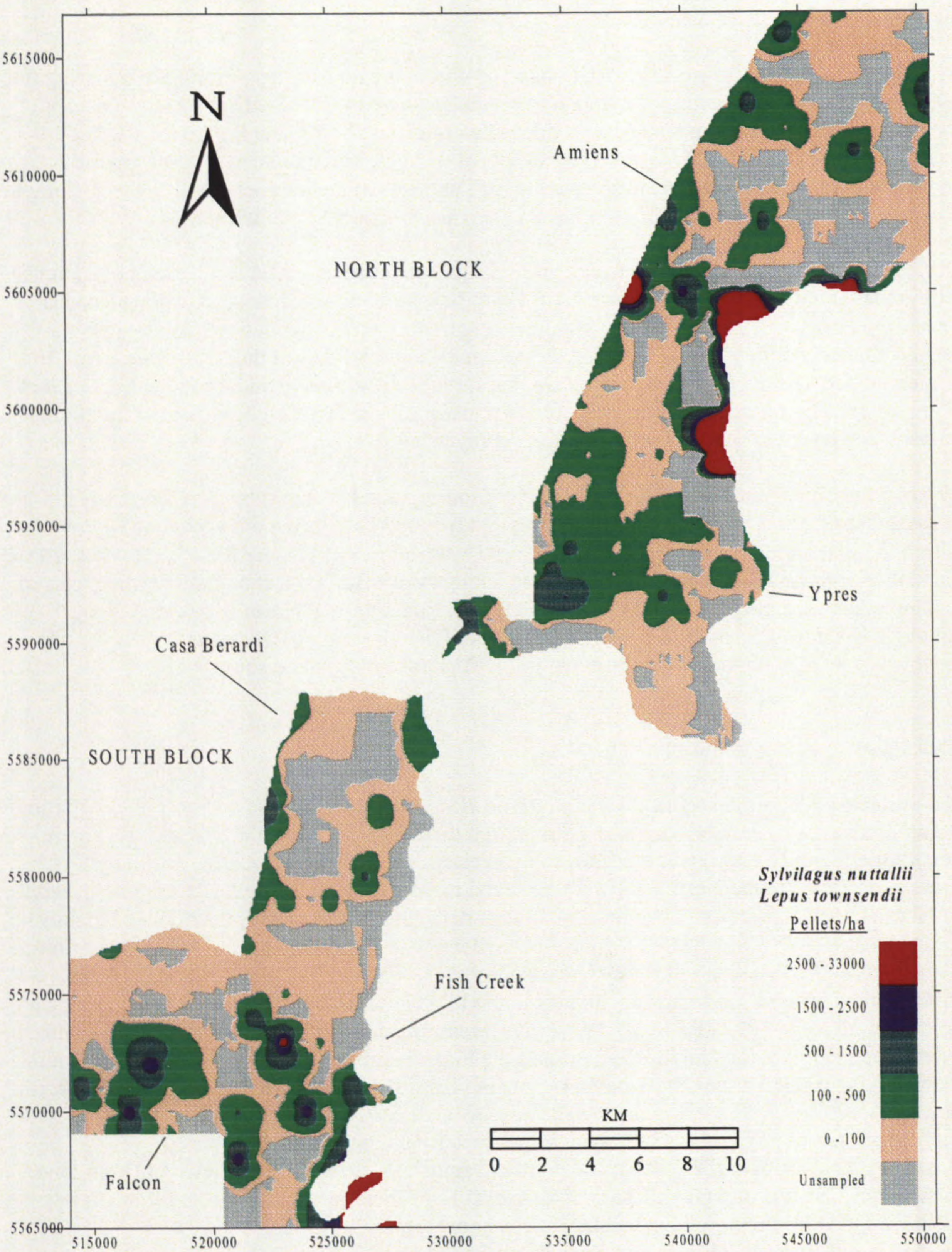

Figure 10. Lagomorph pellet count density (pellets/ha) in the CFB Suffield National Wildlife Area, 1994-1995.

3.3.4 Richardson's ground squirrel

Richardson's ground squirrels were not observed within the boundaries of the SNWA during the 1994 field season. However, they were observed elsewhere in CFB Suffield by various team members at locations along Kangaroo Rat Road west of the SNWA and Rattlesnake Road southwest of the junction of Hussar Trail. Signs of what appeared to be a remnant ground squirrel colony were evident near the junction of Lancer Trail at Antelope Road in the Nishimoto Flats area, but Richardson's ground squirrels were never observed at this site (Figure 1).

During fieldwork in 1995, Richardson's ground squirrels were observed at 4 different locations within the boundaries of the SNWA, and in 1996 they were observed along Antelope Road at Sherwood Forest in Nishimoto Flats (Figure 1; Figure 11). The distribution of Richardson's ground squirrels in the SNWA included the extreme southwest part of the North Block and 3 scattered observations from east, central southeast to the northwest boundary in the South Block (Figure 11). The 1 sighting on the east side of transect line 5571 was a dead animal caught in a pitfall snake trap that was set by the herptile survey team.

Three of the 6 incidental observations of Richardson's ground squirrels in the SNWA were in the Grasslands zone and 3 were in the Shrub Grasslands zone. Five of the 6 observations were within the Flat Uplands topographic habitat and 1 was in the Sand Dunes habitat. However, 4 of the 6 observations were on road rights-of-way, along South Buffalo Road in the northern part of the South Block, along Mule Deer Road in the southern part of the North Block, and along Antelope Road near Sherwood Forest in Nishimoto Flats (Figure 1). During the SNWA study, there was a total of 25 incidental observations of Richardson's ground squirrels.

3.3.5 Thirteen-lined ground squirrel

The thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) was restricted in distribution to mainly 2 areas in the SNWA based on snap trap data and 7 incidental observations (Figure 12). In the South Block, it was confined to the western half of Falcon, mainly within the Grasslands zone. In the North Block, it was found mainly in the northwest part of Amiens within the Shrub Grasslands zone. The plots of medium-density (2-5 caught) were associated mainly with the Grasslands zone, while the plots of low-density (1 caught) were fairly evenly distributed throughout the Grasslands and Shrub Grasslands zones. The individual plot CE values for thirteen-lined ground squirrels were highest in the Flat Uplands topographic habitat, attaining a maximum of 2.9 in 1995 (Table 2). The 2 main areas of catch for thirteen-lined ground squirrels were associated with the Grasslands zone and the Flat Uplands topographic habitat in the South Block, and with the Shrub Grasslands zone and the Sand Dunes topographic habitat in the North Block.

The mean CE values for the thirteen-lined ground squirrel were highest in the Grasslands zone and the Flat Uplands topographic habitat, both at 0.13 (Table 3; Figure 7). The Shrub Grasslands and the Sand Dunes topographic habitats had the next highest mean CE values, each at about one-half of the highest value. None were caught in the Shrubs–Trees zone or in the Ravines and

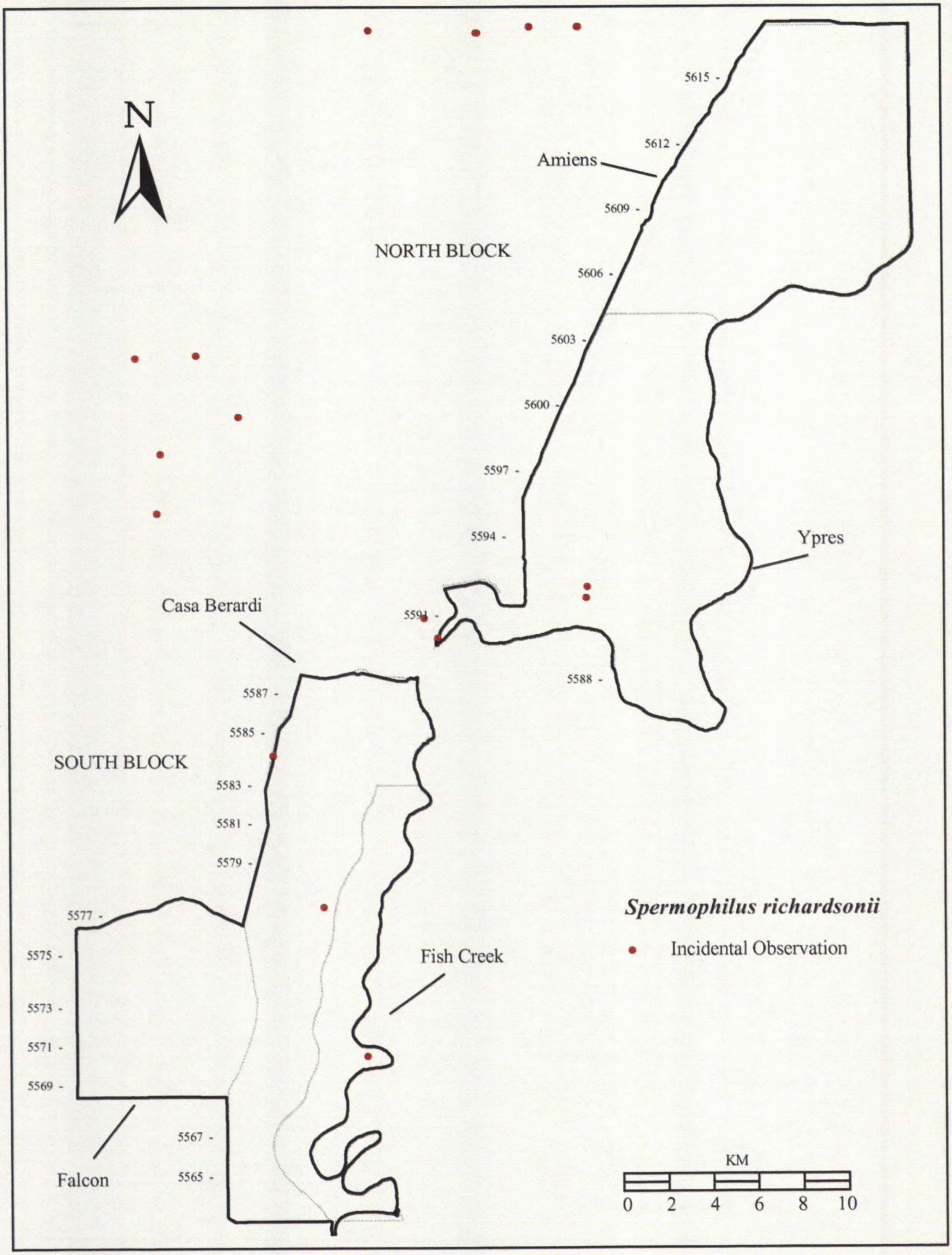

Figure 11. Incidental observations of Richardson's ground squirrel in the CFB Suffield National Wildlife Area, 1994-1996.

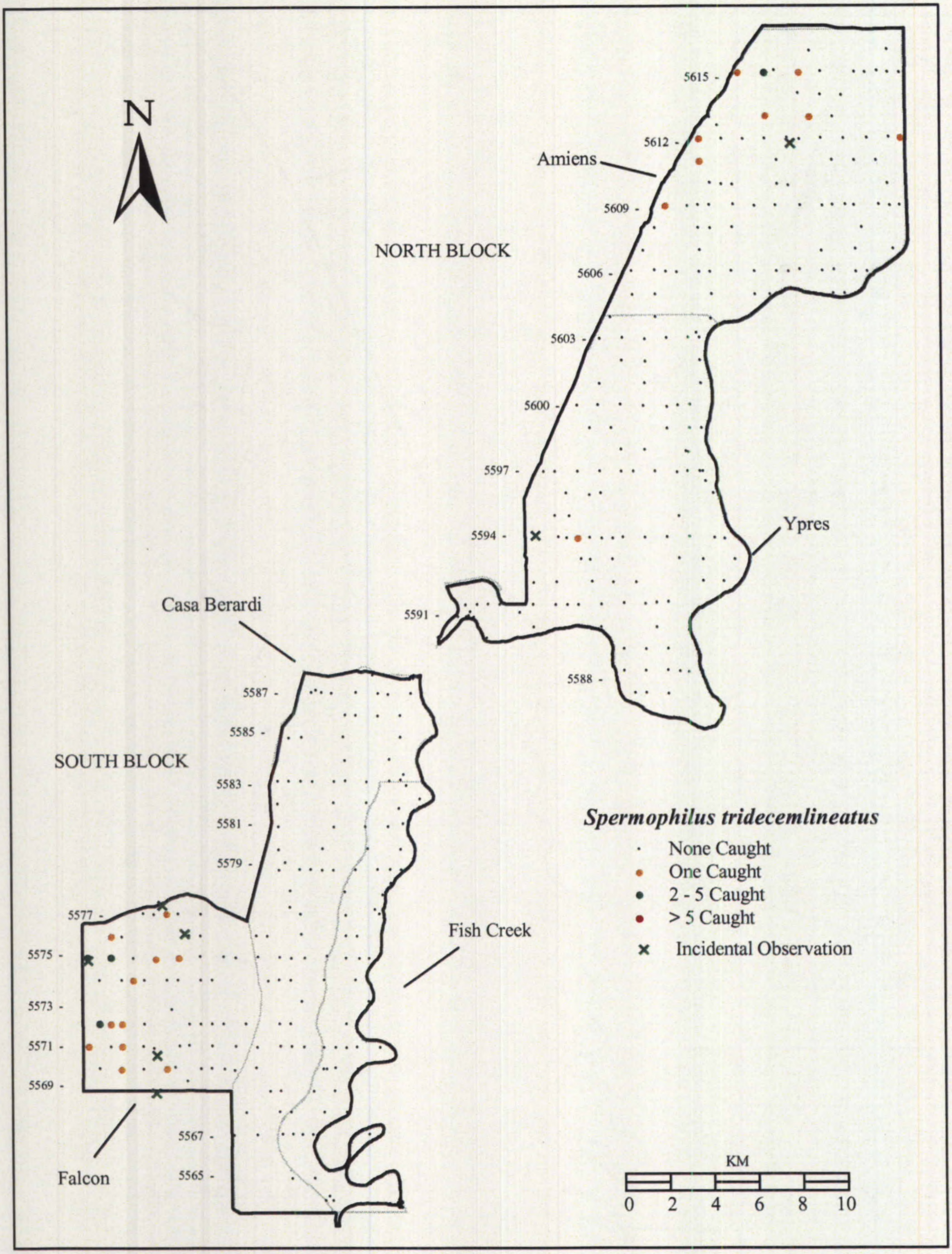

Figure 12. Thirteen-lined ground squirrel trapping distribution and incidental observations in the CFB Suffield National Wildlife Area, 1994-1996.

Wet Areas topographic habitats (Table 3; Figure 7). Within vegetation zones and topographic habitats, the mean CE values were not significantly different (P > 0.05); however, within vegetation zones the Grasslands zone had a much larger mean CE (2 times), as did the Flat Uplands within the topographic habitats (Table 3).

The catch rate for thirteen-lined ground squirrels, based on the number of plots with a catch within vegetation zones, was highest in the Grasslands zone where 8.7% of the plots trapped had a CE > 0. Within topographic habitats, the Flat Uplands was highest with 9.4% of the plots trapped having a CE > 0 (Table 3). Overall, 6.4% of the plots trapped (25/391) had a CE > 0 with a total of 29 thirteen-lined ground squirrels caught in 1994-1995 (Table 3; Table 2). The overall local abundance level for thirteen-lined ground squirrels was medium (Appendix 7). Within vegetation zones, the local abundance level for Grasslands was high, while within topographic habitats the Flat Uplands was high (Table 3).

The proportion of thirteen-lined ground squirrels in the total catch increased from 1.2% and sixth rank in 1994 to 2.9% and fourth rank in 1995. In 1996, it continued to increase to 7.1% of the catch and reached second rank (Table 2). Within vegetation zones, 55.2% (16/29) of the thirteen-lined ground squirrels were caught in the Grasslands zone. The Shrub Grasslands zone was similar but slightly lower at 44.8% (13/29). Within topographic habitats, the Flat Uplands had 69% (20/29) of the catch, the Sand Dunes had 27.6% (8/29), and the Interdunal–Morainal topographic habitat had 3.4% (1/29).

3.3.6 Northern pocket gopher

Although 9 northern pocket gophers were caught by snap trapping from 1994 to 1995, the overall catch rate for trapped plots was extremely low at 2.3% and individual plot CE values attained a maximum of only 1.2. Snap trap methodology proved ineffective to properly delineate the distribution of northern pocket gophers because of the extremely low rate of catch relative to the high density of mounds observed throughout the SNWA. Therefore, we used mound count data (Table 3; Figure 13) to provide a more accurate representation of their distribution in the SNWA.

The distribution of the high density category for northern pocket gopher mounds was basically in the North Block (Figure 13) in the Shrub Grasslands zone and the Sand Dunes topographic habitat. Within the North Block, the Middle Sand Hills area in Amiens and an area in the southern half of Ypres had the highest concentrations of mounds (Figure 13). Within the South Block, the numbers of mounds per hectare were highest along the west boundary and in the central area of Falcon, but at lower density levels than in the North Block (Figure 13). The medium-to-high density counts in the South Block were generally within the Shrub Grasslands and the Grasslands zones, and within the Flat Uplands and Sand Dunes topographic habitats.

The mean numbers of mounds per hectare among the vegetation zones were significantly different (P < 0.05), with the mean mounds per hectare value for Shrub Grasslands being significantly higher than that for both the Grasslands (factor of 4) and Shrubs–Trees (factor of 7) zones (Table 3; Figure 7). Topographic habitats were significantly different (P < 0.05) where the

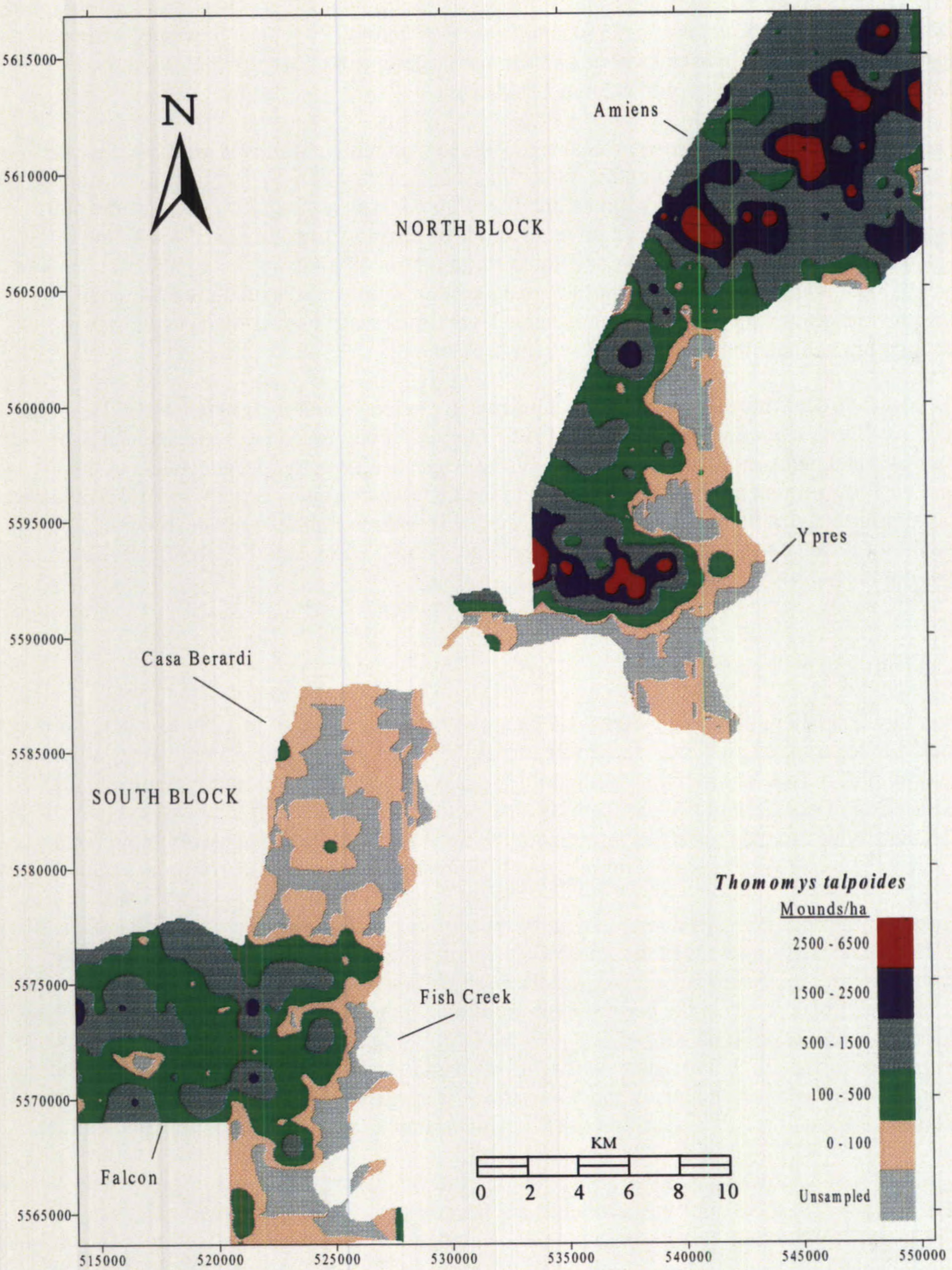

Figure 13. Northern pocket gopher mound count density (mounds/ha) in the CFB Suffield National Wildlife Area, 1994-1995.

mean mounds per hectare in Sand Dunes was 2.8 times greater than the Interdunal–Morainal, 4 times greater than the Flat Uplands, and nearly 11 times greater than the Ravines topographic habitat (Table 3; Figure 7). The Wet Areas topographic habitat had no mounds present.

Based on mound count surveys, the percentage of sampled plots within vegetation zones that had northern pocket gopher mounds present was highest in the Shrub Grasslands zone at 69.3%. Within topographic habitats, the Sand Dunes was highest, with 91.2% of the plots sampled having mounds present (Table 3). Overall, 55.2% of the plots sampled (319/578) had northern pocket gopher mounds present. The overall local abundance level for northern pocket gopher mounds in the SNWA was medium (Appendix 7). Within vegetation zones, the local abundance level for the Shrub Grasslands zone was high, while within topographic habitats the Sand Dunes was high (Table 3).

3.3.7 Olive-backed pocket mouse

Snap trapping results in the SNWA indicated that the olive-backed pocket mouse was distributed mainly throughout the north half of the North Block in Amiens, but in the South Block it was confined to two plots on the east side of Falcon in the central area (Figure 14). The majority of catch plots were within the Shrub Grasslands zone and the Sand Dunes topographic habitat. The individual plot CE values for olive-backed pocket mice were highest in the Sand Dunes topographic habitat, attaining a maximum of 1.1 (Table 2). No plots had more than 1 animal caught in either 1994 or 1995. The 91 incidental observations correlated with the snap trap data and expanded the distributional range to include the roads and trails of Double Wide Fireguard, Whitco Trail, Mounted Rifles Road, Kangaroo Rat Road, and East Boundary Trail in the North Block, and Dugway Trail, Interface/Trumpeter Trail, and South Buffalo Road in the South Block (Figure 1; Figure 14).

The mean CE values for the olive-backed pocket mouse were highest in Shrub Grasslands and Sand Dunes, which was the highest overall (Table 3; Figure 7). Olive-backed pocket mice were not caught in the Shrubs–Trees zone or in the Interdunal–Morainal, the Ravines, and the Wet Areas topographic habitats (Table 3; Figure 7). The mean CE values were significantly different ($P < 0.05$) across vegetation zones (Table 3). The Shrub Grasslands mean CE was significantly higher than that for Grasslands, and it was higher than the Shrubs–Trees zone (Figure 7), but not significant. The mean CE values were significantly different ($P < 0.05$) across topographic habitats (Table 3). The Sand Dunes mean CE was significantly larger than that for Flat Uplands, Interdunal–Morainal, and Ravines topographic habitats.

The catch rate for olive-backed pocket mice, based on the number of plots with a catch within vegetation zones, was highest in the Shrub Grasslands zone where 5.4% of the plots trapped had a CE > 0. Within topographic habitats, Sand Dunes was highest with 10% of the plots trapped having a CE > 0 (Table 3). Overall, 3.3% of the plots trapped (13/391) had a CE > 0 with a total of 13 olive-backed pocket mice caught in 1994-1995 (Table 3; Table 2). The overall local abundance level for olive-backed pocket mice was low (Appendix 7). Within vegetation zones, the local abundance level for Shrub Grasslands was medium, while within topographic habitats

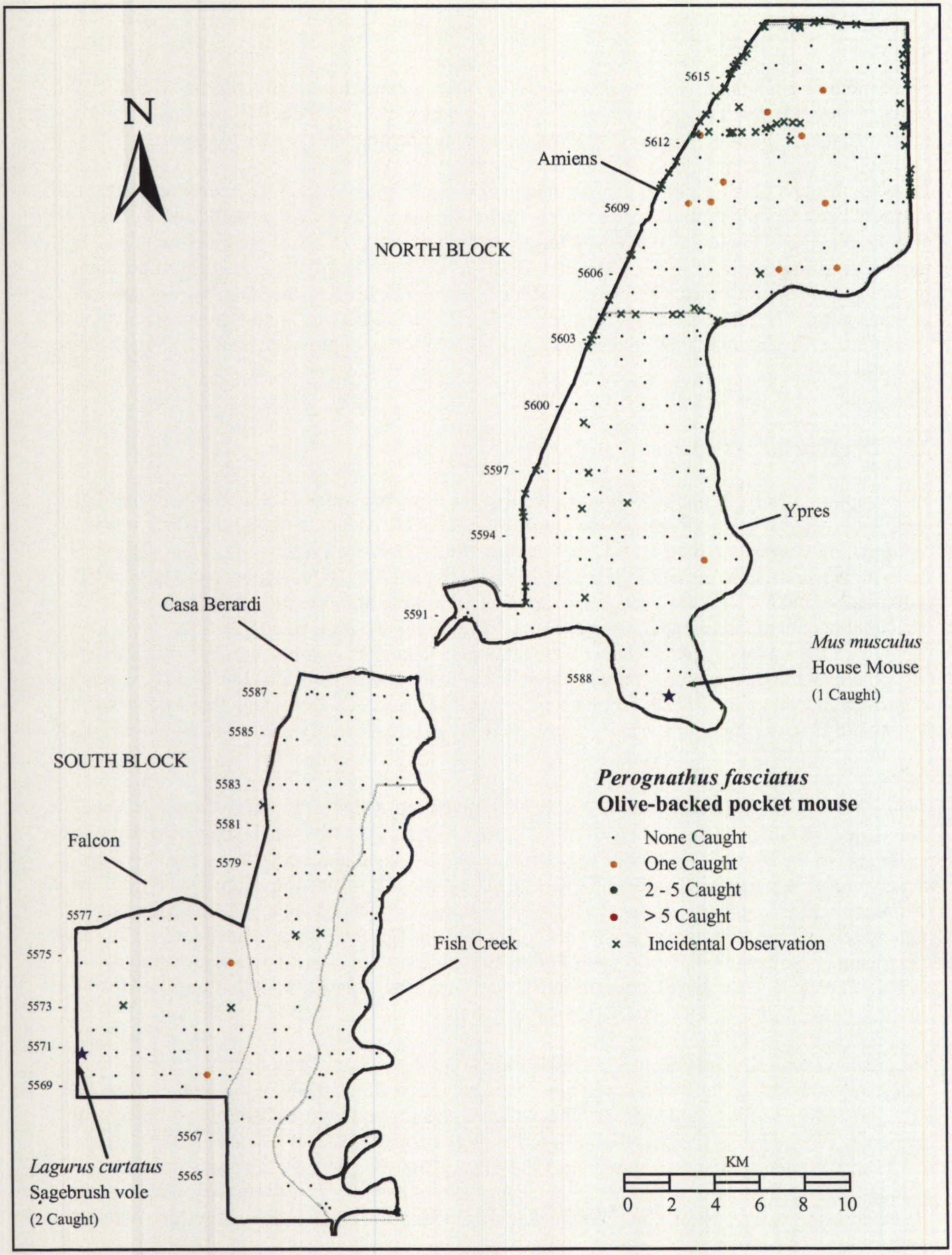

Figure 14. Olive-backed pocket mouse, sagebrush vole, and house mouse trapping distributions and incidental observations in the CFB Suffield National Wildlife Area, 1994-1996.

Sand Dunes was high (Table 3).

The proportion of olive-backed pocket mice in the total catch increased from 0.6% and eighth rank in 1994 to 1.1% of the total catch and seventh rank in 1995. It decreased to 0.4% of the catch in 1996 in a four-way tie at fourth rank (Table 2). Within vegetation zones, 92.3% (12/13) of the olive-backed pocket mice were caught in the Shrub Grasslands zone and 7.7% (1/13) were caught in the Grasslands zone. Within topographic habitats, 84.6% of the catch (11/13) was in the Sand Dunes and 15.4% (2/13) was in the Flat Uplands.

3.3.8 Ord's kangaroo rat snap trap inventory

Based on snap trap results in the SNWA, the Ord's kangaroo rat was distributed mainly in the northeast part of the North Block within the Middle Sand Hills portion of Amiens, but in the South Block it was confined to only 1 plot in Casa Berardi in the extreme northeast corner (Figure 15). The 6 plots of medium-density (2-5 caught) and the 1 plot of high-density (> 5 caught) were all within the Shrub Grasslands zone, and all but 1 of those plots were in the Sand Dunes topographic habitat. Fourteen of the 15 plots of low-density were within the Shrub Grasslands zone with only 1 plot located in the Grasslands zone. Within the topographic habitats, 9 of the 15 low-density plots were in the Sand Dunes, 4 were in the Flat Uplands, and 2 were in the Ravines. The individual plot CE values for Ord's kangaroo rats were highest in the Ravines topographic habitat in 1994, attaining a maximum of 9 (Table 2).

The incidental observations data from the nightlight surveys correlated with the snap trap data and expanded the distributional range to include the Double Wide Fireguard, Mule Deer Road, Whitco Trail, Mounted Rifles Road, Kangaroo Rat Road, and the East Boundary Trail in the North Block (Figure 1). Incidental observations determined that Ord's kangaroo rats were also distributed along the edges of Dugway Trail, Interface/Trumpeter Trail, and South Buffalo Road in the South Block (Figure 1); snap trapping did not reveal these areas of the distributional range.

The mean CE values for the Ord's kangaroo rat were highest in Shrub Grasslands (0.19), in Ravines (0.19), and in Sand Dunes (0.25), the latter being the highest overall (Table 3; Figure 7). The mean CE values were significantly different ($P < 0.05$) across vegetation zones (Table 3), where the mean CE for Shrub Grasslands was significantly higher than that for Grasslands. Ord's kangaroo rats were not caught in any of the 18 plots in the Shrubs–Trees zone (Table 3; Figure 7). The mean CE values were significantly different ($P < 0.05$) across topographic habitats (Table 3), primarily because the mean CE in Sand Dunes was significantly higher than that for Flat Uplands. No Ord's kangaroo rats were caught in any of the 8 plots in the Wet Areas topographic habitat (Table 3; Figure 7).

Based on the number of plots with a catch, the catch rate for Ord's kangaroo rats within vegetation zones was highest in the Shrub Grasslands zone where 9.4% of the plots trapped had a CE > 0. Within topographic habitats, the Sand Dunes was highest with 13.6% of the plots trapped having a CE > 0 (Table 3). Overall, 5.6% of the plots trapped (22/391) in 1994-1995 had a CE > 0, and a total of 41 Ord's kangaroo rats were caught (Table 3; Table 2). The overall

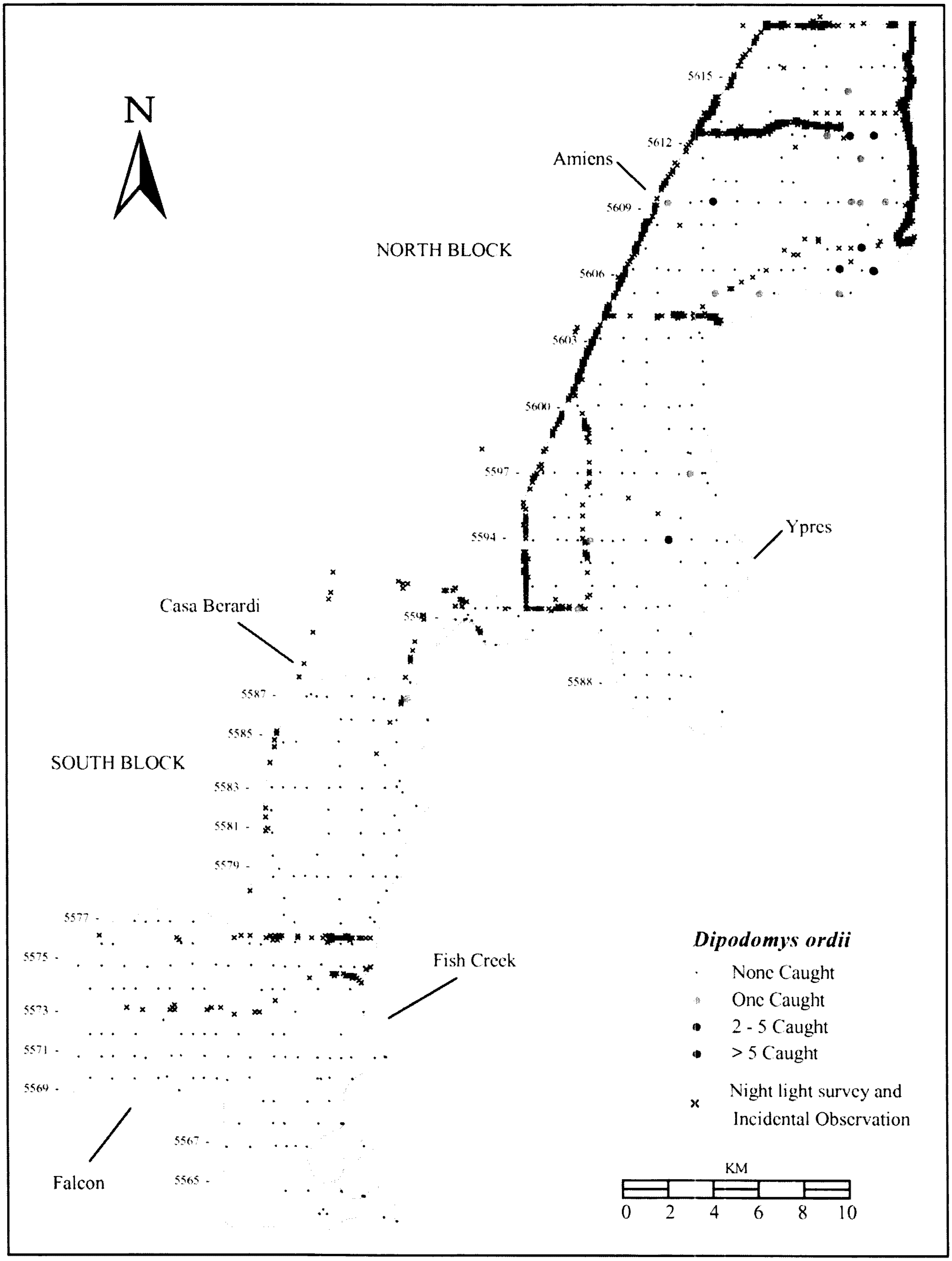

Figure 15. Ord's kangaroo rat trapping distribution, nightlight surveys (Gummer 1999), and incidental observations in the CFB Suffield National Wildlife Area, 1994-1996.

local abundance level for Ord's kangaroo rats in the SNWA was medium (Appendix 7). Within vegetation zones, the local abundance level for the Shrub Grasslands zone was high, while within topographic habitats the Sand Dunes and Ravines levels were high (Table 3).

The proportion of Ord's kangaroo rats in the total catch decreased from 2.5% and fourth rank in 1994 to 1.6% and sixth rank in 1995, and continued to decrease to 0.4% of the catch in 1996 in a four-way tie at fourth rank (Table 2). Within vegetation zones, 97.6% (40/41) of the Ord's kangaroo rats were caught in the Shrub Grasslands zone, with the Grasslands zone at 2.4% (1/41). Within topographic habitats, the proportion of the catch was distributed as follows: the Sand Dunes had 65.9%, the Ravines had 24.4%, while the Flat Uplands and the Interdunal–Morainal had 7.3% (3/41) and 2.4% (1/41), respectively.

Twelve different nightlight surveys were conducted along road and trail rights-of-way to inventory Ord's kangaroo rats between 10 May and 9 November 1994. During 9 of those surveys, 97 kangaroo rats were ear-tagged with sequentially numbered fingerling metal ear tags, but only 5 individuals were ever recaptured. A computer spreadsheet file of 275 individual kangaroo rats and their locations was established and turned over to the research project personnel when the study started in 1995. These data supplemented additional analyses that delineated the abundance and distribution of Ord's kangaroo rats in the SNWA (Gummer 1999).

3.3.8.1 Ord's kangaroo rat research survey

Overall, 2,744 geo-referenced records of Ord's kangaroo rats were collected in CFB Suffield and the general vicinity by Gummer (1999). Of this total, 2,182 records were within the boundaries of the military base of which 2,016 were within the SNWA. Of the latter, 1,891 were in the North Block and 125 were in the South Block (Gummer 1999). A total of 1,090 individual kangaroo rats were enumerated, of which 787 were within the boundaries of CFB Suffield of which 657 were within the SNWA. The nightlighting technique provided the majority of the captures, resulting in enumeration of 970 of the 1,090 total different individuals that were tagged. Ear-tagged individuals were recaptured on 1,161 occasions (Gummer 1999).

The total number of 30-m quadrats searched by nightlighting was 10,176 and kangaroo rats were detected in 1,489 of those quadrats. Kangaroo rat distribution was relatively ubiquitous in that they were caught in all habitats that were sampled by more than 10 quadrats (Gummer 1999). The catch per 100 nightlighting searches data indicated that kangaroo rats were most often detected in the Shrub Grasslands zone and in the Ravines topographic habitat. The mean catch per 100 nightlighting searches values ranged from 0.13 to 0.35 (Gummer 1999). By comparison, the mean CE values, based on the results of the snap trap survey, ranged from 0.01 to 0.25 (Table 3), with the distribution mainly in the northeast part of the North Block (Figure 15).

The nightlighting mean CE values were not significantly different ($P > 0.05$) among vegetation zones and topographic habitats. However, the mean CE for the Shrub Grasslands zone (0.20) was higher than that for the Grasslands zone (0.13) (Gummer 1999). The Ravines topographic habitat, which had the highest mean CE overall (0.35), had a higher mean than the other 4 topographic habitats (Gummer 1999). The Interdunal–Morainal mean CE at 0.24 was the second highest, while Sand Dunes had the third highest mean at 0.18.

3.3.9 Beaver

A total of 42 observations of beavers and beaver signs (tracks, dens, and houses) identified at least 25 animals in 3 general areas directly associated with water systems in the SNWA. The majority of the beaver distribution in the SNWA occurred along the South Saskatchewan River at 2 locations. In the South Block, beavers were found from the south boundary to an area just north of Dugway Forest, while in the North Block they were found in the vicinity of Sherwood Forest north along the river to an area a few kilometres north of where east Whitco Trail meets the river (Figure 16). The second general area of beaver habitation was Old Channel Lake in the southeast corner of the SNWA. The third general area was the pond at Sherwood Forest located near the South Saskatchewan River in the southwest corner of the North Block (Figure 1).

3.3.10 Western harvest mouse

The western harvest mouse was widely distributed throughout the SNWA in both the North and South Blocks (Figure 17). It showed a fairly scattered distribution throughout the North Block, whereas, in the South Block, distribution was more concentrated in the central area and on the east side. It was absent from most of Falcon area and from the northwest portion of Casa Berardi (Figure 17). The South Block contained 61% of the total number of plots that had a catch, yielding a greater number of high; medium; and low-density plots. In the North Block, all 5 of the medium-density plots (2-5 caught) and 16 of the 17 low-density plots (1 caught) were located within the Shrub Grasslands zone. Only 1 of the 17 low-density plots was located in the Grasslands zone.

In the South Block, 1 of the 2 high-density plots (> 5 caught) was located in the Shrub Grasslands zone, and the other was in the Shrubs–Trees zone. Six of the 12 medium-density plots were in the Grasslands zone and 6 were in the Shrub Grasslands zone. Of the low-density plots in the South Block, 9 of the 21 plots were in the Grasslands zone and 12 plots were in the Shrub Grasslands zone. The individual plot CE values for western harvest mice were highest in the Flat Uplands topographic habitat in 1994, attaining a maximum of 6.4 (Table 2). Western harvest mice were caught in only 1 of 18 plots that were trapped in the Shrubs–Trees zone, but it was the highest CE of all plots.

The mean CE values for western harvest mice were highest in the Shrubs–Trees zone and in the Flat Uplands topographic habitat (Table 3; Figure 7). The mean CE values were not significantly different ($P > 0.05$) across vegetation zones nor across topographic habitats (Table 3), although within vegetation zones, the mean CE value for the Shrubs–Trees zone was 2 times greater than that for Grasslands. Within topographic habitats, the Flat Uplands was more than twice that of the Interdunal–Morainal (Figure 7). There was no catch of western harvest mice in the Wet Areas topographic habitat (Table 3; Figure 7).

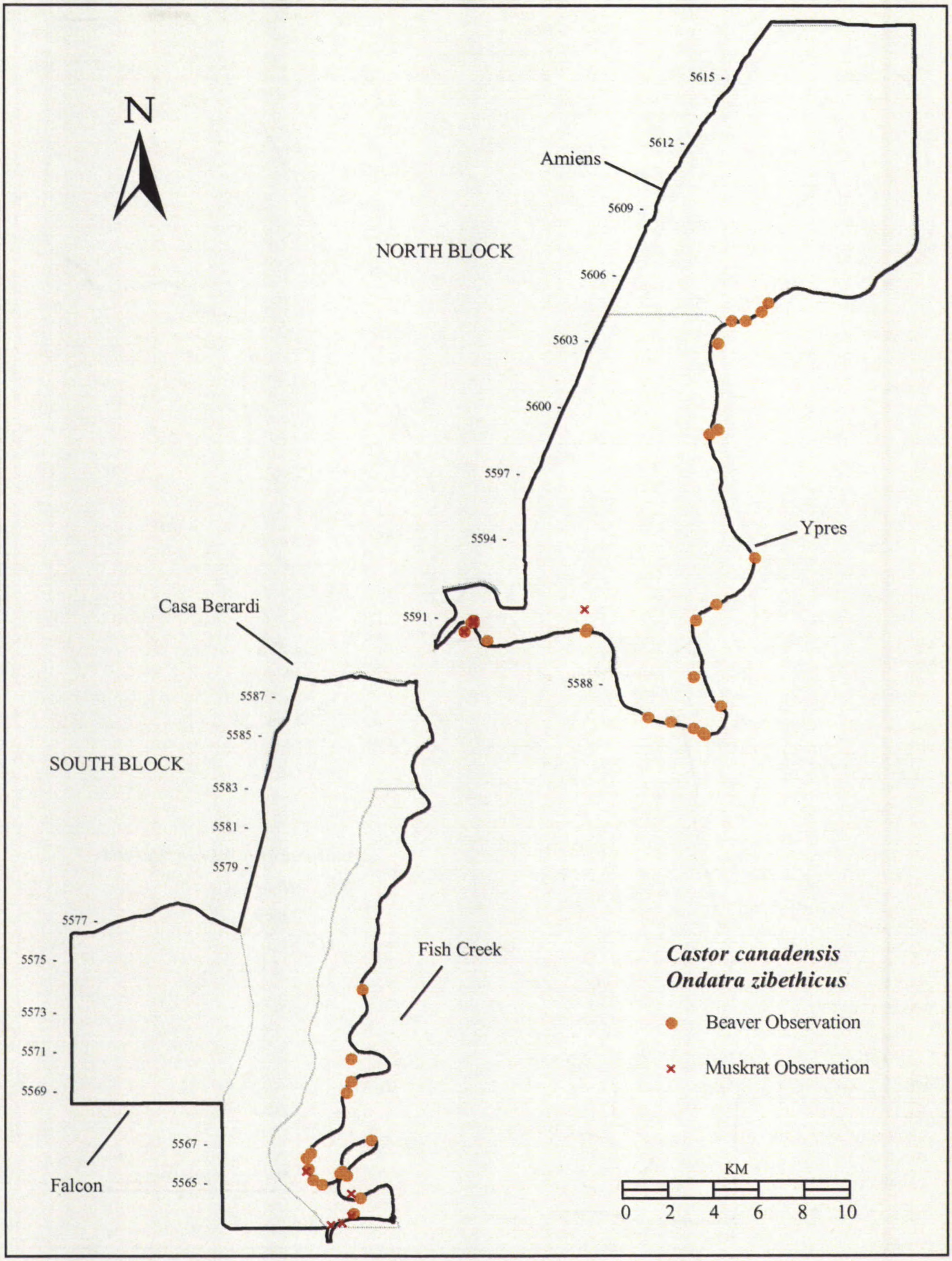

Figure 16. Incidental observations of beaver and muskrat in the CFB Suffield National Wildlife Area, 1994-1996.

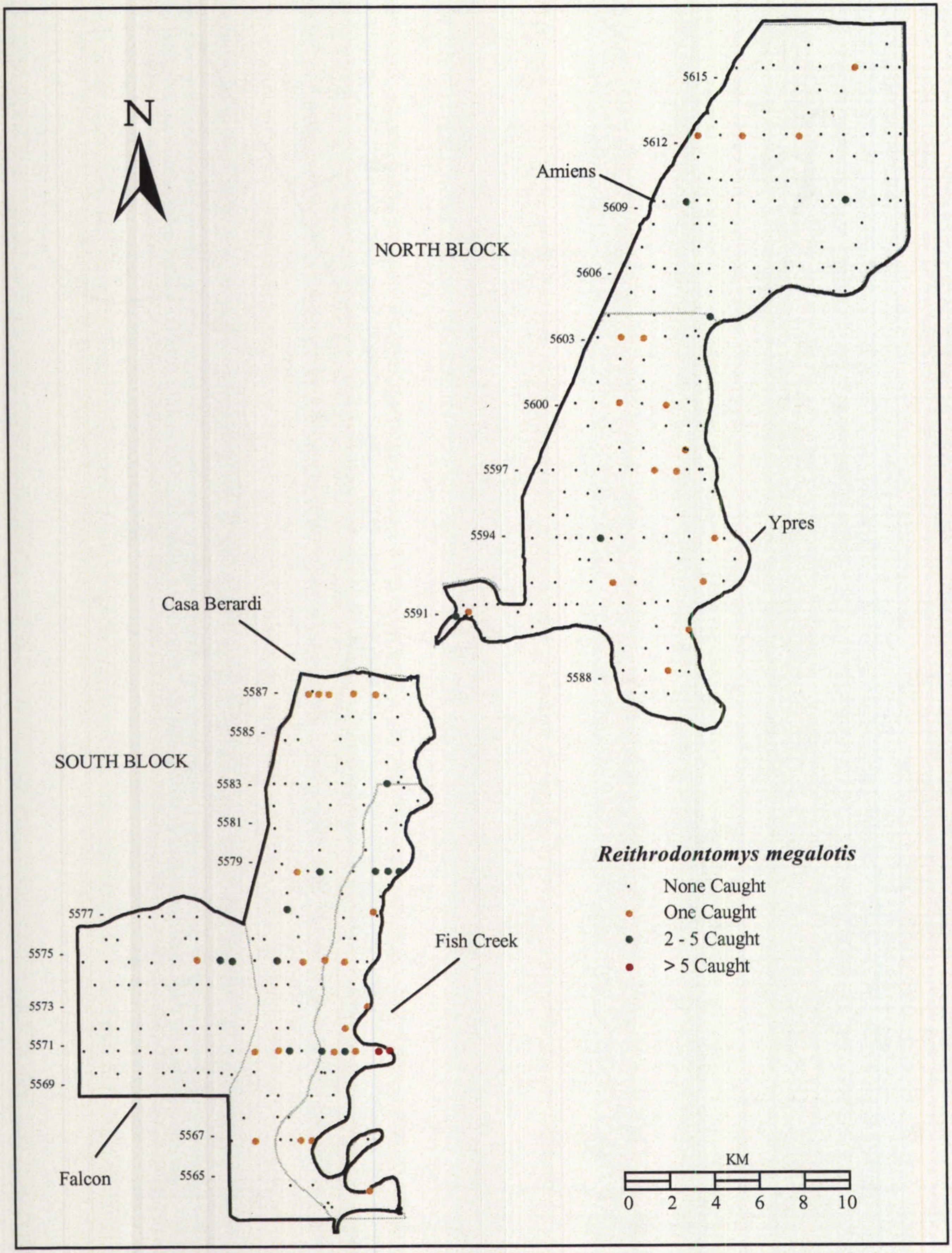

Figure 17. Western harvest mouse trapping distribution in the CFB Suffield National Wildlife Area, 1994-1995.

The catch rate for western harvest mice, based on the number of plots with a catch within vegetation zones, was highest in the Shrub Grasslands zone where 17.4% of the plots trapped had a CE > 0, 11.4% of the plots trapped in the Grasslands zone had a CE > 0, and 5.6% of the plots trapped in the Shrubs–Trees zone had a CE > 0 (Table 3). Within topographic habitats, the Flat Uplands was highest at 18.8% of the plots with a CE > 0, followed by the second highest at 14.3% for the Interdunal–Morainal (Table 3). The Sand Dunes and the Ravines topographic habitats were lowest at 10.9% and 10.5%, respectively. The overall catch rate in 1994-1995 for total plots trapped that had a CE > 0 was the second highest of all species at 14.6% (57/391), with a total of 95 western harvest mice caught (Table 3; Table 2). The overall local abundance level for western harvest mice in the SNWA was high (Appendix 7). Within vegetation zones, the local abundance levels for the Shrub Grasslands and the Shrubs–Trees zones were high, while within topographic habitats only Flat Uplands was high (Table 3).

The proportion of western harvest mice in the total catch decreased from 5.8% and second rank in 1994 to 3.3% and third rank in 1995. None were caught in 1996 (Table 2). Within vegetation zones, 64.9% (61/94) of the western harvest mice were caught in the Shrub Grasslands zone with 28.7% (27/94) caught in the Grasslands zone, and 6.4% (6/94) in the Shrubs–Trees zone. Within topographic habitats, the proportion of the catch was distributed as follows: the Flat Uplands had 61.7% (58/94), the Sand Dunes had 21.3% (20/94), the Ravines had 11.7% (11/94), and the Interdunal–Morainal had 5.3% (5/94).

3.3.11 Deer mouse

Deer mice were well distributed throughout the SNWA in both the North and South Blocks (Figure 18). The majority of high-density plots (> 5 caught), medium-density (2-5 caught), and low-density plots (1 caught) were located within the Shrub Grasslands and the Shrubs–Trees zones in the North Block. A few plots of low-density were distributed within the Grasslands zone. In the South Block, about half of the medium-density plots were located in the Shrub Grasslands and Shrubs–Trees zones, and the other half were in the Grasslands zone. However, about 60% of the low-density plots were located within the Grasslands zone while 40% were in the Shrub Grasslands zone. The individual plot CE values for deer mice were highest in the Sand Dunes topographic habitat in 1994, attaining a maximum of 30.5, which was the highest of all species (Table 2).

The mean CE values for deer mice were highest in the Shrubs–Trees zone and in the Sand Dunes topographic habitat, which was the highest overall (Figure 7; Table 3). The third and fourth highest mean CE values occurred in the Shrub Grasslands zone and the Ravines topographic habitat (Figure 7). The mean CE values ranged from 1.71 to 5.62 for vegetation zones and from 1.36 to 6.14 for topographic habitats (Table 3). In the SNWA, deer mice were 1 of only 2 species that were captured in all vegetation zones and topographic habitats by snap trapping (Table 3; Figure 7).

The mean CE values across vegetation zones were significantly different ($P < 0.05$) (Table 3). The mean CE value for the Shrubs–Trees zone was significantly higher than that for the

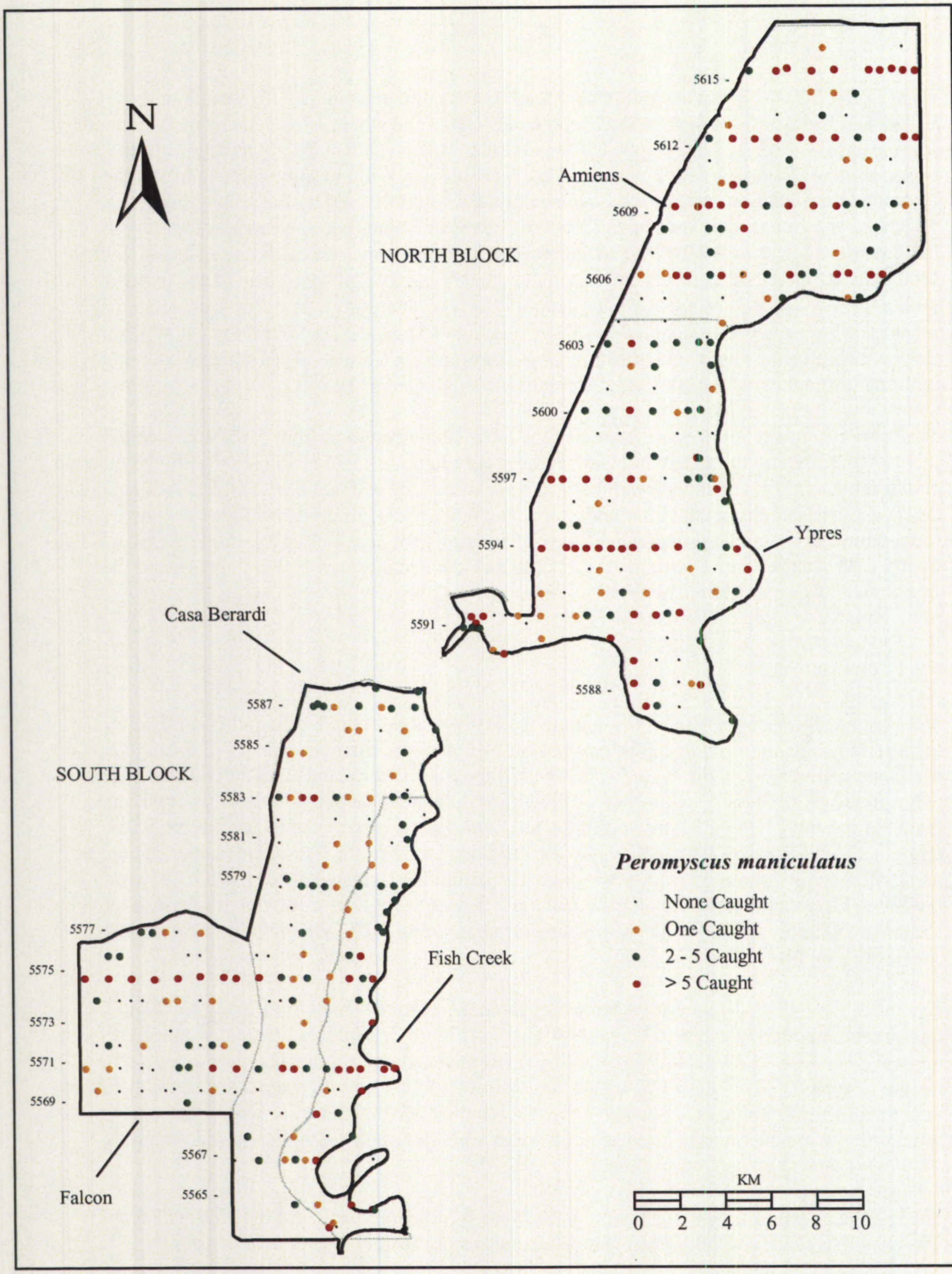

Figure 18. Deer mouse trapping distribution in the CFB Suffield National Wildlife Area, 1994-1995.

Grasslands zone (Table 3). The mean CE value for the Shrub Grasslands zone was also significantly higher than that for the Grasslands zone, but not significantly different ($P > 0.05$) from the Shrubs–Trees zone (Table 3). Across topographic habitats, the mean CE values were also significantly different ($P < 0.05$) (Table 3). The mean CE value for the Sand Dunes topographic habitat was significantly higher than that for the Flat Uplands and the Interdunal–Morainal (Table 3). Also, the mean CE for the Ravines topographic habitat was significantly higher ($P < 0.05$) than that for the Flat Uplands (Table 3).

Within vegetation zones, the catch rate for deer mice, based on the number of plots with a catch, was highest in the Shrubs–Trees zone where 94.4% of the plots had a CE > 0. Of the plots trapped in the Shrub Grasslands zone, 85.7% had a CE > 0 and 59.7% of the plots trapped in the Grasslands zone had a CE > 0 (Table 3). Within topographic habitats, 89.5% of the plots in the Ravines topographic habitat had a CE > 0, while the second highest was 88.2% in the Sand Dunes (Table 3). The Flat Uplands, the Interdunal–Morainal, and the Wet Areas topographic habitats had 67.4%, 65.7%, and 62.5%, respectively, of the trapped plots with a catch (Table 3). In 1994-1995, the overall catch rate for total plots trapped was the highest of all species at 76.2% (298/391), with a total of 1,489 deer mice caught in the SNWA (Table 3; Table 2). The overall local abundance level for deer mice was high (Appendix 7). Within vegetation zones, the local abundance levels for Shrub Grasslands and Shrubs–Trees zones were high, while within topographic habitats Sand Dunes and Ravines were high (Table 3).

The proportion of deer mice in the total catch increased from 81.6% in 1994 to 83.1% in 1995, and continued to increase to 87.6% of the total in 1996 (Table 2). Deer mice were the most abundant species, exceeding 81% of the total catch in all 3 years. Within vegetation zones, 76.8% (1144/1489) of the deer mice were caught in the Shrub Grasslands zone, 16.6% (247/1489) were in the Grasslands zone, and 6.6% (98/1489) were in the Shrubs–Trees zone. Within topographic habitats, the proportion of the catch was distributed as follows: the Sand Dunes had 43.5% (647/1489), the Flat Uplands had 30.8% (458/1489), the Ravines had 17.7% (264/1489), the Interdunal–Morainal had 7.3% (109/1489), and the Wet Areas had only 0.7%.

3.3.12 Northern grasshopper mouse

Based on snap trapping results and 1 incidental observation in the SNWA, distribution of the northern grasshopper mouse appeared to be mainly throughout the north-central part of Amiens with 1 plot located in the west-central part of Ypres in the North Block. In the South Block, it was confined to only 2 plots, 1 in the northwest part of Casa Berardi and the other in the south-central part of Casa Berardi (Figure 19). The 1 incidental observation for northern grasshopper mice was collected near the site of 4 low-density trap plots in the North Block. Of the 3 medium-density plots (2-5 caught), 2 were in the North Block and 1 was in the South Block, but all were in the Shrub Grasslands vegetation zone. Within topographic habitats, 2 of the medium-density plots were in the Sand Dunes and 1 was in the Flat Uplands. Of the 5 plots of low-density (1 caught), 4 were in the North Block and 1 was in the South Block (Figure 19). The North Block plots were in the Shrub Grasslands zone and the Sand Dunes topographic habitat, while the South Block plot was in the Grasslands zone and the Flat Uplands topographic habitat.

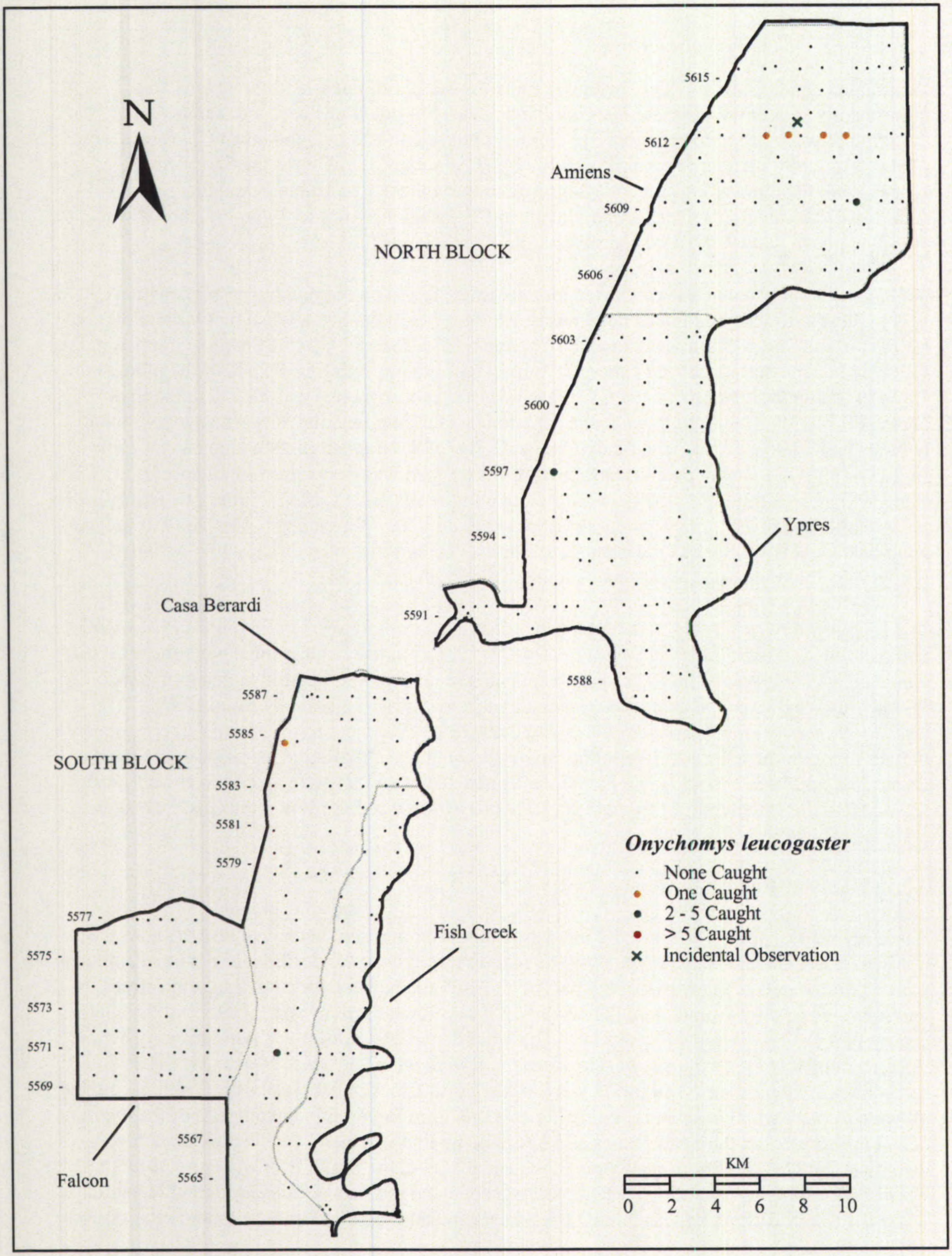

Figure 19. Northern grasshopper mouse trapping distribution and incidental observations in the CFB Suffield National Wildlife Area, 1994-1996.

The individual plot CE values for northern grasshopper mice were highest in the Sand Dunes topographic habitat in 1994, attaining a maximum of 3.1 (Table 2). The Shrub Grasslands zone had 12 of the 13 total northern grasshopper mice caught, and the Sand Dunes topographic habitat had 9 of 13.

The mean CE values for the northern grasshopper mouse were highest in the Shrub Grasslands and Sand Dunes (Table 3; Figure 7). The mean CE values were not significantly different ($P > 0.05$) across vegetation zones or topographic habitats (Table 3); however, within vegetation zones the mean CE value for Shrub Grasslands was 5 times higher than that for Grasslands, and within topographic habitats the mean CE value for Sand Dunes was 4 times higher than for Flat Uplands (Figure 7). Northern grasshopper mice were not caught in the Shrubs–Trees zone or in Interdunal–Morainal, Ravines, or Wet Areas topographic habitats (Table 3; Figure 7).

The catch rate for northern grasshopper mice within vegetation zones, based on the number of plots that had a catch, was highest in the Shrub Grasslands zone where 3.1% of the plots trapped had a CE > 0. In the Grasslands zone, only 0.7% of the plots had a CE > 0 (Table 3). Within topographic habitats, the Sand Dunes was highest, with 5.4% of the plots trapped having a CE > 0. In the Flat Uplands, only 1.1% of the plots had a CE > 0 (Table 3). In 1994-1995, the overall catch rate for total plots trapped was only 2% (8/391) that had a CE > 0, with a total of 13 northern grasshopper mice caught (Table 3; Table 2). The overall local abundance level for northern grasshopper mice in the SNWA was low (Appendix 7). Within vegetation zones, the local abundance level for Shrub Grasslands was medium, while within topographic habitats the Sand Dunes level was high (Table 3).

The proportion of northern grasshopper mice in the total catch decreased from 0.9% and seventh rank in 1994 to 0.2% and tenth rank in 1995. It increased to 0.4% (1 animal) in 1996 in a four-way tie at fourth rank (Table 2). Within vegetation zones, 92.3% of the northern grasshopper mice were caught in the Shrub Grasslands zone, while the Grasslands zone had only 7.7% (1/13) of the catch. Within topographic habitats, the proportion of the catch was 69.2% in the Sand Dunes and 30.8% (4/13) in the Flat Uplands.

3.3.13 Bushy-tailed woodrat

During the 1995 field season, a bushy-tailed woodrat (*Neotoma cinerea*) was found dead within 2 m of sprung snap trap # 33, plot 20, transect 5607, in the Middle Sand Hills of the North Block. The nature of its death was unclear and remains a mystery.

3.3.14 Meadow vole

Based on snap trapping results and incidental observations, the meadow vole (*Microtus pennsylvanicus*) was widely distributed throughout the SNWA with a larger distribution in the North Block, especially in the north half of Amiens and another small area in the central part of Ypres (Figure 20). In the South Block, distribution was greatest in the Falcon area and in the

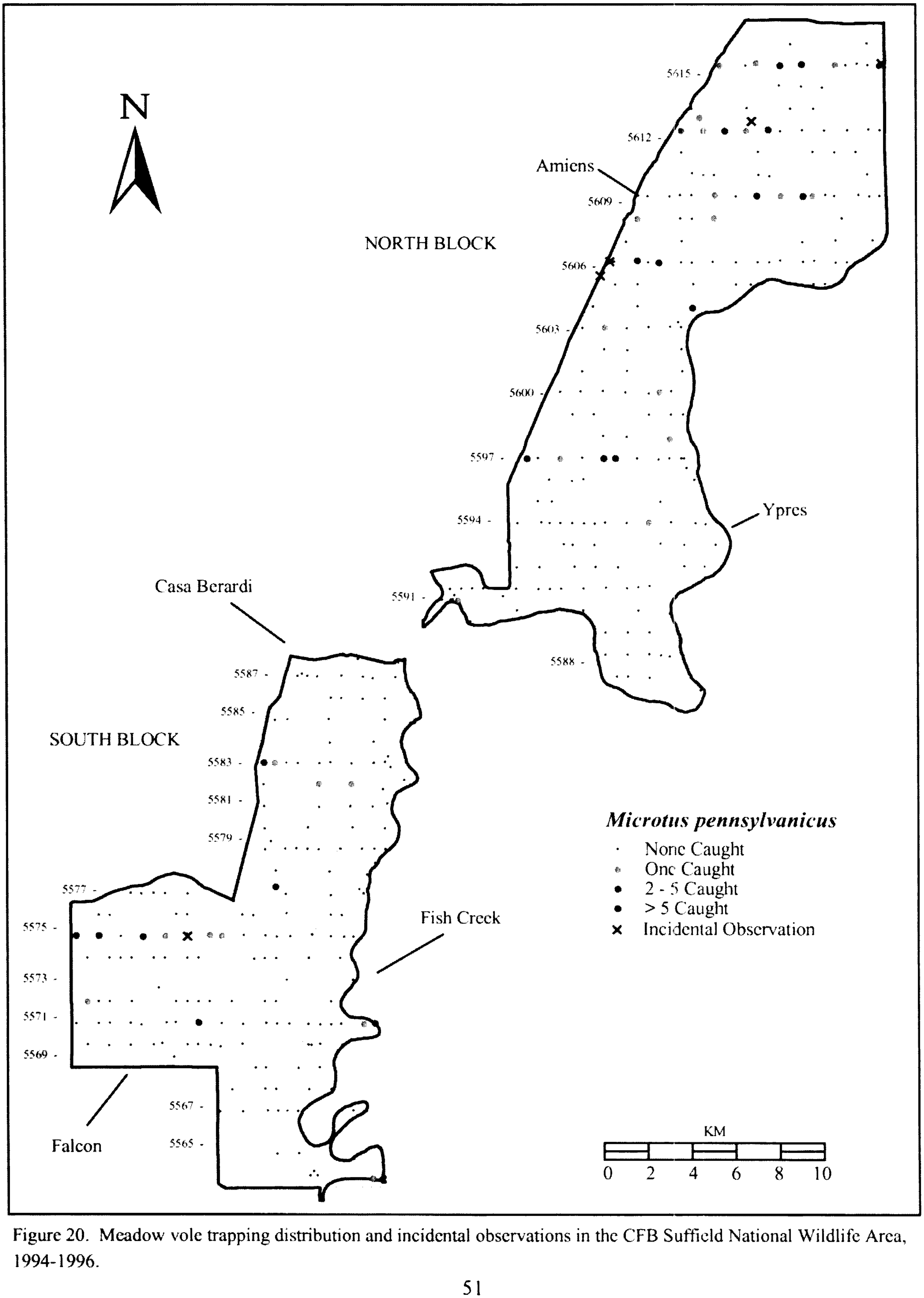

Figure 20. Meadow vole trapping distribution and incidental observations in the CFB Suffield National Wildlife Area, 1994-1996.

northwest part of Casa Berardi (Figure 20). The 5 incidental observations for meadow voles were closely associated with catch plots from the snap trap survey (Figure 20). In the North Block, 100% of the medium and low-density plots were within the Shrub Grasslands zone. In the South Block, 4 of the 7 medium-density plots were located in the Grasslands zone, 2 plots were in the Shrub Grasslands zone, and 1 plot was in the Shrubs–Trees zone. Five of the 9 low-density plots were in the Grasslands zone and 4 plots were in the Shrub Grasslands zone. There were more medium and low-density plots in the North Block than in the South Block, with 66% of the total number of plots with a catch located in the North Block. The individual plot CE values for meadow voles were highest in both the Sand Dunes and the Flat Uplands topographic habitats in 1994, attaining a maximum of 5.2 (Table 2). Meadow voles were caught in 1 of 18 plots that were trapped in the Shrubs–Trees zone, but this plot had the second highest mean CE value.

The mean CE values for meadow voles were highest in the Shrub Grasslands zone and in the Wet Areas topographic habitat (Table 3; Figure 7). The mean CE values ranged from 0.12 to 0.26 within the vegetation zones, and from 0.07 to 0.50 within the topographic habitats (Table 3). In the SNWA, meadow voles were captured in all vegetation zones and topographic habitats that were snap-trapped (Table 3; Figure 7). The mean CE values were not significantly different ($P > 0.05$) across vegetation zones or topographic habitats (Table 3), although within vegetation zones, the Shrub Grasslands mean CE was more than 2 times higher than both the Grasslands and the Shrubs–Trees zones. Within topographic habitats, the mean CE for Wet Areas was 1.6 times higher than that for Sand Dunes, and both of these were considerably higher than the Flat Uplands, the Interdunal–Morainal, and the Ravines topographic habitats (Figure 7).

Within vegetation zones, the catch rate for meadow voles, based on the number of plots with a catch, was highest in the Shrub Grasslands zone where 16.1% of the plots trapped had a CE > 0, while 6.7% of the plots trapped in the Grasslands zone and 5.6% of the plots trapped in the Shrubs–Trees zone had a CE > 0 (Table 3). Within topographic habitats, the catch rate was highest in the Wet Areas where 37.5% of the plots trapped had a CE > 0 while the Sand Dunes was second highest at 19.1% (Table 3). The Interdunal–Morainal, the Flat Uplands, and the Ravines topographic habitats had much lower rates of catch at 14.3%, 8.3%, and 5.3%, respectively (Table 3). The overall catch rate for total plots trapped was 12% (47/391), the third highest of all species. A total of 76 meadow voles were caught during 1994 and 1995 (Table 2). The overall local abundance level for meadow voles in the SNWA was high (Appendix 7). Within vegetation zones, the local abundance level for Shrub Grasslands was medium, while within topographic habitats the Wet Areas local abundance level was high (Table 3).

The proportion of meadow voles in the total catch decreased from 4.6% and third rank in 1994 to 2.7% and fifth rank in 1995. It increased to 3.5% of the catch and third rank in 1996 (Table 2). Within vegetation zones, 75% (57/76) of the meadow voles were caught in the Shrub Grasslands zone, 22.4% (17/76) were caught in the Grasslands zone, and 2.6% (2/76) were caught in the Shrubs–Trees zone. Within topographic habitats, the proportion of the catch was distributed as follows: the Sand Dunes had 44.7% (34/76), the Flat Uplands had 36.8% (28/76), the Interdunal–Morainal had 7.9% (6/76), and the Ravines and the Wet Areas topographic habitats each had 5.3% (4/76).

3.3.15 Sagebrush vole

In 1994, 2 sagebrush voles were caught by snap trapping at 1 site in the southwest Falcon area in the South Block (Figure 14). This site was in the Grasslands zone and in the Flat Uplands topographic habitat (Table 3; Figure 7). None were caught in 1995 and only 1 was caught in 1996. This occurred on the same plot as in 1994, but on the east-west trapline. These 3 sagebrush voles were caught at the same site, from a sample of 442 plots and 48,578 trap nights.

3.3.16 Muskrat

A total of 11 observations of muskrats and muskrat signs (tracks and houses) identified at least 14 animals in 4 general areas that were directly associated with water systems in the SNWA. The major distribution of muskrats in the SNWA was in the southeast corner of the South Block (Figure 16) in and around Old Channel Lake (Figure 1) and its adjoining wetlands. The second general area of muskrat habitation was along the South Saskatchewan River at 2 locations. In the South Block, muskrats were found just north of the Bull Pen in a slump-upslope from the river known as the Frog Ponds; in the North Block, they were found along the river in the vicinity of Sherwood Forest. The third general area, and another main site for muskrats in the SNWA, was the pond at Sherwood Forest located adjacent to the South Saskatchewan River in the southwest corner of the North Block. The fourth general area of muskrat habitation was a water spring in the south-central part of the North Block (Figure 16) near the head of a ravine on the South Saskatchewan River, ending at Mule Deer Road where the road turns north and forms a right angle from the east-west direction.

3.3.17 House mouse

Only 1 house mouse was caught. This occurred in 1995 at a snap trap site located in the southeast part of Ypres (Murphy's Horn) in the North Block (Figure 1; Figure 14). This site was in the Grasslands zone and in the Flat Uplands topographic habitat (Table 3; Figure 7). No house mice were caught in 1994 or 1996 from a snap trap sample of 442 plots and 48,578 trap nights.

3.3.18 Porcupine

Based on 123 observations of porcupines and their signs (tracks and dens), at least 125 animals were identified in the SNWA. They were distributed throughout the wildlife area with about 50% of the total sightings in each of the North and South Blocks (Figure 21). Porcupines were seen in cottonwood trees on at least 15 occasions, and they were observed using hollow trunks of fallen trees, a roof of a fallen shed, and a road culvert as shelter and resting sites. They were also seen feeding on cottonwood trees and willow (*Salix spp.*) shrubs.

Porcupines were distributed throughout the North Block, with higher densities occurring in the Sherwood Forest area in the southwest corner and at the northern boundary along Double Wide

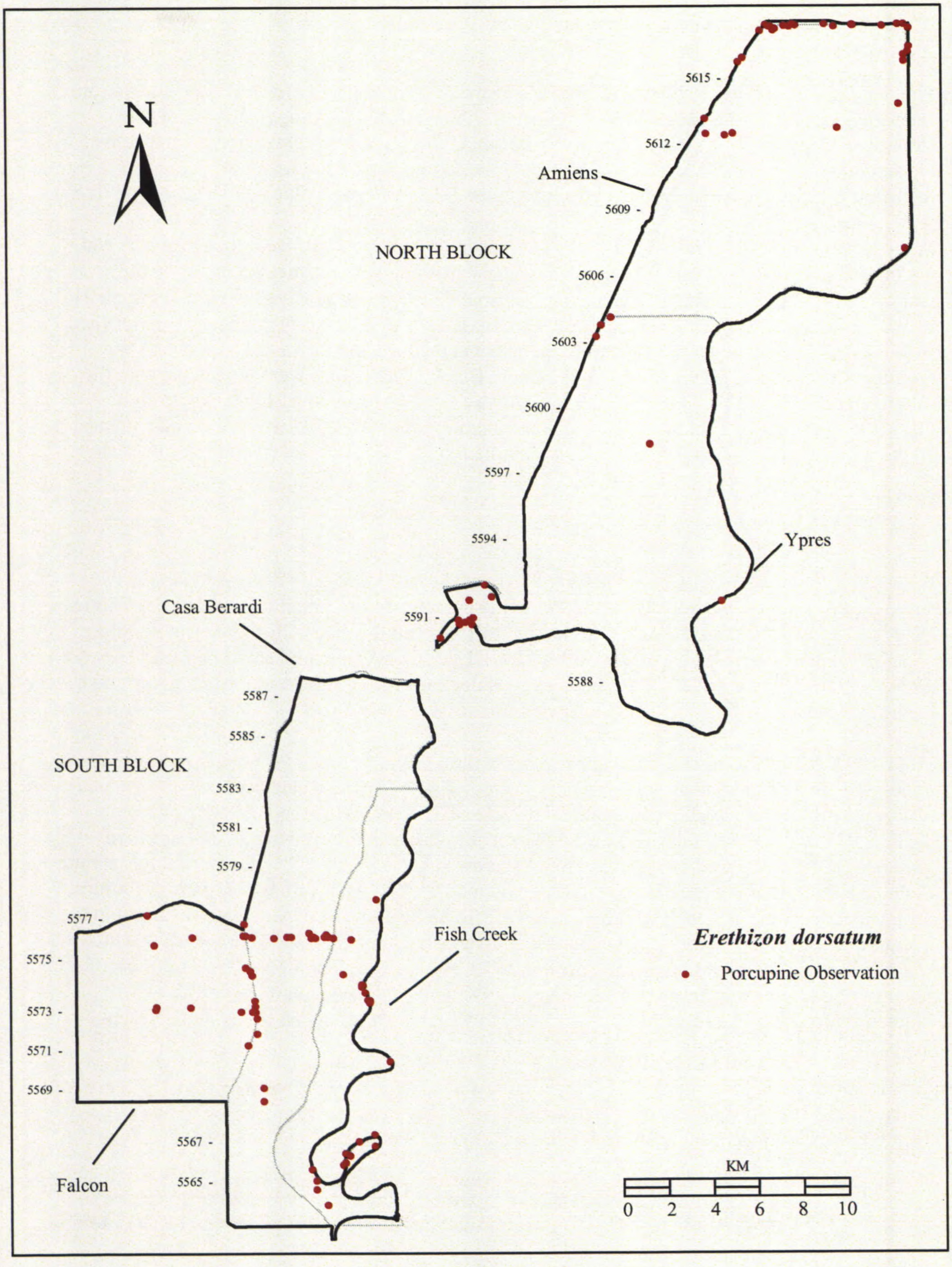

Figure 21. Incidental observations of porcupine in the CFB Suffield National Wildlife Area, 1994-1996.

Fireguard and Kangaroo Rat Road (Figure 1; Figure 21). Most of the North Block observations were associated with the Shrub Grasslands zone, although some sightings occurred in the Grasslands zone and some in the Shrubs–Trees zone. From a topographic habitat perspective, the association was with 3 habitats— the Flat Uplands, the Sand Dunes, and the Interdunal–Morainal, with a few observations in the Ravines topographic habitat along the river.

In the South Block, distribution of porcupines was in the southern half from the Hogsback and the Interface/Trumpeter Trail south to the boundary, with higher densities occurring in the Dugway Forest area and the Bull Pen along the South Saskatchewan River (Figure 1; Figure 21). The large number of sightings along South Buffalo Road and Interface/Trumpeter Trail resulted from road surveys done by the kangaroo rat team and their numerous travels conducting nightlight inventories. The majority of the South Block observations were associated with the Shrub Grasslands and the Grasslands zones, with a few sightings in the Shrubs–Trees zone. From a topographic habitat perspective, the association was with 3 habitats— the Flat Uplands, and to a lesser extent, with the Sand Dunes and the Interdunal–Morainal topographic habitats.

3.4 Annual Changes in Mean Catch Effort

Based on catch effort results in the SNWA, the mean CE for all species decreased 72.2%, approximately 3.5 times, from 1994 to 1995. However, based on a smaller sample size, the mean CE for all species increased 2 times, from 1995 to 1996, but the mean CE for 1996 was only about 0.5 times as large as the mean CE for 1994. Even though the total small mammal population decline was 72.2%, individual species declines varied from a minimum of 30% to a maximum of 94%.

From 1994 to 1995, northern grasshopper mice in the SNWA declined 94% which was the greatest decline of the 8 main snap-trapped species. Ord's kangaroo rats declined 85%, which was greater than the overall small mammal decline of 72.2% and the second highest rate of decline. Western harvest mice declined 84%, the third highest rate of decline after northern grasshopper mice and Ord's kangaroo rats. Meadow voles declined 83%, the fourth highest rate of decline after northern grasshopper mice, kangaroo rats, and western harvest mice. Deer mice declined 72% from 1994 to 1995 which was the fifth highest rate of decline and was equal to the overall decline of 72.2% for small mammals. Olive-backed pocket mice declined 60%, which was lower than the overall population decline of 72.2% and was sixth of 8 species in terms of severity of decline. Prairie shrews declined by 40% which was seventh of 8 species, while thirteen-lined ground squirrels declined by only 30%, the lowest decline of the 8 main snap-trapped species.

3.5 Hantavirus

Hantavirus-positive deer mice were collected throughout the SNWA, ranging from south to north boundaries. The first shipment of deer mice analyzed for hantavirus by Health and Welfare Canada yielded 12% positives (9/75). The second shipment had 11.5% positives (10/87), the third shipment had only 1.1% positives (2/178), and the fourth shipment had 3.1% positives (6/191). Overall, the positive rate averaged 5.1% (27/531). All the tested deer mice were collected during the 1994 field season. Individual sample sites varied from 0 to 36.8% positive. The highest rate was recorded in a ravine of the South Saskatchewan River valley about 1 km from the river on the south side of transect 5598 in the North Block. There are 475 deer mice from the 1994 collection and 327 from the 1995 collection in the Health and Welfare Canada freezer in Ottawa to be tested. Also, there are 41 deer mice from the 1995 collection and 198 from the 1996 collection in the CWS freezer in Edmonton to be shipped to Ottawa for testing.

3.6 Taxonomic Measurements

A data set of taxonomic measurements was compiled for 1,048 deer mice collected during the 1994 field season, 384 deer mice collected in 1995, and 195 deer mice collected in 1996, for a total of 1,627 deer mice. Aside from deer mice, there were 220 small mammal specimens sent to the Provincial Museum of Alberta in Edmonton to confirm species identification and to be added to the museum study skin collection, if suitable.

4.0 DISCUSSION

4.1 Vegetation Zones Validation and Rate of Catch in Habitats

Our designation of the Grasslands zone reflects an absence of shrubs while the Shrub Grasslands zone exhibits a mixture of shrubs and grass. Although there is a small sample (9) for the Shrubs–Trees zone, the mean percent shrub cover data indicated a high percentage of shrub cover for this zone (Figure 5). There is a strong relationship between the actual percent shrub cover on the ground relative to the percent composition of shrubs in the 3 vegetation zones that we defined. These results confirmed that merging the 28 vegetation cover types into 3 vegetation zones is valid, thereby supporting the interpretation of small mammal distributions and habitat relationships based on the vegetation zone classification.

The Grasslands zone was the second largest of the 3 zones at 39% of the SNWA (Table 1; Figure 3), but had the lowest rate of catch of small mammals based on the number of plots that were trapped that had a CE > 0. The Shrub Grasslands was the largest zone in the SNWA at 58% of the area, and had the second highest rate of catch of small mammals. The Shrubs–Trees zone was the smallest zone at 2.3% of the area (Table 1; Figure 3), but it had the highest catch rate of small mammals.

The percent shrub cover distribution for the SNWA using the individual plot shrub cover estimates from Adams *et al.* (1997) is shown in Figure 22. Those areas with > 10% shrub cover and those with 5% to 10% shrub cover correspond well with the designated Shrubs–Trees and Shrub Grasslands zones (Figure 3) that we used in our analysis by merging 28 vegetation cover types into 3 vegetation zones. In the vegetation zone classification, the shrub cover increased from the Grasslands zone to the Shrub Grasslands zone to the Shrubs–Trees zone. This shrub

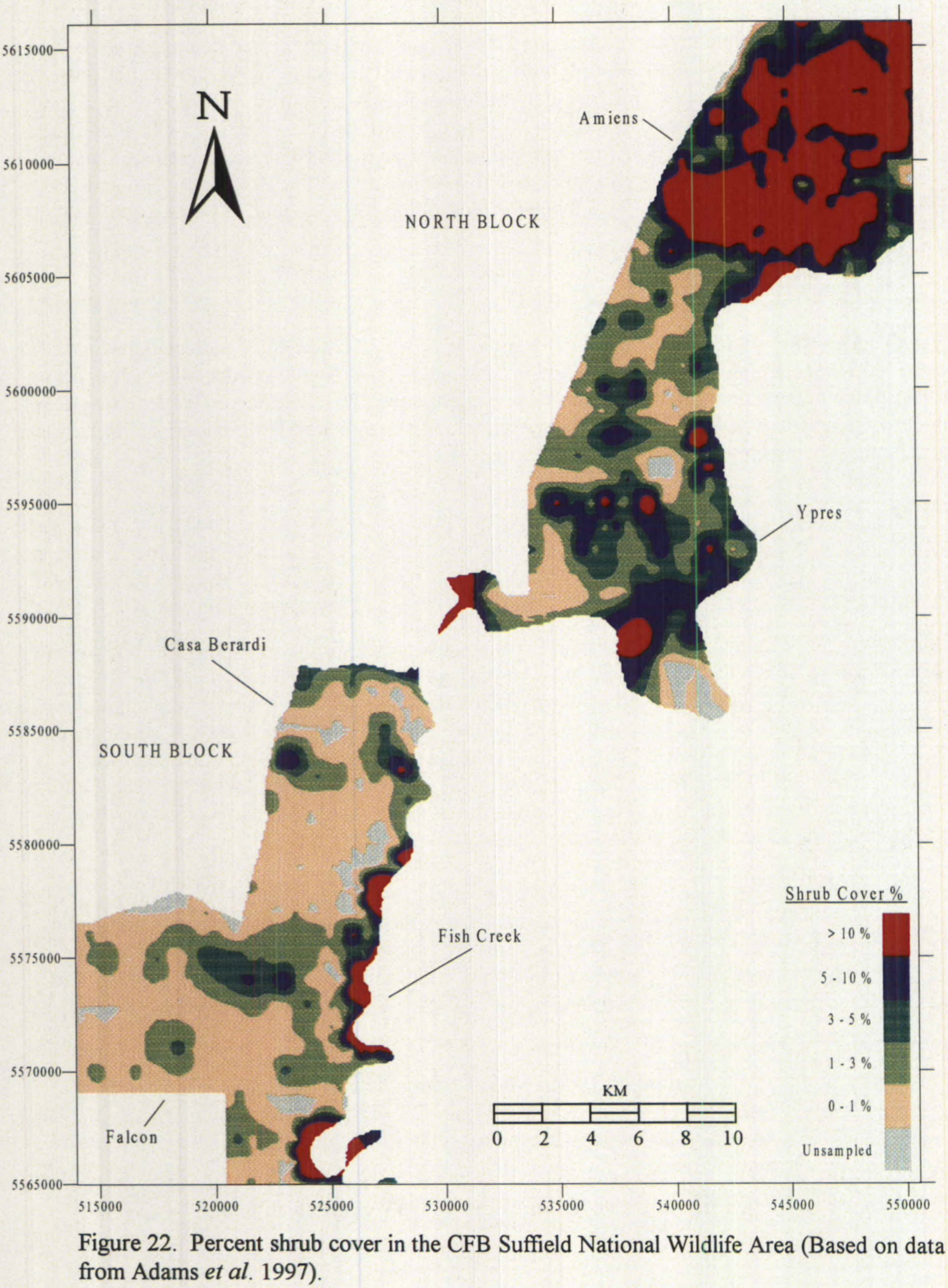

Figure 22. Percent shrub cover in the CFB Suffield National Wildlife Area (Based on data from Adams *et al.* 1997).

cover increase was accompanied with a corresponding increase in the overall rate of the small mammals catch, from 71% of the trapped plots with a CE > 0 in Grasslands, to 88% in Shrub Grasslands, to 94% in Shrubs–Trees (Table 1). Similarly, as topography increased from low, rolling, flat uplands and wetlands to steeper, higher relief Sand Dunes and Ravines topographic habitats, the rate of catch of small mammals tended to increase. This rate varied from a low of 66% of the trapped plots with a CE > 0 in the Interdunal–Morainal topographic habitat, to 75% in the Wet Areas, to 91% in the Ravines, to the highest rate of 92% in the Sand Dunes (Table 1).

An increase in the amount of cover in the habitat owing to an increase in the amount of shrubs and trees, resulted in an increased catch of small mammals, based on the higher percentage of plots with a CE > 0. Similarly, as topographic relief increased from flat and low rolling prairies to undulating steeper sand dune areas and rugged ravines-type topography, the catch of small mammals also tended to increase. However, deer mice dominated the catch in all 3 years (> 81%) and the increased catch rate of small mammals is biased by the high percent composition of deer mice.

4.2 Composition of the Catch, Capture Success, and Population Decline

Deer mice were caught most often in the SNWA, exceeding 81% of the total catch in 1994, 83% in 1995, and 87% in 1996 (Table 2). This was comparable to, but lower than other mixedgrass prairie areas where deer mice comprised 96% of the live-trap captures during the 1995 to 1996 winter study conducted at the Onefour Research Station near Manyberries in southeast Alberta (Klausz 1997). Also, deer mice represented 94% of the live-trap captures in August 1996 in Grasslands National Park near Val Marie in southern Saskatchewan (McCanny *et al.* 1997). By contrast, in a tallgrass prairie site in eastern Nebraska, deer mice contributed only 15% of the catch of 10 species of small mammals (Kirsch 1997), 5 of which were the same species caught in the SNWA. The deer mouse component in the Nebraska study increased to 21% of the total when samples from adjacent cornfields and roadside ditches were included.

Small mammal captures from snap trapping are assumed to represent an index of population abundance that measures relative density to a reasonable degree (Fleharty and Navo 1983; Krebs 1994). Trapability differences among the 11 species caught in the SNWA were not measured, but they could have affected the results. The trap success (the number of animals caught divided by the number of trap nights) for total small mammals decreased by a factor of 4, from 7.1% in 1994 to 1.9% in 1995 (Table 2). We considered this to be a substantial decline. McCanny *et al.* (1996; 1997) reported an extremely low trap success of 0.6% in Grasslands National Park in the summer of 1995 and a trap success of 3% in the summer of 1996, while Klausz (1997) reported trap success as declining from 3.7% in early winter of 1995 to 0.5% in mid winter, with a slight increase to 0.9% in late winter for the Manyberries area in southeastern Alberta. The overall trap success averaged over 3 trapping sites for the Manyberries area during the winter of 1995 to 1996 was 1.7%.

Trap success rates in the SNWA in summer 1995, in Grasslands National Park in summer 1995, and in the Manyberries area in the winter of 1995 to 1996 were indicative of widespread, generally low population densities for small mammals during 1995 (McCanny *et al.* 1996; Klausz 1997). This would suggest that conditions in the southwestern Canadian prairies during the winter of 1994 to 1995 were severely harsh and populations of small mammals probably crashed to below normal springtime lows in 1995. Oftentimes small mammal populations reach similar low densities across many grassland habitats (Grant and Birney 1979). This situation may be caused by a combination of factors such as availability of food, weather conditions, drought, and disease (Herman and Scott 1984).

Small mammal populations attain peak population numbers by early winter, but then decline overwinter until spring when reproduction resumes (Krebs and Wingate 1985; Klausz 1997). Intrinsic factors that may contribute to this trend are poor winter survival, emigration, trapability, and a cessation of breeding (Krebs and Wingate 1985). The length of the breeding season in deer mice throughout North America shows considerable geographic variation according to latitude. Generally the shortest breeding seasons occur in harsh, more northern, or alpine environments (Millar *et al.* 1979). In these environments, reproductive activity in small mammals is restricted to a few months of the year because of low temperatures and short growing seasons.

Plant species diversity and structural diversification in the vegetation component of the habitat provide small mammals with a greater variety and quantity of foods and more complex microhabitats for nesting and reproduction, foraging, and escape cover from predators, which in turn creates a more favourable microenvironment (Birney *et al.* 1976). Small mammal diets in the mixedgrass prairie consist mainly of herbage when compared with mammal communities in other grasslands and deserts (French *et al.* 1976). However, an important dietary item in most grasslands is animal protein, composed mainly of invertebrates, and this may be a limiting factor to small mammal populations throughout prairie ecosystems (French *et al.* 1976).

In open habitats, earlier snow melt and therefore earlier seasonal availability of food results in earlier breeding and larger litters of deer mice which is probably the situation with other species as well. In Alberta, the onset of breeding can vary by as much as 4 weeks (Millar *et al.* 1985). In contrast, open habitats have higher winter mortality than protected forested habitats because of exposure to harsher environmental conditions (Sharpe and Millar 1991), certainly a factor to be considered in prairie environments such as the SNWA. It is clear that distribution and abundance of small mammal populations vary depending on habitat characteristics.

Small mammal populations are often cyclic (Boonstra *et al.* 1998) and experience precipitous declines, as shown by the differences in CE between 1994 and 1995 in the SNWA and confirmed by the much lower trap success rate in 1995. Often following a population decline there is a 7-year phase of low population numbers that can last from 1 to 3 years in microtines and from 2 to 4 years in hares (Boonstra *et al.* 1998). Possible theories for this low phase come from 2 schools of thought. The first involves extrinsic factors, where the most likely cause is predation, which acting either directly or indirectly has delayed density-dependent effects on prey populations during the low phase. The second theory involves intrinsic factors, where something may be wrong internally with the animals themselves, such as maternal effects or age effects on fitness during the low phase. The latter theory is the most likely explanation (Boonstra *et al.* 1998). In order to explain population cycles, it is necessary to understand what operates and controls the low phase period. When planning long-term management actions for prairie ecosystems, the cyclic nature of small mammal populations must be considered to ensure that survival and persistence of the species is possible during years of extremely low population numbers.

Based on CE results in the SNWA, the total catch of small mammals declined by about 3.5 fold (72.2%) from 1994 to 1995. Since deer mice dominated the catch, any decline in this species would influence the total species decline, reflecting a strong species bias effect. Deer mice constituted at least 81% of the total small mammal catch for all 3 years of this study. Declines in the mean CE for individual species varied from 94% to 30%. The 4 species that exceeded the overall total small mammal decline were northern grasshopper mice (94%), Ord's kangaroo rats (86%), western harvest mice (84%), and meadow voles (83%). Why these 4 species declined at rates greater than the overall species average is unknown. The 2 species that showed the least amount of decline between years were prairie shrews (40%) and thirteen-lined ground squirrels (30%). The effect of habitat differences resulting from different trapping locations on the numbers of individual species caught was not determined, but could have influenced trapping results.

The impacts of disease on the population decline of small mammals in the SNWA is not known. The deer mice in the SNWA averaged 5.1% positive for hantavirus. The internal effects of this virus on deer mice and in general on small mammal populations is not known, although it is assumed that this disease is not detrimental to its host.

Weather conditions probably influence small mammal productivity and survival. While the dry spring of 1994 coupled with the early summer was considered to be average for moisture conditions in the SNWA, the summer of 1995 was wetter and had above-average moisture conditions for the mixedgrass prairie region. It is unlikely that food shortages based on limited herbage production would have occurred because of the wetter conditions. However, mid to late winter of 1994 to 1995 was continuously cold with below freezing temperatures from mid December through to late March where only 2 short spells of above-freezing temperatures occurred in early and late February (Table 4). This cold weather, coupled with relatively little snowfall and snow cover throughout the same period, probably contributed to higher-than-normal mortality in small mammal populations. This mortality would have been caused by lack of adequate snow cover to allow small mammals to move aboveground but under the insulation of a blanket of snow for foraging and protection from predation. Freezing cold temperatures coupled with lack of snow cover could limit movement of small mammals and contribute to mortality by starvation, hypothermia, and increased predation.

The winter of 1995 to 1996 was similar, if not colder, in terms of mean temperatures, but above-average snowfall yielding a substantial cover of snow from mid November 1995 through to early March 1996 would have provided adequate insulation to protect small mammals from freezing temperatures and predation, and would have permitted them to move in search of food. Therefore, survival would have increased over the winter of 1995 to 1996 which would have resulted in recovery of population numbers during the spring and summer of 1996. This was indicated by the snap trap data of greater numbers of animals caught and higher trap success in 1996 (Table 2).

Table 4. Average daily mean, maximum, and minimum temperatures (°C), maximum snow on the ground during the period (cm), and daily water equivalent (total snowfall and precipitation) summed (mm) for 2 time periods (1-15; 16-31) for each of 5 months at CFB Suffield, 1993-1996. (Data from Atmospheric Environment Branch, Environment Canada, Edmonton)

		Average of Daily Mean Temperatures (degrees C)			
Month	**Days**	**1993-94**	**1994-95**	**1995-96**	**1996**
November	1-15	0.4	0.9	-6.2	-2.0
	16-31	-6.3	-4.9	-2.2	-17.2
December	1-15	-2.1	-10.5	-15.7	-9.3
	16-31	-4.8	-0.2	-12.9	-22.3
January	1-15	-16.4	-12.7	-9.5	
	16-28	-9.5	-8.5	-27.3	
February	1-15	-14.0	-6.6	-8.9	
	16-31	-18.3	-2.4	-6.8	
March	1-15	3.1	-5.0	-6.1	
	16-30	3.3	2.8	-4.4	

		Maximum Snow on Ground During the Period (cm)			
Month	**Days**	**1993-94**	**1994-95**	**1995-96**	**1996**
November	1-15	2	1	12	9
	16-31	9	6	7	20
December	1-15	10	2	23	16
	16-31	1	4	23	38
January	1-15	21	7	30	
	16-28	27	7	11	
February	1-15	11	1	12	
	16-31	20	5	4	
March	1-15	16	8	7	
	16-30	2	6	3	

		Daily Water Equivalent Summed (Total snowfall/Precipitation [mm])			
Month	**Days**	**1993-94**	**1994-95**	**1995-96**	**1996**
November	1-15	6.55	1.8	12.7	12.5
	16-31	15.65	6	19.7	16.1
December	1-15	3.35	0.9	21.8	7.6
	16-31	2.05	2.7	0.6	27.7
January	1-15	21.5	6.8	13.6	
	16-28	4.3	0.6	7.7	
February	1-15	1.4	1.2	2.5	
	16-31	13	4.4	3.2	
March	1-15	1.8	6.4	7.7	
	16-30	3.6	12.3	9.7	

Table 4. Continued.

Month	Days	Average of Daily Maximum Temperatures (degrees C)			
		1993-94	1994-95	1995-96	1996
November	1-15	5.4	6.3	-0.3	2.2
	16-31	-1.8	0.4	2.1	-12.3
December	1-15	2.3	-4.5	-11.0	-3.5
	16-31	0.0	4.9	-7.1	-16.8
January	1-15	-12.1	-8.7	-4.2	
	16-28	-5.2	-2.6	-22.8	
February	1-15	-7.7	-0.9	-3.1	
	16-31	-14.4	3.8	-1.9	
March	1-15	8.1	2.1	-1.5	
	16-30	10.0	10.0	0.2	

Month	Days	Average of Daily Minimum Temperatures (degrees C)			
		1993-94	1994-95	1995-96	1996
November	1-15	-4.7	-4.5	-12.0	-6.2
	16-31	-10.9	-10.3	-6.5	-22.0
December	1-15	-6.5	-16.5	-20.4	-15.0
	16-31	-9.6	-5.4	-18.5	-27.8
January	1-15	-20.6	-16.6	-14.9	
	16-28	-13.6	-14.4	-31.7	
February	1-15	-20.2	-12.3	-14.7	
	16-31	-22.2	-8.5	-11.8	
March	1-15	-1.9	-12.1	-10.7	
	16-30	-3.4	-4.4	-9.0	

4.3 Species Distributions, Abundance, and Habitat Analysis

4.3.1 Prairie shrew

The prairie shrew's overall North American range covers roughly the grasslands of the northern Great Plains from southeast Alberta south and eastward into Missouri (Pattie and Hoffmann 1992). In Alberta, it is found in the southeast from the United States border north to Smoky Lake and St. Paul, from the Saskatchewan border west to Edmonton and Pigeon Lake, and south to Calgary and Milk River (Smith 1993). In this region, the prairie shrew inhabits prairie areas from the arid grasslands to the parklands where it uses suitable habitat in dense vegetation, shrubby areas, and meadows (Pattie and Hoffmann 1992; Smith 1993). General biological information on the prairie shrew is located in Appendix 6.

Although the prairie shrew ranked fourth in total number of animals caught (45) in the 1994 to 1995 wildlife survey, it was widely distributed throughout the SNWA and occurred in most habitats, suggesting that this species has few habitat restrictions. Since prairie shrews are primarily insectivorous, habitat selection does not need to be specific to vegetation patterns. In terms of catch effort, the abundance of prairie shrews did not increase with the increase in shrub cover from absolute grasslands to shrub-tree areas.

Although not significant, some habitats stood out in the SNWA in terms of catch effort values for the prairie shrew. Prairie shrews appeared to be associated with the Shrub Grasslands zone (7.7% mean shrub cover), sand dune-dominated eolian landforms, and Interdunal–Morainal as well as Ravines topographic habitats. Based on distribution of numbers of animals caught and the rate of catch, these habitats support more prairie shrews than other sites, and therefore may be considered as important habitats in terms of survival of prairie shrews in the SNWA. In contrast, habitats associated with wetlands and wet meadows did not appear to support prairie shrews and may be avoided.

Within vegetation zones, the high variation of catch associated with the Shrub Grasslands zone compared with the Grasslands zone arises from a higher number of plots with no catch. However, within these two habitats the catch rate was fairly consistent at 11% and 9%, respectively. There is probably no habitat difference among vegetation zones since the mean CE values were not significantly different, even though the Shrubs–Trees zone is poorly represented as a result of small sample size. The majority of plots in the Shrubs–Trees zone had no catch, which contributed to a higher variation.

Within topographic habitats, the Ravines and Interdunal–Morainal habitats had higher mean CE values than the Flat Uplands. However, prairie shrews were caught more often in Sand Dunes and Flat Uplands topographic habitats which also had the first and second highest proportion of the catch, respectively, of the 5 types. Prairie shrews showed a fairly consistent rate of catch (9% to 13%) across the 4 topographic habitats in which they were caught. Therefore, it appears that a topographic habitat relationship does not exist except for Wet Area sites which may not have been used. Prairie shrews appear to tolerate minor changes in topographical relief, as indicated by no adverse effects on their density. The SNWA trapping data corresponds well with habitat descriptions in the literature for prairie shrews regarding their preferred association with dense vegetation and shrubby areas within moderately undulating to flat grassland habitats.

In Alberta, the prairie shrew is categorized as "Status Undetermined" because insufficient information is available to determine its status; however, at present it is not known to be at risk (Appendix 7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is medium, varying from nil in Wet Areas to medium and high density in the other vegetation zones and topographic habitats. High densities were displayed in the Shrub Grasslands zone and in the Sand Dunes, Interdunal–Morainal, and Ravines topographic habitats.

4.3.2 Bats

4.3.2.1 Little brown bat

The little brown bat is found throughout North America from central Alaska to Newfoundland. Its range extends south along the eastern seaboard into northern Florida in the central west part, southward into the middle of Mexico, and south along the Pacific coast to just south of San Francisco (Pattie and Hoffmann 1992). The little brown bat is the most common species in Canada, and is a common inhabitant of the prairies region. It ranges throughout the entire province of Alberta in areas of suitable habitat, especially within the parkland region and the more heavily forested areas exclusive of the Rocky Mountains (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). General biological information on this species is located in Appendix 6.

Little brown bats are common throughout Alberta in habitats of deciduous trees, coniferous forests, and accessible old buildings that are located near both trees and water where they can hunt for insects at dusk and throughout the night (Soper 1964; Smith 1993). Such suitable areas are prime for nursery colonies and provide open meadow and stream courses for uninterrupted flight (Soper 1964). Alberta populations of this species are the only ones known to use exposed diurnal roosts throughout the summer months (Riskin and Pybus 1998). The selection of these daytime roosts appears to be based on several factors including thermoregulation, predator avoidance, and desiccation avoidance (Riskin and Pybus 1998). In the SNWA study, only 4 of 86 bat captures (4.6%) were little brown bats, a much lower than expected rate of catch for the SNWA since they are the most common bat species in Canada (McNalley and Barclay 1995).

In Alberta, the little brown bat is on the Green list, which means populations are stable, key habitats are generally secure, and the species is not considered to be at risk (Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is low (Appendix 7).

4.3.2.2 Long-eared bat

The long-eared bat is essentially a western montane species that ranges across south-central British Columbia and Alberta into the Cypress Hills of Saskatchewan, and south to western

North Dakota (Pattie and Hoffmann 1992). Along the western boundary, it extends south to Baja, California, occupying montane coniferous and coastal forests within this region. In Canada, it occurs in south-central British Columbia and in the southern plains areas of Alberta and Saskatchewan (Soper 1964; Pattie and Hoffmann 1992). In Alberta, the long-eared bat occupies the southern 25% of the province and is found in the mountains from Jasper south to Waterton, and on the southern grasslands as far north as Trochu and the Red Deer River system (Smith 1993). General biological information on the long-eared bat is located in Appendix 6.

Life-history information is generally lacking for this species in the prairie region, and nothing is known about its predators or economic value (Soper 1964; Pattie and Hoffmann 1992). The long-eared bat occupies river valleys and ravines in southern Alberta where rock outcrops provide shelter and suitable habitat (Smith 1993). Occasionally, members of this species occupy buildings and they occur in small numbers wherever forests exist within their distributional range. The long-eared bat is considered to be uncommon in prairie grasslands and rare in the mountains, with only rare appearances in Alberta in the past (Soper 1964; Smith 1993). In the SNWA study, 28 of 86 bat captures (32.6%) were long-eared bats, the second highest rate of catch in the SNWA, which was much higher than expected based on known abundance and occurrence information for Alberta (McNalley and Barclay 1995).

In Alberta, the long-eared bat is classified as "Status Undetermined" where the species is not presently known to be at risk, but for which insufficient information is available (Appendix 7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is medium (Appendix 7).

4.3.2.3 Long-legged bat

The long-legged bat is a western North American bat ranging from Mexico to Alaska. The Montana and North Dakota records are mainly from forested and riparian areas near water (Pattie and Hoffmann 1992). Within the prairie region, there are records from central and southern Alberta, but none from Saskatchewan or Manitoba (Pattie and Hoffmann 1992). In Alberta, the long-legged bat is a western and southern representative extending from Spirit River in the north, south along the mountains in the west and eastward along the Milk River in the south (Smith 1993). At local sites, this bat is relatively common. The type locality is from Henry House, Jasper National Park (Soper 1964). Individuals of this species that occupy grassland areas are lighter-coloured than those individuals that live in forested areas (Smith 1993). General biological information on the long-legged bat is located in Appendix 6.

Throughout its Alberta range, the long-legged bat inhabits areas of suitable habitat that include rocky outcrops along the Milk River and caves in the mountains (Smith 1993). In the SNWA study, 1 of 86 bats captured (1.2%) were long-legged bats which confirms their presence but in extremely low numbers (McNalley and Barclay 1995).

In Alberta, the long-legged bat is classified as "Status Undetermined" where this species is presently not known to be at risk, but for which insufficient information is available (Appendix

7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is low (Appendix 7).

4.3.2.4 Western small-footed bat

The North American range of the western small-footed bat includes the driest part of the prairies region, extending southward from the Red Deer River in Alberta and the South Saskatchewan River in Saskatchewan across the arid portions of Montana and western North Dakota, west to the west coast of California, south to central Mexico, and east to Oklahoma and Kansas (Pattie and Hoffmann 1992). In the northwest, its range extends into the Okanagan Valley of southern British Columbia. In Alberta, the western small-footed bat is found only on the grasslands, occurring as far north as Rumsey but south of the Red Deer River, and extending as far west as Lethbridge (Smith 1993). The western small-footed bat is nearly always associated with rocky outcrops and crevices in badlands where it uses rocks for cover and hiding (Pattie and Hoffmann 1992; Smith 1993). General biological information on the western small-footed bat is located in Appendix 6.

In the western part of the range where the western small-footed bat is considered to be common, day roosts are unknown. The western small-footed bat is generally considered to be uncommon throughout Alberta ranges; however, in some areas of the grassland region such as Dinosaur Provincial Park this species can be relatively abundant (Pattie and Hoffmann 1992). In the SNWA survey, 43 of 86 bat captures (50%) were western small-footed bats, which represented the most abundant bat species caught in the SNWA, a finding somewhat contrary to expectations based on known occurrence information for Alberta (McNalley and Barclay 1995).

In Alberta, the western small-footed bat is on the Yellow B list, indicating that this species is naturally rare with a clumped breeding distribution, but one that is presently not in decline (Appendix 7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is high (Appendix 7).

4.3.2.5 Big brown bat

Big brown bats range from central British Columbia on the west coast to northern Alberta, extending to southeast Manitoba. They range from coast to coast in the United States, extending southward to northern South America (Pattie and Hoffmann 1992). In Alberta, big brown bats range throughout the entire province except for the northwest corner (Smith 1993). Along with the little brown bat, these are the most common bats in the prairie region. General biological information on the big brown bat is located in Appendix 6.

Most big brown bats are found in old deserted buildings where there is easy access; however, they also occupy caves and crevices (Smith 1993). Although this species is relatively common, its survival is vulnerable to the destruction of older buildings (Smith 1993). In the SNWA bat survey, 6 of 86 captures (7%) were big brown bats, the third most abundant bat species caught in this area (McNalley and Barclay 1995).

In Alberta, the big brown bat is on the Green list, where this species is not considered to be at risk because of stable populations and generally secure key habitats (Appendix 7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is low (Appendix 7).

4.3.2.6 Hoary bat

The hoary bat has the most extensive distribution of any North American bat, extending northward from Uruguay and Argentina through Central America to Southampton Island at the northern edge of Hudson Bay (Pattie and Hoffmann 1992). It has also been recorded in Iceland, the Orkeny Islands, and Hawaii, but has not yet been recorded in the Yukon Territory (Pattie and Hoffmann 1992). It is absent from the western Arctic, Alaska, and most of British Columbia. In Alberta, it is believed this bat is a summer inhabitant of wooded areas and can be found throughout the province except for the northwest corner (Soper 1964; Smith 1993). General biological information on the hoary bat is located in Appendix 6.

The hoary bat is a truly arboreal species where both coniferous and deciduous trees in forest communities provide suitable habitat (Soper 1964; Smith 1993). The hoary bat is relatively common with several sightings every year, but few bats are actually encountered because of their solitary habits (Smith 1993). It is a wide-ranging species occupying a variety of habitats that differ with changing latitude. In the SNWA bat survey, 4 of 86 bat captures (4.6%) were hoary bats, the same number as little brown bats. Together these two species shared the fourth most abundant position in the bat fauna of the SNWA (McNalley and Barclay 1995).

In Alberta, the hoary bat is classified as "Status Undetermined" where this species is presently not known to be at risk, but for which insufficient information is available (Appendix 7; Alberta Environmental Protection 1996). Its overall local abundance level status in the SNWA is low (Appendix 7).

4.3.2.7 Habitat

As a result of the bat fauna survey in the SNWA, all species that were expected to inhabit the mixedgrass prairies were actually found there. However, the SNWA bat community was dominated by two species— the western small-footed bat (50% of catch) and the long-eared bat (33% of catch). The species that was expected to dominate the bat fauna of the SNWA was the little brown bat, which happened to be only 4.6% of catch. In addition to being the most abundant and widely distributed bat in Canada, the little brown bat is a species that forages over or close to water (McNalley and Barclay 1995). Based on this information and the results of the SNWA inventory, one would think that the majority of netting sites probably were not near water. To the contrary, at least one third of the netting locations (15) were close to or on the banks of the South Saskatchewan River, and of these, little brown bats were caught at only 1 site.

This suggests that the little brown bat is truly not abundant in the SNWA. The general lack of large water bodies in the SNWA may be a limiting factor for the little brown bat, as well as a scarcity of sites that provide buildings and hollow trees for roosts (McNalley and Barclay 1995). On the other hand, the hoary bat is an arboreal species that roosts in trees and migrates south for winter. It was an unexpected inhabitant of this prairie grassland, and the hoary bat probably uses primarily cottonwood trees for roosts during its stay in the SNWA.

Many of the western small-footed bats were caught in the Fluvial landforms, sites that consisted of ravines and secondary stream channels (Appendix 1). This suggests that these areas are important foraging sites for this species. Their known association with rocky outcrops and crevices in badlands as preferred habitat partially explains why western small-footed bats were the most abundant species caught in the SNWA. Based on the results of this survey, we concluded that the Ravines topographic habitat in the SNWA is important to the survival of western small-footed bats in Alberta.

The high numbers of long-eared bats, the second most abundant species caught in the SNWA, was surprising and contrary to literature reports of this species being a forest dweller, relatively uncommon on prairie grasslands, and rare in Alberta (Soper 1964). A possible explanation is that long-eared bats have a flexible foraging strategy allowing them to use different habitats by foraging on insects associated with vegetation, insects associated with the ground, or on airborne insects (McNalley and Barclay 1995). The light-tagging observations in the SNWA study tended to support this idea. Furthermore, the results substantiated the literature that long-eared bats in southern Alberta occupy ravines where rock outcrops provide shelter and suitable habitat (Smith 1993).

The Fluvial ecosection (Ravines topographic habitat) was used more than any other ecosection by all species of bats in the SNWA. Although these areas tend to be located close to roosting sites, the high number of feeding buzzes recorded in ravines confirms that bats use these habitats for feeding as well as for travel corridors (McNalley and Barclay 1995). It is clear that Fluvial ecosection sites in the SNWA are particularly important foraging areas for bats, although the more open areas of Eolian ecosection sites, Glacial-fluvial ecosection sites, and Morainal ecosection sites are also used for foraging, but to a lesser extent. The distribution of bats in the SNWA may have been influenced by the cool wet summer of 1995 because foraging behaviour is usually altered by ambient temperature, rainfall, and other environmental conditions that directly affect the amount of available prey (McNalley and Barclay 1995).

4.3.3 Lagomorphs

4.3.3.1 Nuttall's cottontail

In North America, the range of the Nuttall's cottontail occurs almost entirely west of the Montana-North Dakota border, extending to the Cascade Mountains and south along the east slopes of the Sierra Nevada into central Mexico (Pattie and Hoffmann 1992). In Alberta, the Nuttall's cottontail is distributed throughout the grassland region of southeast Alberta, from the

Saskatchewan border to near Calgary, and from the United States border north to the Red Deer River. Generally, they diminish in numbers from south to north (Soper 1964; Smith 1993). Nuttall's cottontails have not been recorded in the extreme southwest corner of the province in the Waterton Lakes area, nor have there been any specimens to substantiate their presence in the Red Deer River region (Smith 1993). General biological information on the Nuttall's cottontail is located in Appendix 6.

Nuttall's cottontails occurred throughout the SNWA, but in a somewhat scattered distribution (Figure 9). These small rabbits were seen most frequently in ravines along the South Saskatchewan River in the North and South Blocks, in lowland wet habitat in the southeast part of the South Block near Old Channel Lake (Figure 1), in Sand Dunes in the northwest part of the North Block, and in the central part of the South Block. As well, they were found in the Dugway and Sherwood forests along the river. Of the 2 species of lagomorphs, cottontails inhabit ravines and river breaks almost exclusively, using the cover of rocks and boulders, brushy shrubs, and fallen trees. The only other habitats they were associated with in the SNWA contain human-created structures such as dugouts, windmills and corrals, as well as sheds and other buildings. These observations substantiate the literature reports of favourite habitat sites being shrub-cottonwood and river bottomlands and associated slopes, ravines with lots of shrub cover, badlands, tributary ravines, rocky valley sides, and prairie grasslands with lots of scrub brush cover (Soper 1964; Smith 1993). This is the type of habitat where Nuttall's cottontails were observed most frequently in the SNWA.

The majority of observations (70%) of Nuttall's cottontails in the South Block occurred within the Shrub Grasslands zone, with a few in the Shrubs–Trees zone, and some in the Grasslands zone. In addition, the majority of the North Block observations were in the Ravines topographic habitat with some in the Sand Dunes and the Interdunal–Morainal habitats. Nuttall's cottontails avoid open, coverless plains, instead showing a high preference for rugged terrain with lots of scattered thickets of common wild rose (*Rosa woodsii*), silver-berry (wolf willow) (*Eleagnus commutata*), buckbrush (*Symphoricarpus occidentalis*), sagebrush (*Artemisia cana*), and greasewood (*Sarcobatus vermiculatus*) (Soper 1964). They are seldom seen far from the cover of brush, rugged and rocky terrain, or buildings. Activity levels are the highest at twilight and during night, but this activity is severely reduced with inclement weather (Pattie and Hoffmann 1992). Based on their known behaviour of hiding, seclusion, and restricted activity, it is probable that Nuttall's cottontails are underrepresented in the SNWA using the incidental observations data.

Following a population status evaluation in 1994, the Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classified Nuttall's cottontails as "not at risk" (Appendix 7). In Alberta, the Nuttall's cottontail is on the Yellow B list, which means this species is naturally rare with a clumped breeding distribution, but is presently not in decline (Alberta Environmental Protection 1996). We assessed its overall local abundance level status in the SNWA as medium (Appendix 7).

4.3.3.2 White-tailed jack rabbit

In North America, the white-tailed jack rabbit is distributed across the Northern Great Plains from the eastern slopes of the Cascade Mountains and Sierra Nevada east to near the Mississippi River, then north to central Alberta and Saskatchewan (Pattie and Hoffmann 1992). In Alberta, the white-tailed jack rabbit is a prairie resident with the centre of its distribution in the grassland areas of the southern part of the province, ranging to a northern limit of Dapp in the Aspen Parklands Region (Soper 1964; Smith 1993). The western boundary closely parallels 114^0 W longitude in the northern part of its range to a line approximating west Calgary, continuing south to the Waterton townsite (Smith 1993). General biological information on the white-tailed jack rabbit is located in Appendix 6.

The white-tailed jack rabbit is a big, open-country hare with powerful hind legs that provide an explosive propulsion for speed to escape from predators. These hares are most active during moonlit nights when they feed continuously from about 1 h after sunset until sunrise. They depend solely on their remarkable speed as an escape mechanism when threatened (Pattie and Hoffmann 1992). White-tailed jack rabbits were fairly well distributed throughout both Blocks according to the incidental observations (Figure 9) and the pellet count densities (Table 3; Figure 10). They appeared to be more widely distributed in the SNWA than the cottontail. Based on incidental observations, white-tailed jack rabbits were mostly associated with the Grasslands and Shrub Grasslands zones, and with the Flat Uplands and Sand Dunes topographic habitats. The majority (70%) of observations of white-tailed jack rabbits in the South Block occurred in the Grasslands zone with the remaining observations in the Shrub Grasslands zone. This is the opposite of what was observed for Nuttall's cottontails.

Overall, the white-tailed jack rabbit uses upland habitat almost exclusively. This supports the literature which states the preferred habitat of white-tailed jack rabbits is open grassland prairies with intermittent shrubby cover provided by bunchgrass and clumps of snowberry, wild rose, silver-berry, sagebrush, and greasewood (Soper 1964). These prairies are abundant in the SNWA and white-tailed jack rabbits were observed most frequently in this habitat. In comparison, cottontails avoid open, coverless plains, but prefer shrub-cottonwood tree groves and brushy ravines and grasslands. Similarly, jack rabbits differed from cottontails by having little association with the Ravines topographic habitat (< 5% of observations) whereas cottontails were almost exclusively associated with ravines along the South Saskatchewan River. Locomotor and foraging activity by white-tailed jack rabbits are maintained under a wide range of environmental conditions such as low ambient temperature and snowfall because these animals are well insulated (Rogowitz 1997).

The white-tailed jack rabbit is a creature of the open plains and grasslands in the south, open meadows in the north, and treeless alpine tundra in the mountains (Pattie and Hoffmann 1992; Smith 1993). During winter, they often seek shelter in open woodlands, but avoid dense timber (Pattie and Hoffmann 1992). Jack rabbits require wide open, generally flat grasslands for visibility where they depend on their superior running ability to escape predators. Contrarily, cottontails require shrubs for cover and steep rugged terrain for hiding to escape predators. The foraging and locomotor activities of white-tailed jack rabbits are influenced by environmental, social, and predator effects with these activity patterns being significantly influenced by the seasonal effects of photoperiod, reproductive activity, and snow cover (Rogowitz 1997).

More than 90% of the observations of white-tailed jack rabbits were in the North Block, with the Double Wide Fireguard, Whitco Trail, Mule Deer Road south, Mounted Rifles Road, and Kangaroo Rat Road (Figure 1; Figure 9) being areas of concentrated observations. Most of the incidental observations were collected by the kangaroo rat team during nightlight surveys which biased the count based on their road work. A large part of the North Block is within the Shrub Grasslands zone and partially explains why about 80% of the incidental observations were in Shrub Grasslands. However, the majority of North Block observations occurred along open roads and trails where visibility was high and cover intermittent. Because of these biases, the pellet density contours probably better represent white-tailed jack rabbit numbers in the North Block than do incidental observations. Based on road survey bias, the behaviour of white-tailed jack rabbits to run when alarmed, and their long periods of nighttime activity, it is probable that white-tailed jack rabbits are overrepresented by the incidental observations data, especially in the North Block.

Normal densities of white-tailed jack rabbits throughout their distributional range are from 4-8/km^2 up to 11-54/km^2 (Pattie and Hoffmann 1992). Populations often fluctuate from extraordinarily high numbers (abundance) to extremely low numbers (scarcity) in what appears to be 8-10 year cycles (Soper 1964). In Alberta, the white-tailed jack rabbit is on the Green list and this species is not considered to be at risk because of stable or increasing populations and key habitats that are secure (Alberta Environmental Protection 1996). We assessed its overall local abundance level status in the SNWA as medium (Appendix 7).

4.3.3.3 Habitat

Although lagomorph species differentiation was not possible from pellet count surveys, comparison of the species observations distribution map with the contour map of pellet count densities provided some insights as to individual species habitat preferences. The distribution of Nuttall's cottontails and white-tailed jack rabbits as determined by incidental observations (Figure 9) and pellet count densities (Figure 10) were complementary. The incidental observations provided insights at the species level while pellet count densities provided a more thorough picture of the overall distribution of lagomorphs. However, 2 limitations of the data require clarification.

The first limitation is a bias caused by collection of the incidental observations from multiple road surveys, as represented in Figure 9, where the data collectors and their efforts were not evenly distributed throughout the North Block. The second limitation is a bias that was created by overwintering lagomorphs that tend to be sedentary and accumulate pellets at individual animal resting places. This meant that the fecal pellet distribution of overwintering animals, as represented in Figure 10, was not evenly distributed throughout the area. Therefore, because of effort bias in the North Block, the distribution of lagomorphs should be interpreted from the South Block incidental observations. This analysis suggests that Nuttall's cottontails and white-tailed jack rabbits have approximately the same number of observations and are fairly evenly represented in the SNWA (Figure 9). Furthermore, extremely high-density pellet sites should be interpreted as possible overwintering areas for lagomorphs (Figure 10).

Based on pellet counts, about 38% of the total number of sampled plots had lagomorph pellets present, which suggests a wide distribution of the 2 species in the SNWA. The scattered distribution of lagomorph pellets throughout the North Block (Figure 10) occurred mainly in the Shrub Grasslands zone as well as in the Ravines, the Flat Uplands, and the Sand Dunes topographic habitats. This suggests that these habitats are used by both species. The medium-density sites in the northwest corner of the North Block (Figure 10) occurred in the Sand Dunes topographic habitat which, when assessed by the incidental observations, reflects use by both species (Figure 9). The high-density sites along the South Saskatchewan River in the middle part of the North Block (Figure 10) occurred in the Ravines topographic habitat which reflects almost exclusive use by cottontails (Figure 9). Ravines are known to be important habitat for Nuttall's cottontails. The high-density concentration of pellets in the area of the junction of Whitco Trail and Double Wide Fireguard (Figure 1; Figure 10) occurred in the Flat Uplands and the Interdunal–Morainal topographic habitats, and based on incidental observations reflects sole use by jack rabbits (Figure 9).

Within the South Block, the distribution of lagomorph pellets was more scattered and densities were lower overall than in the North Block (Figure 10). In general, the majority of pellets occurred in the Grasslands zone and in Flat Uplands and Interdunal–Morainal topographic habitats. Both species of lagomorphs were found to be fairly evenly represented in the South Block; however, Nuttall's cottontails had a slightly higher frequency of incidental observations (Figure 9). The high density of pellets per hectare in the Bull Pen (Figure 1; Figure 10) occurred in the Flat Uplands topographic habitat, and based on incidental observations reflects use by both cottontails and jack rabbits (Figure 9). The other high-density pellet area in the east-central part of Casa Berardi and Falcon areas (Figure 10) occurred in the Sand Dunes, Flat Uplands, and Interdunal–Morainal topographic habitats. Based on incidental observations, this reflects a use by both cottontails and jack rabbits (Figure 9). Other areas of low- to medium-density lagomorph pellet concentrations were along the southern stretch of the South Saskatchewan River and in the southeast corner of the South Block in the lowland area (Figure 10). These sites were in the Flat Uplands and Wet Areas topographic habitats where, based on incidental observations, Nuttall's cottontail was the most common species (Figure 9).

Nuttall's cottontails were the main user of lowland wet areas based on incidental observations and pellet counts (Figure 9; Figure 10). Also, the second highest mean number of pellets per hectare (483) occurred in the Wet Areas topographic habitat which supports the understanding that cottontails are the most common species in lowland areas. However, the high mean pellets per hectare value can be explained by the small sample size where only 1 of 3 plots sampled had pellets present, but at high density (Table 3). Within topographic habitats, Sand Dunes had the third highest mean number of pellets per hectare (298) which is partially explained because of the highest percent (39%) of sampled plots with pellets present (Table 3) and the maximum individual plot density of 34,750 pellets/ha.

4.3.4 Richardson's ground squirrel

The North American distribution of the Richardson's ground squirrel includes the northern Great Plains of northern and central Montana, most of North Dakota except the southwest corner, northeast South Dakota, western Minnesota, southwest Manitoba, and southern Saskatchewan and Alberta (Pattie and Hoffmann 1992; Michener 1998). In Alberta, the Richardson's ground squirrel is distributed throughout the grasslands and parklands as far north as Athabasca (Smith 1993). The western boundary extends from Thunder Lake in northern Alberta to the Ya Ha Tinda Ranch northwest of Calgary, continuing south to the grasslands of Waterton Lakes National Park (Soper 1964; Smith 1993). General biological information on the Richardson's ground squirrel is located in Appendix 6.

During the nineteenth century, the Richardson's ground squirrel was the most abundant terrestrial mammal on the prairies. Although current populations are a small percentage of their former numbers, they still are one of the most frequently seen prairie mammals because they use roads and trails as vantage points (Pattie and Hoffmann 1992). Historically, densities in Alberta may have reached as high as 8,287/km^2. Recent densities have been estimated at 1,500/km^2 on grasslands, 1,200/km^2 on abandoned farms, 200-1,000/km^2 on native prairie, 750/km^2 on cultivated grain fields, and 500/km^2 on irrigated fields (Pattie and Hoffmann 1992). However, pre-development densities of Richardson's ground squirrels will probably never occur again because of the loss of native prairie habitats to agriculture and urban development. The preferred habitat of Richardson's ground squirrels is wide open, short and mixedgrass prairies as well as landscapes that include tundra and overgrazed pastures (Pattie and Hoffmann 1992; Smith 1993). They also inhabit roadside ditches, grain fields, and hay meadows (Smith 1993).

Throughout the distributional range of Richardson's ground squirrels, they do not inhabit areas with loose sand or heavy clay soils (Pattie and Hoffmann 1992). This appeared to be the situation in the SNWA where Richardson's ground squirrels were essentially absent from the extremely sandy soils of the North Block and they were scarce in the mainly sandy soils of the South Block. Furthermore, the majority of observations were associated with road rights-of-way where the normally loose, sandy soils have been stabilized from compaction, and in some cases from clay-capping and gravel as a result of road construction. At these sites, the soil base more closely resembles typical Richardson's ground squirrel habitat. Most of the observations in the SNWA were associated with the Flat Uplands topographic habitat. This correlates with the literature which states the preferred habitat is mixedgrass prairie and overgrazed pastures where long-distance visual surveillance for predators is possible.

The dead Richardson's ground squirrel caught at the snake trap on transect line 5571 in the sagebrush flat adjacent to the South Saskatchewan River was unexpected. How Richardson's ground squirrels arrived at this site is not known, but swimming across the river from the east side is a possibility. Local belief suggests that Richardson's ground squirrels are absent or are in extremely low numbers because of predation by prairie rattlesnakes (*Crotalus viridis*); however, we believe the main limiting factor in the SNWA is poor quality habitat because of sandy soils.

In Alberta, Richardson's ground squirrels are presently not at risk, but they are considered to be a sensitive species. At some time in the future, demographics that make Richardson's ground squirrels vulnerable to human-related changes in the environment may have to be addressed and special management considerations may be required. Their status in Alberta is classified as Yellow A, which suggests concern over long-term declines in numbers, a situation that may merit extra attention to ensure their continued survival and conservation (Appendix 7; Alberta Environmental Protection 1996). The overall local abundance level status of Richardson's ground squirrels in the SNWA is extremely low (Appendix 7).

4.3.5 Thirteen-lined ground squirrel

In North America, the thirteen-lined ground squirrel is distributed across the Great Plains of Canada and the central United States. In Alberta, it is found throughout the aspen parkland as far north as Cold Lake and as far west as Rocky Mountain House. It is also found in extreme southern Alberta from the townsite of Waterton east to the Cypress Hills and north along the Saskatchewan border to Empress. Most of its Alberta range coincides with the distribution of the Richardson's ground squirrel as it is abundant on the eastern side, but becomes progressively less numerous westward. Smith (1993) identified an area in south-central Alberta east of Calgary and south of the Red Deer River where this species has never been collected. The 46 specimens from the 1994 to 1996 SNWA study now have confirmed their presence in the eastern side of this void, which has resulted in a continuous distribution that connects the Cypress Hills region with the prairies north of the Red Deer River. General biological information on the thirteen-lined ground squirrel is located in Appendix 6.

Thirteen-lined ground squirrels were most associated with the Grasslands zone based on high-density plots, the highest mean CE value, the highest rate of catch, and the highest proportion of the catch at 55.2% (16/29). The low-density plots were more associated with the Shrub Grasslands zone. These results indicate a strong affinity for grassland habitat that includes dense vegetation cover and adjacent areas with shrub components. The thirteen-lined ground squirrel had a relatively low overall catch rate (6.4%). It was caught over a narrow range of habitat types, suggesting a restricted habitat requirement and distribution. There appears to be a trend of decreasing CE with an increasing amount of shrub cover in the habitat from the highest in the Grasslands zone to a medium level in the Shrub Grasslands to nil in the Shrubs–Trees zone (Figure 7). Based on the distribution of numbers of animals caught and catch rate within topographic habitats, the Flat Uplands had the highest proportion of the catch at 69% (20/29) of the 5 types, while the Sand Dunes had a much lower proportion of the catch at 27.6% (8/29). Thirteen-lined ground squirrels were not caught in the Shrubs–Trees zone nor in Ravines and Wet Areas topographic habitats, suggesting that these habitats were not used and may even be avoided.

Thirteen-lined ground squirrels are cryptically coloured prairie mammals that are strictly diurnal (Soper 1964; Pattie and Hoffmann 1992; Kirsch 1997). They are best adapted to flat grassland habitat with sandy soils where they can dig elaborate burrow systems, detect predators from a distance, readily escape, and where they blend in with prairie grasses. Such prairie grasslands provide seasonal resources of cover and food items of seeds, grasses, leaves, roots, and a variety of prairie insects. Thirteen-lined ground squirrels are native to tallgrass prairies but are common in shortgrass prairies as well (Kirsch 1997). In a small mammal study of the tallgrass prairies of northeastern Kansas, thirteen-liners were 6th of 15 species which represented 3.2% of the total catch (Clark *et al.* 1987). They were minor representatives of other tallgrass prairie studies in northeastern Kansas (Peterson *et al.* 1985; McMillan and Kaufman 1994). Favoured habitat of thirteen-lined ground squirrels includes the edges of shrubby areas where non-woody vegetation is dense such as hay fields, open pastures, uncultivated wastelands, and mixedgrass prairies (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). In western Kansas, thirteen-lined ground squirrels used croplands only to a limited extent where the frequency of cultivation and the state of crop development limited the distribution of this species (Navo and Fleharty 1983). However, they were considered to be transient dispersers in irrigated cornfields, were caught in a wheat field after the July harvest, and were trapped only in July in the adjacent sandsage prairie area (Fleharty and Navo 1983; Navo and Fleharty 1983). In the SNWA, thirteen-lined ground squirrels live primarily in the Grasslands zone and the Flat Uplands topographic habitat, probably making these habitats important to survival of the species. Therefore, it was not surprising that they used flatter grassland habitat which included dense vegetation and scattered shrubs for cover.

In Alberta, the thirteen-lined ground squirrel is considered to be a sensitive species that presently is not at risk. However, special management consideration to address demographics that make thirteen-lined ground squirrels vulnerable to human-related changes in the environment may soon be required because of naturally low populations and a limited distribution. The status of thirteen-lined ground squirrels in Alberta is listed as Yellow A, which suggests concern over possible long-term declines in numbers that may soon warrant extra attention to ensure their protection, conservation, and continued survival (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status in the SNWA as medium (Appendix 7).

4.3.6 Northern pocket gopher

The low trap success of the northern pocket gopher in the SNWA can be partially explained by its fossorial (pertains to the habit of digging burrows and dens for life underground) habits and underground-dwelling behaviour, which means it is only vulnerable to snap trapping during aboveground expeditions. A high density of mounds were obvious signs of their presence throughout the SNWA which, when considered with the extremely low rate of catch (2.3%), suggested that snap trapping is ineffective to properly determine the distribution of northern pocket gophers. Therefore, we used mean mound count densities to provide a more detailed picture of the distribution of northern pocket gophers in the SNWA.

The northern pocket gopher is found throughout the northern Great Plains and the central Rocky Mountains region of North America that extends from Manitoba to Alberta and continues south to Nebraska, Colorado, northern Arizona, and New Mexico (Pattie and Hoffmann 1992). The distributional range of this species in Alberta is disjunct, with a parkland population that extends from Lac La Biche in the north to Trochu in the south, and continues along the foothills into the mountains in the Crowsnest and Waterton Lakes area on the west, extending south from there to the United States border. Another group, the grassland population, extends along the southern Alberta border from the town of Milk River east to the Saskatchewan border, and continues north to Cypress Hills, extending farther north to Empress. Northern pocket gophers are absent from an area in south-central Alberta that lies between these two regions and extends north from Lethbridge and east from Calgary, Drumheller, and Oyen (Smith 1993). The western boundary of the grassland group forms the eastern border of the SNWA subpopulation. General biological information on the northern pocket gopher is located in Appendix 6.

The northern pocket gopher is an extremely adaptable small mammal that occupies a wide variety of soil and vegetation types, but avoids dense forest where the forage plants on which it depends are absent (Pattie and Hoffmann 1992). The species inhabiting the SNWA is an extremely light, buff-brown colour that closely matches the colour of the sandy soils where it lives. Mound count surveys indicated that northern pocket gophers are distributed in the Shrub Grasslands zone and the Sand Dunes topographic habitat throughout the North Block. The high percentage of sampled plots with mounds present (55%) confirms a wide-ranging distribution. The Middle Sand Hills area in Amiens and an area in the southwestern part of Ypres in the North Block had the highest concentrations of mounds (Figure 13), suggesting a specific soils-habitat requirement.

Within the South Block, the number of mounds was highest along the west boundary and central parts of Falcon, but at lower density levels than in the North Block (Figure 13). Similarly, the majority of mounds in the South Block were in the Shrub Grasslands zone and Sand Dunes and Flat Uplands topographic habitats. This suggests an affinity for sandy soils and grassland habitat with an associated dense cover of vegetation and shrubs.

The distribution of northern pocket gopher mounds appeared to be in direct association with eolian areas in the Sand Dunes topographic habitat and also with the sandy areas of the Interdunal–Morainal topographic habitat. When soils became more clay-based and were shifted away from sandy substrates, pocket gopher mound densities decreased substantially. Likewise, northern pocket gophers were noticeably absent from the Ravines habitat along the South Saskatchewan River valley in both the North and South Blocks, the uplands and upland ravines in the northern half of Casa Berardi, Fish Creek, and Ypres areas, and from the wetlands in the central and southwest Falcon area (Figure 13).

Within vegetation zones, northern pocket gophers were most associated with the Shrub Grasslands. Northern pocket gophers in the SNWA are basically a Sand Dunes topographic habitat dwelling species as Sand Dunes are the most commonly frequented, and likely provide the most important habitat for them. Clearly, northern pocket gophers had only a minor association with the Shrubs–Trees zone and the Ravines topographic habitat. Since their mounds were not observed in the Wet Areas topographic habitat nor were any animals caught, this suggests they may avoid this habitat. These findings agree with the literature that states the preferred habitat of the northern pocket gopher is associated with sandy uplands, black loamy soils, and gray, peaty, stony soils. Such habitats include native grasslands, hay meadows, roadside ditches, gardens, and alfalfa (*Medicago spp.*) fields (Soper 1964; Smith 1993).

In Alberta, northern pocket gophers are on the Green list which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status in the SNWA as medium (Appendix 7), varying from nil in Wet Areas, to low, medium, and high density in the other vegetation zones and topographic habitats. As a result of mound count surveys in the SNWA, high densities occurred in the Shrub Grasslands zone and the Sand Dunes topographic habitat.

4.3.7 Olive-backed pocket mouse

In North America, the distributional range of the olive-backed pocket mouse extends from near Saskatoon, Saskatchewan, into southeast Alberta and southwest Manitoba, south into extreme northern Nebraska, southern Colorado, and northeast Utah, occupying a major portion of the Great Plains (Pattie and Hoffmann 1992; Smith 1993). In Alberta, the olive-backed pocket mouse occupies the southeast corner of the province where the northern boundary is the Red Deer River and the western border is a line through Taber and the townsite of Milk River. The first recorded specimen in Alberta was taken in 1951, suggesting that a northward range extension from Montana probably occurred sometime after the 1927 international bioinventory was conducted (Soper 1964). General biological information on the olive-backed pocket mouse is located in Appendix 6.

Olive-backed pocket mice are widely distributed, but population densities are quite variable from area to area (Pattie and Hoffmann 1992; Smith 1993). The low number (14) collected and the extremely low rate of catch (3.3%) in the SNWA study supports the literature that throughout their distributional range, typically densities are low and animals are scarce (Smith 1993). No more than 1 animal was caught at any sample plot, indicating the probability of a low-density population. A low susceptibility to snap trapping because of trap shyness (Don Pattie, personal communication) could have been a factor that contributed to the low number of olive-backed pocket mice caught in the SNWA.

The distribution of the olive-backed pocket mouse in the SNWA is similar to that of the northern pocket gopher. Incidental observations from nightlight surveys contributed to an expanded distribution map for olive-backed pocket mice, and are important and useful data. Within vegetation zones, olive-backed pocket mice were most associated with the Shrub Grasslands zone based on high-density plots, the highest mean CE value, the highest rate of catch, and the highest proportion of the catch at 92%. The Grasslands zone had a mean CE that was 6 times lower, a catch rate about 8 times lower, and only 1/12 of the catch, suggesting this vegetation zone is less frequented by olive-backed pocket mice. Within topographic habitats, the majority of the catch plots were associated with the Sand Dunes, indicating a strong affinity for grassland habitat with sandy soils and an associated dense cover of vegetation and shrubs.

The olive-backed pocket mouse is associated with short and mixedgrass prairies that receive less than 500 mm of mean annual precipitation (Pattie and Hoffmann 1992). Its habitat is restricted to open grasslands on light, sandy soils. Based on the distribution of numbers of animals caught and rate of catch, we concluded that the olive-backed pocket mouse in the SNWA is basically sand dependent and is a Sand Dunes habitat dwelling species. In this habitat the dominant vegetation cover is a mixture of grasses and shrubs. Sand dunes are the most occupied and used sites, and likely provide the most important habitat for olive-backed pocket mice in the SNWA. Olive-backed pocket mice were not caught in the Shrubs–Trees zone nor in the Interdunal–Morainal, Ravines, and Wet Areas topographic habitats, suggesting that these habitats were not used and may be avoided. The olive-backed pocket mouse was caught over a narrow range of habitats, indicating a restricted distribution and habitat requirement in the SNWA.

In Alberta, the olive-backed pocket mouse is on the Yellow B list, indicating this species is naturally rare with a clumped breeding distribution, but one that is presently not in decline (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status in the SNWA as low (Appendix 7), varying from nil in the Shrubs–Trees zone and the Interdunal–Morainal, Ravines, and Wet Areas topographic habitats, to medium in the Shrubs Grasslands zone, to high in the Sand Dunes topographic habitat.

4.3.8 Ord's kangaroo rat snap trap inventory

The North American range for Ord's kangaroo rat occurs as far south as central Mexico, while in the United States it extends between central Oregon and Oklahoma where it occupies a major portion of the Great Plains grassland and sagebrush semi-desert (Pattie and Hoffmann 1992). In Canada, its limited distribution in southeast Alberta and southwest Saskatchewan represents the northern fringe of its North American range (Gummer 1995). General biological information on the Ord's kangaroo rat is located in Appendix 6.

In the SNWA, Ord's kangaroo rats were most associated with the Shrub Grasslands based on the highest mean CE value, the highest rate of catch, and the highest proportion of the catch. The Grasslands zone had a mean CE that was much lower, a catch rate about 13 times lower, and only 2% of the total catch, indicating a minor association with this vegetation zone. Within topographic habitats, Ord's kangaroo rats were most associated with Sand Dunes and Ravines habitats based on the highest and second highest overall mean CE values (Figure 7), the highest and second highest rate of catch, and the highest and second highest proportion of the catch. The Interdunal–Morainal topographic habitat had a mean CE that was more than 6 times lower, a catch rate that was about 2 times lower, and about 2% of the catch, indicating a minor association with this topographic habitat. None were caught in the Shrubs–Trees zone nor in the Wet Areas topographic habitat, suggesting that these habitats were not used.

Even though Ord's kangaroo rats were snap-trapped at only 1 plot in the northeast corner of the South Block in the SNWA, the nightlight surveys found them along the sandy segments of the Dugway and Interface/Trumpeter trails, suggesting a much wider distribution than that shown by snap traps (Figure 1; Figure 15). Ord's kangaroo rats were distributed in the South Block in association with sandy areas along roads and trails (Gummer 1999). In the SNWA, they had an overall medium to low catch rate (5.6%), although the total catch of 41 animals in 1994 to 1995 was fifth overall. This catch occurred over a fairly narrow range of habitats, suggesting a moderately restricted distribution and habitat requirement for Ord's kangaroo rats.

Ord's kangaroo rats occur in arid grassland and open scrubland environments where, because of their bipedal locomotion and fossorial lifestyle, they prefer sandy soil with a sparse grass cover (Smith 1993; Gummer 1997b). Sparsely vegetated sand is an important characteristic of Ord's kangaroo rat habitat and, in Canada, they are almost exclusively associated with actively eroding sand dune complexes in association with scurf pea (*Psoralea lanceolata*) and common wild rose (Nero and Fyfe 1956; Baron 1979; Gummer 1997b). Breeding kangaroo rats established as semiresidents in irrigated cornfields in western Kansas where seedbed preparation displaced or destroyed them, but as the growing season progressed and cover became denser they increased in numbers (Fleharty and Navo 1983). They were also common in the adjacent sandsage prairie areas as they were represented by breeding populations along with northern grasshopper mice (Fleharty and Navo 1983).

The majority of the catch plots in the SNWA were associated with the Shrub Grasslands zone and the Sand Dunes topographic habitat, suggesting a strong affinity for sandy soils in a shrubby-grassland habitat with a direct relationship to sandy areas. Based on the distribution of numbers of animals caught and rate of catch, we concluded that the Shrub Grasslands zone and the Sand Dunes topographic habitat were the most commonly frequented habitats by Ord's kangaroo rats. The large number of Ord's kangaroo rats caught during nightlight surveys suggested that human-disturbed areas such as roads, trails, and fireguards appeared to provide them with additional habitat.

In Canada, the Ord's kangaroo rat is at the northern limit of its range and is reproductively isolated from its southern counterparts in a distribution that is restricted by its unique habitat requirement of sparsely vegetated sand hills. It is at risk because of its occurrence at the fringe of the distributional range within small restricted areas of habitat and, thereby, has been classified as "vulnerable" by COSEWIC (Appendix 7; Gummer 1995). In Alberta, the Ord's kangaroo rat is on the Blue list which is considered to be at risk because of limited distribution in the province and its dependence on sparsely vegetated sandy habitats (Appendix 7; Alberta Environmental Protection 1996; Gummer 1997b). We assessed the overall local abundance level status in the SNWA for the Ord's kangaroo rat as medium (Appendix 7), varying from nil in Shrubs–Trees and Wet Areas to low and to high density in other vegetation zones and topographic habitats. High densities were displayed in the Shrub Grasslands zone and in Sand Dunes and Ravines topographic habitats.

4.3.8.1 Ord's kangaroo rat research survey

Based on the results of the ecological research project, Ord's kangaroo rats were more common, more widely distributed, and more abundant in the SNWA than expected according to the systematic snap trap inventory and literature reports on status (Gummer 1999). Although the snap trap survey and the quadrat nightlight survey results were complementary, the nightlight survey provided a more complete picture of the distribution and abundance of kangaroo rats for the area searched in the SNWA. The incidental observations supplemented both the nightlight survey and the snap trap databases.

Survival of Ord's kangaroo rats was poorest during winter, possibly as a result of starvation and hypothermia. They had an extremely low annual survivorship (< 10%) and, in spite of an overall large population in the SNWA, poor winter survival caused individuals to have difficulty finding mates in spring (Gummer 1999). Therefore, persistence of the northern population of Ord's kangaroo rats is somewhat precarious because of low survival rates in the SNWA population. Further research is required to determine the ecological factors affecting the long-term survival of Ord's kangaroo rats in the SNWA. The core of the provincial population of Ord's kangaroo rats is located in the Middle Sand Hills in the SNWA, emphasizing the importance of this area to the long-term survival of Ord's kangaroo rats in Alberta.

Kangaroo rats have a distinct affinity for loose, bare, sandy soils and shrubby vegetation (Gummer 1997a;1999). Therefore, it was somewhat of a surprise that the Ravines topographic habitat had the highest mean catch per effort, with 1 particular site having a high catch rate. On closer examination it was determined that this sample site (Whitco Springs area) was not truly representative of the typical Ravines topographic habitat because it was composed of extremely loose, blowing, sandy soil (Gummer 1999). Fieldwork in 1998 did not detect any kangaroo rats at this site, which confirms that annual variation in the abundance and distribution of kangaroo rats makes it difficult to base interpretations on short-term studies. Although Ord's kangaroo rats were most often detected in the Shrub Grasslands zone and in the Ravines, Interdunal–Morainal, and Sand Dunes topographic habitats, their distribution within the SNWA was not strictly correlated with these habitats. Ord's kangaroo rats in the SNWA have used anthropogenic habitats such as fireguards, roads, and trails (Gummer 1999). Possible negative consequences of kangaroo rats inhabiting these habitats include increased mortality as a result of predation, hypothermia, insufficient diet, and high prevalence of botfly parasitism (Gummer 1999). A hypothesis on the relationship between habitat and botfly infestation of Ord's kangaroo rats has been developed whereby kangaroo rats in anthropogenic habitats may be more likely to be parasitized by botfly larva, or more heavily parasitized than kangaroo rats in natural sand dune areas (Gummer *et al.* 1997; Gummer 1999). Ord's kangaroo rats were caught in every anthropogenic habitat that was sampled by more than ten 30-m quadrats in the SNWA (Gummer 1999). Because the research project was looking to maximize the number of easily caught kangaroo rats, the majority of enumerated rats were found in alternative habitats created by human disturbance (Gummer 1999).

The Ord's kangaroo rat data from the SNWA study were summarized without accounting for important factors such as moon stage (which affects activities and capture success), weather, seasonality of capture, age-class, sex, diet, home range, reproduction, dispersal movement, and parasites (Gummer 1999). Undoubtedly, these ecological factors probably affected the spatial distribution and abundance of Ord's kangaroo rats in the SNWA and should be taken into consideration in future studies. More detailed research information regarding ecology, status, distribution, and habitat of Ord's kangaroo rats in the SNWA can be found in Gummer (1997a; 1997b; 1999).

One factor that may have affected Ord's kangaroo rat distribution in the SNWA is dune stability.

An assessment of sand dune activity in the Middle Sand Hills of CFB Suffield found that from 1962 to 1971 the trend was toward stabilization of the sand hills, but from 1985 to 1993 the trend was toward active processess including marked increases in overgrazed areas, new critically sensitive sand dune crests with little or no vegetative cover, and new or enlarging active sand dune areas (McNeil 1993). From 1985 to 1993, a deteriorating range resource in the Middle Sand Hills was revealed by a comparison of 7 critically susceptible areas observed on 1985 air photos with conditions observed on the ground in June 1993 (McNeil 1993). This study documented that an overall decreasing stabilization of sand dunes occurred from 1971 to 1993 (McNeil 1993). Therefore, at this time we are not sure what role dune stabilization has had in kangaroo rat distribution nor do we know what specific impact roads and fireguards (anthropogenic habitats) have had on modifying the distribution of Ord's kangaroo rats in the SNWA since 1971.

4.3.9 Beaver

In North America, distributional range for the beaver includes suitable habitat from the northern limit of the boreal forest south into northern Mexico with eastern and western boundaries that extend from the Atlantic to the Pacific coasts, with the exception of the peninsula of Florida and portions of the southwest desert (Pattie and Hoffmann 1992). In Alberta, beavers occur throughout the province in wooded waterways, lakes, sloughs, rivers, streams, and creeks where an adequate supply of water, willow, aspen (*Populus tremuloides*), or other acceptable woody deciduous vegetation is within easy access (Pattie and Hoffmann 1992; Smith 1993). General biological information on the beaver is located in Appendix 6.

In the SNWA, beavers are primarily river residents and were found associated with the South Saskatchewan River and its system of ponds and lakes along the floodplain. They live mostly in dens along the river bank, but a few lodges and dams occur in drainages that flow into the South Saskatchewan River, such as at Sherwood Forest and Old Channel Lake. Here they have access to the many treed areas along the river where they feed on cottonwood trees and willow shrubs that grow along the river banks. All beaver locations in Figure 16 are within easy access of treed or willow shrubland areas associated with the river and its water system.

In Alberta, the beaver is on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status in the SNWA as low (Appendix 7).

4.3.10 Western harvest mouse

In North America, the range of the western harvest mouse extends north from central Mexico to southern Alberta and Saskatchewan, east to Illinois and Missouri, and west to the Pacific coast (Pattie and Hoffmann 1992). In Alberta, the western harvest mouse is at the northern fringe of its distributional range in North America, occupying a small restricted area. Prior to the SNWA inventory, it had been collected at only 3 southeast Alberta locations: Medicine Hat, Milk River, and the Pinhorn Grazing Reserve southwest of Manyberries (Smith 1993). General biological information on the western harvest mouse is located in Appendix 6.

The western harvest mouse is restricted to habitats with abundant overhead cover, but they tend to avoid dense forest. Western harvest mice selectively used grasslands where they showed a preference for native prairies which had taller, thicker, lush vegetation relative to other habitats especially in the tallgrass prairies of eastern Nebraska and northeastern Kansas, and in the grasslands of Oklahoma which had well-developed litter layers (Clark *et al.* 1987; Kaufman *et al.* 1988; Clark and Kaufman 1991; McMillan and Kaufman 1994; Kirsch 1997; Clark *et al.* 1998). Preferred habitats are flat and upland grasslands with dominant vegetation mixtures of grassland species and shrubs that provide a required dense cover. These preferred sites may be open grasslands, sagebrush areas, fence lines, benchlands, sandy river flats, pastures, and even marsh edges (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The western harvest mouse was the most common species in lowland tallgrass prairie in northeastern Kansas because of the well-developed layer of plant debris that had accumulated in the litter of the unburned prairie (Peterson *et al.* 1985; Kaufman *et al.* 1988).

Western harvest mice exhibited a negative response to fire in the tallgrass prairies of northeastern Kansas and in the grasslands of Oklahoma (Peterson *et al.* 1985; Kaufman *et al.* 1988; Clark and Kaufman 1991; Clark *et al.* 1998). In tallgrass prairies in northeastern Kansas, the greatest densities of western harvest mice occurred during year 2 to 4 post fire rather than during the first year (Peterson *et al.* 1985; Kaufman *et al.* 1988). Low densities during year 1 post fire may reflect direct mortality of some adults and young in nests, but it also reflects lack of a dense litter layer required by this aboveground nester for nest construction and the loss of seed availability to this omnivore because of destruction by fire (Peterson *et al.* 1985; Kaufman *et al.* 1988).

Although the western harvest mouse was common in irrigated cornfields in central Kansas throughout the year except during May (Fleharty and Navo 1983), they were rare in cornfields in a tallgrass prairie region of eastern Nebraska (Kirsch 1997). The fact that the western harvest mouse prefers dense stands of herbaceous vegetation which were not available during April and May in cornfields probably resulted in exclusion of them from croplands at that time (Fleharty and Navo 1983). However, they were residents in adjacent sandsage prairie habitat but at low density. Although western harvest mice were present in wheat and grain sorghum croplands in west-central Kansas they were not abundant, but they were the most abundant species at a relatively high density in an adjacent relict grassland (Navo and Fleharty 1983). It would appear that western harvest mice use agricultural croplands only to a limited degree, similar to thirteen-lined ground squirrels (Navo and Fleharty 1983).

Western harvest mice were the second most abundant small mammal in tallgrass prairie in northeastern Kansas, constituting 24.7% composition of the total 15 species caught (Clark *et al.* 1987). The western harvest mouse was the second most common small mammal caught in the mixedgrass prairie of the SNWA during 1994 at 5.8% of the catch, and was the third most abundant species trapped during 1995 at 3.3% of the catch. A total of 95 specimens were collected in those 2 years. Each catch of the western harvest mouse in the SNWA was a northern range extension to the previously known Alberta distribution.

The western harvest mouse was widely distributed in the SNWA with the majority of the catch plots being associated with the Shrub Grasslands zone, based on the highest rate of catch and the highest proportion of the catch (64.9%). This suggests a strong affinity for gently undulating grassland habitat with an associated dense cover of vegetation and shrubs. The overall catch rate was the second highest of all species (14.6%), where the western harvest mouse was caught over a wide range of habitat types indicating a wide distribution. On the other hand, the Shrubs–Trees zone had a small sample size but it had the highest mean CE overall at about 1.3 times greater than the Shrub Grasslands zone. However, the rate of catch at 5.6% and the proportion of the catch at 6.4% were the lowest of the vegetation zones, and 17 of 18 plots did not have a catch, resulting in high variation. Only 1 plot in the Shrubs–Trees zone had a CE > 0 (Table 3) and this plot was located along the South Saskatchewan River in a cottonwood forest with a dense shrub cover, where 6 western harvest mice were caught in a total of 19 specimens. The catch at this plot included 4 different species for a maximum CE of 6.4. Therefore, we concluded that western harvest mice had only a minor association with the Shrubs–Trees zone, contrary to the fact that the highest mean CE value occurred in this zone. Furthermore, western harvest mice appeared to have only a moderate association with the Grassland zone, based on a lower mean CE, a lower proportion of the catch, and much greater variation.

Within topographic habitats, the Flat Uplands was the most frequented of the 5 habitats, based on the highest mean CE, the highest rate of catch, and the highest proportion of the catch at 62%. The majority of the catch plots were associated with the Flat Uplands topographic habitat, indicating a strong affinity for low relief, flat, or gently undulating grasslands with sandy soils and an associated dense cover of vegetation and shrubs. Western harvest mice were not caught in the Wet Areas topographic habitat, suggesting that they did not occupy this habitat or used it only minimally. Based on the rate of catch and the distribution of the number of animals caught, we concluded that the Shrub Grasslands zone and the Flat Uplands topographic habitat were the most used habitats and probably are important to the survival of western harvest mice in the SNWA.

Presently, COSEWIC classifies the western harvest mouse as "indeterminate status" since there is insufficient scientific information available to support a designation (Appendix 7). In Alberta, the western harvest mouse is on the Yellow B list, indicating this species is naturally rare with a clumped breeding distribution, but one that is presently not in decline (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status for western harvest mice in the SNWA as high (Appendix 7), varying from nil in the Wet Areas topographic habitat, to medium and high densities in other vegetation zones and topographic habitats. High densities were displayed in the Shrub Grasslands and the Shrubs–Trees zones and in the Flat Uplands topographic habitat.

4.3.11 Deer mouse

The deer mouse has a ubiquitous distribution and is North America's most widespread mouse.

Its northern range extends along the Yukon River nearly to Alaska and throughout the boreal forest almost to the mouth of the Mackenzie River; it also extends to the treeline of the mountains. In the Northwest Territories, it follows the northern treeline eastward across Labrador. It is found from the Atlantic to Pacific coasts and extends into south-central Mexico at its southern limit (Pattie and Hoffmann 1992). The deer mouse ranges throughout the province of Alberta and is found in nearly all available habitats over a wide range of types, from human habitations to dense northern forests and alpine meadows, and to open sand dunes and grasslands (Smith 1993). The deer mouse is one of the most abundant and adaptable species of small mammals in Alberta and is the most common and widespread small mammal in the SNWA. General biological information on the deer mouse is located in Appendix 6.

Deer mice selected habitats where they could avoid well-developed litter layers, fence rows, and lowland prairies with forbs and shrubs, and they showed a preference for areas with a high proportion of exposed soil, limited vertical structure in the vegetation, and open habitats with sparse ground cover in the tallgrass prairies of eastern Nebraska and northeastern Kansas and in the grasslands of Oklahoma (Kaufman *et al.* 1988; Clark and Kaufman 1991; McMillan and Kaufman 1994; Kirsch 1997; Clark *et al.* 1998). In the tallgrass prairies of northeastern Kansas and eastern Nebraska, deer mice were negatively associated with the amount of litter and positively related to the amount of exposed soil and grass (Kaufman *et al.* 1988; Kirsch 1997). Deer mice were abundant in central Illinois but were characteristic of sparsely vegetated non-woody habitats and cultivated fields; they were significantly more abundant in upland mowed prairie than in other Oklahoma grassland habitats; they were the most abundant species in cornfields and ditches in eastern Nebraska tallgrass prairies; and, they were permanent residents of irrigated cornfields in western Kansas and croplands in Illinois (Fleharty and Navo 1983; Kirsch 1997; Clark *et al.* 1998; Getz and Hofmann 1999).

The deer mouse exhibited a positive response to conditions following fire in the tallgrass prairies of eastern Nebraska and northeastern Kansas where they usually were the first species to recolonize burned prairies, they were the most common species in burned uplands, and they selected recently burned areas over those burned in previous years (Peterson *et al.* 1985; Kaufman *et al.* 1988; Clark and Kaufman 1991; Kirsch 1997). Fire mortality of deer mice is low because they are belowground nesters where nest temperatures are little affected by surface fire (Kaufman *et al.* 1988). Deer mice select burned areas because of the increased availability of food as seeds and the increased openness of the soil surface as a result of litter removal by fire (Peterson *et al.* 1985; Kaufman *et al.* 1988). Experimentally, deer mice foraged selectively in patches with sparse litter but consumed a greater proportion of seeds from these habitats than did western harvest mice (Clark and Kaufman 1991). In native tallgrass prairie in eastern Nebraska, mowing greatly increased the density of deer mice, at least until the grasses grew back, a similar effect to that caused by burning (Lemen and Clausen 1984).

Among small mammals, deer mice tend to have the greatest habitat breadth (Kirsch 1997). In mixedgrass prairies in north-central Kansas, the highest densities of deer mice were on ungrazed limestone breaks. This habitat selection relates to a high number of cavities near and under rocks that provide a high density of safe nest sites not often found in upland and lowland prairies (Kaufman *et al.* 1988). Deer mice are known to have a flexible diet regarding seeds and insects which when combined with a greater preference for early successional habitat types, probably allows them to use cropfields earlier in the season than other species (Navo and Fleharty 1983).

Deer mice were the highest at 35.9% composition of 15 species of small mammals caught in a tallgrass prairie in northeastern Kansas (Clark *et al.* 1987). They were the second most abundant species next to the western harvest mouse in a relict area in the west-central Kansas grasslands (Navo and Fleharty 1983), and the third most common of 7 species of small mammals caught in the tallgrass prairies of northeastern Kansas (Peterson *et al.* 1985). Although present, deer mice were only ninth of 12 species caught in other grasslands of northeastern Kansas (McMillan and Kaufman 1994) and they were not common in the tallgrass prairies of eastern Nebraska (Kirsch 1997).

Deer mice were widely distributed throughout the SNWA and were caught in every vegetation zone and topographic habitat, confirming a ubiquitous distribution. Deer mice and meadow voles were the only 2 species found in all sampled habitats. Although deer mice were found almost everywhere, the highest densities were associated with the Shrub Grasslands and Shrubs–Trees zones, while the lowest densities and plots without a catch were associated with the Grasslands zone. Plots sampled in the Shrubs–Trees zone were more consistent in mean CE values than in either of the other 2 zones in spite of smaller sample sizes. Also, the Shrubs–Trees zone had the highest rate of catch (94%) and the second highest mean CE (5.62) overall, suggesting a more consistent use of the Shrubs–Trees zone by deer mice and an affinity for increased cover in the habitat as provided by more shrubs and trees.

The Sand Dunes topographic habitat was the most frequented of the 5 topographic habitats based on the highest overall mean CE, the second highest rate of catch, and the highest proportion of the catch. The Ravines topographic habitat was the next most frequented habitat with the second highest mean CE, indicating a strong affinity for shrubby habitat with variable topography and an associated rugged terrain with a dense cover of shrubs. Sand Dunes and Ravines topographic habitats appeared to be the most frequented and are likely important to maintain high densities of deer mice in the SNWA. The Wet Areas topographic habitat, with the lowest mean CE and rate of catch, appeared to be the least frequented.

The Shrubs–Trees and the Shrub Grasslands zones and the Sand Dunes and the Ravines topographic habitats were frequented more than any other habitats, based on mean CE values and catch rates. It appeared that as the amount of shrub cover in the habitat increased, the density of deer mice tended to increase dramatically. This was shown in the Shrub Grasslands and the Shrubs–Trees zones and the Sand Dunes and the Ravines topographic habitats, which had higher densities of deer mice. The increase in cover habitat appeared to benefit deer mice, likely by contributing to a higher rate of survival. Furthermore, when Ravines were sampled in any vegetation zone, the numbers of animals in the catch increased, suggesting that steep topography (terrain) equally benefits deer mice and possibly contributes to an increased survival. It appears that cover habitat and steep topography may be 2 limiting factors, whereby an increase in cover habitat and steep topography is often associated with a substantial increase in the density of deer mice. Therefore, we believe that the Shrubs–Trees and Shrub Grasslands zones and the Sand Dunes and Ravines topographic habitats provide abiotic features that contribute to overall higher densities of deer mice and possibly to increased survival. The Grasslands zone, and the Interdunal–Morainal, Flat Uplands, and Wet Areas topographic habitats appeared to be the least frequented, and; therefore, were considered to be of poorer quality for deer mice.

In Alberta, the deer mouse is on the Green list which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). Deer mice were the highest caught species in the SNWA, exceeding 81% of the catch in all years with an overall local abundance level status of high (Appendix 7). Although the local abundance level varied from low to high, high densities were displayed in the Shrub Grasslands and Shrubs–Trees zones and in the Sand Dunes and Ravines topographic habitats (Table 3).

4.3.12 Northern grasshopper mouse

In North America, the northern grasshopper mouse ranges across a large portion of the Great Plains and the Rocky Mountain region of the United States. It is widely distributed from southwest Manitoba and western Minnesota, south to the tip of Texas and northern Mexico, extending west to the Cascade Mountains of Washington, Oregon, and northern California (Pattie and Hoffmann 1992). In Canada, it occurs in southwest Manitoba, southern Saskatchewan, and southeast Alberta. In Alberta, the northern grasshopper mouse inhabits the southeast grasslands, with a distributional range extending north to Compeer along the east boundary, from there southwest to Calgary, and then southeast to Lethbridge along the west boundary (Soper 1964; Smith 1993). The northern grasshopper mouse is a poorly-understood species (Stapp 1999). General biological information on this species is located in Appendix 6.

This largely carnivorous and nocturnal mouse is supposed to be relatively common throughout its prairie region range, but it typically occurs at low population densities (Stapp 1997; 1999) and seldom leaves any sign of its presence, making it nearly impossible to detect without the use of traps (Soper 1964; Smith 1993). This was confirmed in the SNWA by the low number of animals collected (14) during the small mammal inventory. The extremely low overall rate of catch (2%), the lowest rate of all species except for the sagebrush vole and the house mouse, and the low CE values, suggests that the northern grasshopper mouse is at low density in the SNWA and it exists over a narrow range of habitat types. This indicates that the northern grasshopper mouse has a restricted habitat requirement and distribution. Because northern grasshopper mice are also insectivorous, patterns of microhabitat use reflect small-scale spatial variation in availability of their main dietary source of arthropod prey (Stapp 1997).

Within vegetation zones, the Shrub Grasslands had the highest mean CE value, the highest rate of catch, and the highest proportion of the total catch at 92.3%, while the Grasslands zone had a catch of only 1 animal. This suggests that the Shrub Grasslands zone stands out in terms of use by the northern grasshopper mouse and may be considered important habitat, and possibly contributes to its survival in the SNWA. The low mean CE in the Grasslands zone suggests a minor association with this vegetation zone. Within topographic habitats, the Sand Dunes had the highest overall mean CE, the highest rate of catch, and the highest proportion of the catch.

This suggests that the Sand Dunes topographic habitat was the most frequented by the northern grasshopper mouse and may be considered important habitat, possibly contributing to its survival.

The results of the SNWA study indicate that northern grasshopper mice have an affinity for sandy soils in a shrubby-grassland habitat where sand dunes or sandy areas dominate the topography. They tend to avoid litter and dense vegetation preferring patches of bare ground (Stapp 1997). They require loose, dry sand for dust bathing (Stapp 1997) and are; therefore, often found in habitats with olive-backed pocket mice and kangaroo rats, other species that sand bathe (Pattie and Hoffmann 1992). In the shortgrass prairie in northeast Colorado, the northern grasshopper mouse showed an affinity for disturbed soils and burrows associated with pocket gopher mounds where they concentrated activities in these areas, but did not show any association with shrub cover (Stapp 1997). Insect prey were more abundant on pocket gopher mounds than in other microhabitats. Mounds and burrows provide arthropods with access to subterranean refuges which results in a concentration and accessibility of prey for northern grasshopper mice (Stapp 1997). A follow-up study of behavioural observations (Stapp 1999) confirmed that northern grasshopper mice spent a considerable amount of time on pocket gopher mounds, travelling quickly over the areas between mounds. The Flat Uplands had only 2 plots out of 181 with a catch, but had 31% (4/13) of the catch for topographic habitats. Based on this result, we consider it to be of minor importance to northern grasshopper mice. It is apparent that the Shrub Grasslands zone and the Sand Dunes topographic habitat are the most important habitats to northern grasshopper mice, and probably contribute to their existence and survival in the SNWA.

The northern grasshopper mouse occurs in a wide variety of open grassland habitats with sandy or gravelly soils that are often interspersed with sagebrush, but it avoids alkali flats, marshy areas, and rocky sites (Pattie and Hoffmann 1992). In a study on the shortgrass prairie in northeastern Colorado, it occupied a relatively large home range (1.7 ha) for its body size, approximately 5 times greater than that predicted for a 33 g mammal (Stapp 1999). Soper (1964) reported that the northern grasshopper mouse reached peak abundance under semi-arid conditions where grass and weed cover was short, sparse, and impoverished. Therefore, it is not surprising that northern grasshopper mice were not caught in the Shrubs--Trees zone nor in the Interdunal–Morainal, Ravines, or Wet Areas topographic habitats which suggests that these habitats are not frequented by northern grasshopper mice in the SNWA. In western Kansas, irrigated cornfields provided suitable habitat for resident populations of northern grasshopper mice along with deer mice, house mice, and western harvest mice (Fleharty and Navo 1983). They were also common in the sandsage prairie with well-established breeding populations in addition to kangaroo rats (Fleharty and Navo 1983). In west-central Kansas, northern grasshopper mice were common but not abundant in a grain sorghum field, less abundant in a new wheat field, and were not caught in a relict grassland habitat (Navo and Fleharty 1983).

In Alberta, the northern grasshopper mouse is on the Yellow B list, indicating this species is naturally rare with a clumped breeding distribution, but one that is presently not in decline (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status for northern grasshopper mice in the SNWA as low (Appendix 7), varying from nil in the Shrubs–Trees zone and the Interdunal–Morainal, Ravines, and Wet Areas topographic habitats, to medium in the Shrub Grasslands zone, and to high density in the Sand Dunes topographic habitat.

4.3.13 Bushy-tailed woodrat

The North American range of the bushy-tailed woodrat extends north and west of northern New Mexico and Arizona to Nevada, California, British Columbia, and the southern Yukon Territory, continuing east and south to the North Dakota Badlands, south and west of the Missouri River (Pattie and Hoffmann 1992). In Alberta, the bushy-tailed woodrat is widely distributed along the Rocky Mountains extending north to the Peace River. It is also found along the south boundary in the Milk River drainage, extending north to the Cypress Hills along the east border between Alberta and Saskatchewan (Soper 1964; Smith 1993). Prior to this inventory, skeletal remains had been found along the South Saskatchewan River at Sandy Point just northeast of the SNWA, but no live animals are known from this area (Smith 1993). Extralimital specimens of the bushy-tailed woodrat have been recorded from Edmonton, Leduc, Ponoka, and Strathmore, but whether or not they were accidentally transported to these sites is not known (Smith 1993). This study confirms the presence of bushy-tailed woodrats in the SNWA, but probably represents a rare extralimital occurrence, which may have been an accidental transportation to the area. General biological information on the bushy-tailed woodrat is located in Appendix 6.

In Alberta, the bushy-tailed woodrat is on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). It is a common species throughout the mountains of western Alberta and the Milk River drainage of southern Alberta (Smith 1993). However, because of this unexpected occurrence the bushy-tailed woodrat is considered to be extremely rare in the SNWA.

4.3.14 Meadow vole

In North America, the meadow vole is distributed from Alaska to Newfoundland, south along the Appalachian Mountains to Georgia, and northwest to Idaho and Washington. A disjunct population exists in northern Arizona, New Mexico, Colorado, and Nebraska, that is separated from the eastern and northern populations by a land buffer of about 160 km (Pattie and Hoffmann 1992). Meadow voles are the most widespread and commonest of North American voles, and in some years can be extremely abundant in Alberta. General biological information on the meadow vole is located in Appendix 6.

The meadow vole was widely distributed throughout the SNWA; however, there was a more even distribution and a higher density of animals in the North Block. Meadow voles were most associated with the Shrub Grasslands zone, based on the highest proportion of the catch, the highest rate of catch, and the third highest overall mean CE. This suggests an affinity for undulating grassland habitat with a dense cover of vegetation and shrubs. The Shrub Grasslands zone was the most frequented by the meadow vole and, therefore, may be considered as important habitat possibly contributing to its survival in the SNWA. Meadow voles appeared to have only a minor association with the Shrubs–Trees zone based on the low proportion of the catch (2.6%) and the low rate of catch where only 1 of 18 plots had a catch. In tallgrass areas of eastern Nebraska, meadow voles were more associated with the prairies than they were with roadside ditches (Kirsch 1997).

Within topographic habitats in the SNWA, meadow voles were caught in the Wet Areas with the highest overall mean CE, the highest rate of catch (37.5%), but the lowest proportion of the catch (5.3%). This suggests that the Wet Areas topographic habitat was the most frequented, and meadow voles have a strong affinity for wetland habitat. The Sand Dunes topographic habitat, the next most frequented had the second highest mean CE value (0.32), the second highest rate of catch (19%), and the highest proportion of the total catch at 44.7%. Furthermore, the majority of catch plots were associated with the Sand Dunes topographic habitat, and to a lesser extent the Flat Uplands, indicating a strong affinity for low relief, flat, or gently undulating grassland habitat that provides a dense cover of vegetation and shrubs. The Flat Uplands and the Interdunal–Morainal topographic habitats were often used by meadow voles and are probably an important part of their SNWA habitat requirements.

These findings confirm the literature which states that meadow voles occupy a diversity of habitats throughout their range. However, they have a preference for wet grasslands, open, grassy, moist meadows, especially along stream bottomlands and margins of sloughs and potholes, as well as slopes, dry grasslands, high plains, and badlands where they seek thick herbaceous and shrub cover (Soper 1964; Krebs 1977; Pattie and Hoffmann 1992; Smith 1993). Overall the most important habitat for the survival of meadow voles in the wildlife area is probably the Sand Dunes topographic habitat because the SNWA supports only a small proportion of wet grasslands and the majority of catch plots for meadow voles were associated with the Sand Dunes habitat. Meadow voles are affected by the density of the vegetation where mowing, like burning of tallgrass prairies, substantially reduces the use of an area by voles (Lemen and Clausen 1984; Kirsch 1997). Sufficient cover allows meadow vole populations to increase to a peak whereby a threshold level between 400 g/m^2 and 500 g/m^2 has been identified as required for them to undergo multi-year cycles (Birney *et al.* 1976). The aboveground herbaceous cover must reach about 700 g/m^2 to support high densities of meadow voles and when it drops to less than 280 g/m^2, there is a precipitous decline in the population (Lemen and Clausen 1984). Meadow vole densities are significantly related to the amount and thickness of grass cover which is affected by vegetation patterns as a result of prairie fires, mowing, and habitat structure (Birney *et al.* 1976; Lemen and Clausen 1984; Kirsch 1997). It is probable that the Sand Dunes topographic habitat provided sufficient cover for meadow voles to survive at high-density in the SNWA. Male meadow voles have larger home ranges and better developed spatial abilities than do females (Slade *et al.* 1997). The space-use patterns of female meadow voles appear to be driven by food availability whereas males respond mainly to availability of receptive females (Fortier and Tamarin 1998).

The overall catch rate for meadow voles was the third highest of all species (12%) in the SNWA, suggesting a high-density population. In addition, the meadow vole was caught over a range of habitats indicating a wide-ranging distribution with few, if any, limiting habitat restrictions. Typically, tallgrass prairies support relatively low densities of small mammals (Clark *et al.* 1987; Kaufman *et al.* 1988). However, in tallgrass prairie in central Illinois meadow voles were continuously present at relatively high densities with neither distinct annual nor multi-annual fluctuations evident, although erratic population fluctuations did occur (Getz and Hofmann 1999). Experimentally, high-density populations exhibited a reduction in breeding effort, individual growth rates, and inter-trap movement distances (Pugh and Ostfeld 1998). Natural fires have been a regular source of disturbance on North American grasslands and probably have had a tremendous impact on the density and population cycles of rodents inhabiting those prairies, especially meadow voles (Lemen and Clausen 1984).

In Alberta, the meadow vole is on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). The overall local abundance level for meadow voles in the SNWA is high (Appendix 7), varying from low to high, with a high-density status only in the Wet Areas topographic habitat. A medium-density status occurred in the Shrub Grasslands zone and in the Sand Dunes and Interdunal–Morainal topographic habitats.

4.3.15 Sagebrush vole

In North America, the sagebrush vole occurs throughout the arid central Great Plains and Great Basin semi-desert that extends from Calgary, Alberta, southeast across Saskatchewan to Glen Ulin, North Dakota, south and west to northern Colorado, Utah, and eastern California with a west and north extension of its range into central Washington (Pattie and Hoffmann 1992; Smith 1993). In Alberta, the sagebrush vole is found throughout the southern grasslands, occurring as far north as Compeer along the eastern border and Cochrane on the west boundary, and from there it extends south to the Porcupine Hills and continues southeast to the United States border (Smith 1993). General biological information on the sagebrush vole is located in Appendix 6.

The habitat of the sagebrush vole includes southern dry plains in association with an impoverished plant cover of sparse grasses, herbaceous growth, cacti (*Opuntia spp.*; *Escobaria sp.*) and sagebrush (Soper 1964). As their name implies these voles are often found in grassland ranges where sagebrush dominates the vegetation cover. Within these arid ranges, they appear to prefer shady, northeasterly facing slopes (Pattie and Hoffmann 1992). In the Val Marie area of southern Saskatchewan, sagebrush voles were often found associated with sagebrush along gentle slopes where trails, burrow holes, and pale blue-gray to light green-tan coloured droppings were convincing evidence of their presence (Phil Taylor, personal communication). Other indicators of their presence are evidence of burrows in dry sagebrush habitat and runways littered with grass cuttings.

In the SNWA, the site in southwest Falcon Area where sagebrush voles were caught did not conform to these conventional habitat descriptions as closely as did many other trap sites where sagebrush voles were not caught. Some of these non-catch sites were in the sagebrush flats along the river in the South Block, the sagebrush flats adjacent to Sherwood Forest, and the sagebrush-dominated grasslands in the Middle Sand Hills of the North Block. We do not know why sagebrush voles were not caught at sites that appeared to be typical habitat.

In September 1994 at the end of the trapping season, the Falcon Area catch site was examined and the only evidence of possible presence of sagebrush voles was a series of small burrow holes in and around a few patches of prickly-pear cactus (*Opuntia polycantha*). We attempted to catch additional sagebrush voles at this site by placing 25 Sherman live traps spaced at 10-m intervals in a rectangular grid for 3 consecutive nights, checking the traps every morning and evening. However, at the end of the trapping session, no sagebrush voles were caught nor were any other small mammals. In southern Saskatchewan, sagebrush voles were not difficult to trap in areas where localized pockets of them were found (Phil Taylor, personal communication). This was not the case in the SNWA, as we were unable to catch additional animals at the original catch site using live traps. Based on the Saskatchewan information, we speculate that few localized pockets of sagebrush voles exist in the SNWA, but if they do, overall extremely low numbers of animals exist. On the other hand, catching sagebrush voles using snap traps may be more difficult in the SNWA than in other areas.

Throughout the distributional range, sagebrush voles are generally uncommon and often occur in extremely spotty or localized areas where they are seldom seen or captured (Pattie and Hoffmann 1992; Smith 1993). Furthermore, collectors have often failed to detect sagebrush voles because of their nocturnal activities, periodically low numbers, spotty local occurrence, and a widely scattered distribution (Soper 1964). In addition, population numbers tend to be highly variable between years. In spite of high numbers of other species of small mammals caught in the SNWA during 1994, we did not catch sagebrush voles at any other site and none were caught in 1995 during the general population decline. The 1994 catch rate for sagebrush voles was 0.6% with a trap success of 0.01%, indicating an extremely spotty, scarce, low-level population. Sagebrush voles are often found in small colonies that may represent family groups of 1 or more generations; however, relatively few individuals inhabit any given colony (Soper 1964). This appeared to be the situation in the SNWA, as all 3 animals were caught at the same plot within a 100-m radius of the centre. The capture site in southwest Falcon area may be 1 of only a few colonies of sagebrush voles that exist in the SNWA. Assuming no major differences in catch rates of sagebrush voles from other small mammal species in the SNWA, we conclude that sagebrush voles are present in the SNWA, but they are extremely rare.

The sagebrush vole is classified as "indeterminate status" by COSEWIC because there is insufficient scientific information available at present to support a designation (Appendix 7). In Alberta, the sagebrush vole is listed as "Status Undetermined" because insufficient information is available to presently determine its status; however, it is not known to be at risk (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status of the sagebrush vole in the SNWA as extremely low.

4.3.16 Muskrat

Muskrats in general range throughout North America, except for most of Florida, Texas, and

California in the southern United States and for most of the tundra in Alaska and Canada (Pattie and Hoffmann 1992). In Alberta, muskrats are found throughout the province wherever there is long-standing or permanent water and available food (Smith 1993). They are common in sloughs, marshes, lakes, streams, and rivers that contain cattails (*Typha latifolia*), spike rushes (*Eleocharis spp.*), and permanent open water, except at high elevations in the mountains where their niche is filled by another large microtine rodent, the water vole (*Microtus richardsoni*) (Pattie and Hoffmann 1992; Smith 1993). Man-made dams, dugouts, irrigation reservoirs, and canals provide calm water and emergent vegetation which are suitable habitats for muskrats. Thus, in the irrigation district of southern Alberta muskrats have become more widespread than previously because of the addition of these anthropogenic habitats (Soper 1964; Pattie and Hoffmann 1992). General biological information on the muskrat is located in Appendix 6.

In the SNWA, muskrats were found associated with the South Saskatchewan River and its water system of ponds and lakes along the floodplain (Figure 16). They are primarily pond residents in the southeast corner of the South Block in and around Old Channel Lake and its associated wetlands, as well as in the pond at Sherwood Forest adjacent to the South Saskatchewan River (Figure 1). In these habitats, muskrats have sufficient shoreline and emergent herbaceous vegetation on which to feed as well as a permanent source of water that meets their aquatic needs. In addition, there are a few river-dwelling residents. Overall, muskrats were not as common as beavers based on fewer observations; however, it appears that they occupy all of the available suitable habitat in the SNWA.

In Alberta, the muskrat is on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status in the SNWA as low (Appendix 7).

4.3.17 House mouse

The house mouse is widespread across North America inhabiting nearly every hamlet and farm from the Atlantic to Pacific coasts, occupying a range that extends north to the Mackenzie Delta in the Northwest Territories although they do not inhabit the tundra or extremely cold areas (Pattie and Hoffmann 1992). In Alberta, house mice occur almost anywhere there is human habitation and they are generally well established throughout the settled parts of the province north to latitudes of High Prairie, Valleyview, and Grande Prairie. However, there are no records from the extreme northern parts of the province or the mountain parks (Soper 1964; Smith 1993). In southeast Alberta, they have been collected from around granaries on farms and in shrubby areas on open grasslands (Soper 1964; Smith 1993). "Wild" house mice have been collected from Canmore and Banff and at several prairie grassland sites (Soper 1964; Smith 1993). This list now includes the SNWA. General biological information on the house mouse is located in Appendix 6.

The house mouse is mainly a nocturnal foreign pest with much the same history of invasion of North America as that of the brown or Norway rat (*Rattus norvegicus*) (Soper 1964; Pattie and

Hoffmann 1992). The usual habitat of the house mouse is human habitations, including dwellings in villages, towns and cities, and buildings on farms. There is little doubt of their ability to attain high densities in such habitat when food is plentiful (Kaufman and Kaufman 1990). The house mouse is a frequent resident of agricultural croplands and other disturbed habitats as they inhabit regular and irrigated cornfields in eastern and western Kansas and grain sorghum and new wheat fields in west-central Kansas (Fleharty and Navo 1982; Navo and Fleharty 1983; Kirsch 1997). It is in rural areas that they often seek shelter in stacks of hay or straw bales. During spring and summer, house mice habitually disperse up to 3.5 km from farms and ranches to establish summer populations in fields and prairie areas, but they usually return to the shelter of barns and granaries for the winter. The house mice that stay in open areas often succumb to winter cold because temperatures lower than -6^0 to -10^0C cannot be tolerated (Soper 1964; Pattie and Hoffmann 1992). Low relative densities and the transient nature of house mice caught in natural and disturbed habitats in the prairies of Kansas suggested that these animals were dispersers (Kaufman and Kaufman 1990). Establishment of the house mouse in the SNWA by dispersal from farms and ranches is unlikely because the area in southwest Ypres, Murphy's Horn (Figure 1; Figure 14), where it was caught is probably the furthest from human habitation of any area in the SNWA. This location is the least likely for natural dispersion to have taken place. Therefore, we speculate that the house mouse could have been a transient accidentally brought into the site with straw bales to be used for stabilization as part of energy development reclamation work, or it traveled in with maintenance and servicing equipment vehicles, unbeknownst to the operators. It would appear that this was a random, infrequent, and chance occurrence since house mice were not caught at any other site in the SNWA. This surprise capture of the house mouse made it an unexpected inhabitant of the SNWA.

House mice comprised about 15% of the rodents captured in irrigated cornfields in southwest Kansas, but they were associated with building structures and vegetation around the irrigation wells at the centres of fields and were absent from areas more than 400 m away from these structures (Fleharty and Navo 1983). The house mouse is uncommon in grassland habitats across Kansas; is a minor component of southern and northern tallgrass and shortgrass prairies; and is a minor component of rodent assemblages in the Great Plains grasslands, including shortgrass prairies in northern Colorado, sandsage prairies in west and southwest Kansas and grassland habitats in Oklahoma as they do occur at low densities (Grant and Birney 1979; Fleharty and Navo 1983; Clark *et al.* 1987; Kaufman and Kaufman 1990; McMillan and Kaufman 1994; Clark *et al.* 1998). House mice constituted 7.6% of small mammals captured in roadside ditches and 11% in cornfields in eastern Nebraska, and < 0.5% of roadside ditches and 2.5% of cropfields in north-central Kansas, whereas they constituted only 0.3% composition of the small mammals caught on a tallgrass prairie site in northeast Kansas (Clark *et al.* 1987; Kirsch 1997). It is unlikely that house mice pose any threat to prairie grasslands or to native rodents in this ecosystem, nor is it likely that they will ever become abundant in the grasslands of the Great Plains (Kaufman and Kaufman 1990).

In Alberta, the house mouse has been placed on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). We assessed the overall local abundance level status of the house mouse in the SNWA as extremely low (Appendix 7).

4.3.18 Porcupine

In North America, the porcupine is a widely distributed rodent, ranging north to slightly beyond the northern edge of the boreal forest that extends across the continent from Alaska to northern Labrador. It ranges south to Virginia along the east boundary and to Texas and northern Mexico on the west boundary, encompassing an area that includes most of the prairie region (Pattie and Hoffmann 1992). In Alberta, porcupines are found throughout the province, occupying ranges up to 1,340 m in elevation (Soper 1964; Smith 1993). Porcupines generally inhabit mixedwood forests in the north and wooded riparian habitats in the south. These southern prairie areas include brushy gulches, ravines, sagebrush flats, wooded bottomlands adjacent to rivers and creeks, and caves along watercourses or beside cliffs (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). General biological information on the porcupine is located in Appendix 6.

In the SNWA, porcupines were most closely associated with areas that supported trees and shrubs which they used for food and cover. Of the 4 high-density areas identified, 3 of those, Sherwood Forest, Dugway Forest, and the Bull Pen, were the most heavily treed areas of the SNWA. These areas were closely associated with the South Saskatchewan River and contained cottonwood trees and willow shrubs. The other high-density area in the vicinity of the Double Wide Fireguard at the junction of Kangaroo-Rat Road resulted from a family group that had setup home in the road culvert where they had taken advantage of an ample food supply of shrubs and trees in the nearby sand hills. Porcupines were often seen in this area using the culvert for shelter and to escape from enemies. In addition, several porcupines were observed west of the wildlife area along the Kangaroo-Rat Road from the west boundary of the SNWA to the Oil Access Area, but these animals were directly associated with the aspen groves located along Kangaroo-Rat Road.

Within Alberta, porcupines appear to be maintaining population densities of 1-11/km^2 over much of their distributional range in spite of low reproduction and high road mortality. Porcupines may cause minor losses to forestry by occupying a tree for weeks, completely stripping bark from its limbs (Pattie and Hoffmann 1992). This was evidenced in the SNWA at Sherwood Forest, the Bull Pen, and along the South Saskatchewan River in some of the cottonwood-treed areas (Figure 1), especially Dugway Forest, where numerous white, barkless limbs were tell-tale signs of feeding by porcupines.

During winter, porcupines often seek shelter in abandoned farm buildings where they may stay for months. The accumulated piles of droppings along with a distinct pungent odour is evidence of their presence (Pattie and Hoffmann 1992). In the SNWA, hollow trunks of large toppled cottonwood trees and the roof of a fallen shed were items used for cover, indicating that the opportunistic nature of the porcupine is probably a factor that contributes to its ability to survive in prairie landscapes. The area of multiple observations along South Buffalo Road and Interface/Trumpeter Trail (Figure 1; Figure 21) in the South Block probably resulted from several porcupines living in 2 nearby areas known as the Cottonwood Grove and Van Will Corral where adequate food and cover were available. This site was 1 of the main routes for kangaroo rat surveys where numerous road trips through the area increased the probability of encountering wandering porcupines.

In Alberta, the porcupine is on the Green list, which means populations are stable or increasing, key habitats are generally secure, and the species is not considered to be at risk (Appendix 7; Alberta Environmental Protection 1996). Although more porcupines were observed in the SNWA than expected, we assessed the overall local abundance level status as low (Appendix 7).

4.4 Considerations for Management of an Important Protected Area

The SNWA, approximately 459 km^2 in size, is part of perhaps the largest area of relatively undisturbed (essentially untilled) mixedgrass prairie remaining in Canada. This protected area supports a high species diversity and richness, the likely product of a conservative approach to grazing management, and thereby contributes significantly to global biological diversity. The SNWA possesses an outstanding degree of prairie endemism as exemplified by: the Arthropod kingdom in the diversity of wasps; the high number of provincially rare (41) and nationally rare (8) vascular plants (Adams *et al.* 1997); the high number of endemic birds breeding in the SNWA (2-60 times higher than in the prairies as a whole); the high number of ungulates, where 15% of the Alberta pronghorn population is provided protection (Shandruk *et al.* 1998); and the provision of a sanctuary for rare and disjunct populations of small mammals, such as the olive-backed pocket mouse, the Ord's kangaroo rat, the western harvest mouse, the northern grasshopper mouse, and the sagebrush vole.

The SNWA supports and maintains a wide spectrum of native prairie fauna including 24 species of small mammals. Here the Ord's kangaroo rat and the olive-backed pocket mouse are at the northern limit of their North American ranges, and as established disjunct populations they have diverged substantially from their southern relatives. Our study confirmed that the SNWA supports a significantly large population of the western harvest mouse, a rare Canadian species, and it is the northern range limit for this species. In addition, the SNWA is a significant refuge for a few uncommon Canadian prairie small mammal species that occur in low numbers across prairie Canada such as, the olive-backed pocket mouse, the northern grasshopper mouse, and the sagebrush vole, and 4 species which are of limited distribution and are possibly declining elsewhere; namely, the prairie shrew, Nuttall's cottontail, Richardson's ground squirrel, and the thirteen-lined ground squirrel. Indeed, the SNWA is an important refuge providing the necessary protection for the long-term survival of many grassland-endemic small mammals.

In the SNWA, the Ravines topographic habitat is important to 2 species of bats, the western small-footed bat and the long-eared bat. Although these bats are relatively uncommon in Alberta, they comprised 83% of the bat fauna of the SNWA. Five of the 6 species of bats that were caught by mist nets in the SNWA are colonial. Essentially, there are no roosting sites for colonial bats in this region other than those found in the 3 fluvial landforms that are associated with the South Saskatchewan River valley. Therefore, protection of the Ravines topographic habitat is essential to maintain roosting sites to ensure the survival of populations of the 5 species of colonial bats that use this prairie ecosystem.

4.5 Management and Research Recommendations

- Continue to monitor Ord's kangaroo rats, western harvest mice, northern grasshopper mice, and sagebrush voles to determine their long-term survival in relation to current grazing and wildfire management policies.

- The SNWA represents 1/3 of the Canadian range for Ord's kangaroo rats; therefore Canadians will view this protected area and the way it is managed as critical to the future conservation of this vulnerable species in Canada. Monitoring surveys should be conducted to determine the ecological factors influencing habitat use as effected by vegetation cover management (e.g. roads and road maintenance, grazing, and wildfire control) by comparing relative abundance, movements between, and survival in, road-side habitats and fireguards (anthropogenic habitats), and the off-road expanses of the sand hills complex (native sand dune habitat). This would include an evaluation of Ord's kangaroo rat abundance, distribution, and survival in the context of dune stabilization trends and their impact on population status, and it would also identify the benefits or disadvantages to Ord's kangaroo rat survival in human-modified habitats such as roads and fireguards.

- Additional information is required on the general ecology of western bat populations to gain insights into reproductive biology, foraging habits as affected by seasonal variation in temperature and precipitation, roosting sites, and winter hibernation sites. Research is required to determine the importance of ravines associated with the South Saskatchewan River valley as foraging areas for bats in the SNWA.

- At Suffield there are opportunities to learn more about habitat relationships of western bat species especially those dependent on river break complexes in the prairie ecosystem, including the western small-footed bat and the long-eared bat.

- Paleoecological research should be initiated in the SNWA to identify the ecological disturbance factors and states that have affected the grassland ecosystem and the prairie small mammal species inhabiting this system, especially in sand hills habitats.

- Future research activities in the SNWA would be considerably enhanced with the installation of a GPS benchmark base station to provide differential corrections to GPS locations in future biological studies.

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7.0 APPENDICES

Appendix 1: Ecological land classification hierarchy for the CFB Suffield National Wildlife Area.

Ecoregion (1) An area characterized by a distinctive climate as expressed by vegetation. The identification of ecoregions was based on those recognized within the provincial system (Strong 1992).	**Ecodistrict (5)** A subdivision of the ecoregion based upon distinct physiographic and/or geologic patterns. The primary requirements for this subdivision are areas having similar patterns of relief, geology, geomorphology, and genesis of parent materials.	**Ecosection (13)** A subdivision of an ecodistrict based on recurring patterns of slope, landform, soil, and vegetation. **Ecosite (103)** A subdivision of an ecosection, with a unique recurring combination of vegetation, soil, landform, and other environmental components.
Dry Mixedgrass Ecoregion (Map symbol - **1**)	**Eolian Landforms** – Landforms developed from wind erosion and deposition. (Map symbol – **E**)	**E1** – Sand dunes are the dominant feature. 10 ecosites (E1.1 – 1.10)
	Fluvial Landforms – Landforms created by flowing water which can be either erosional or depositional. (Map symbol – **F**)	**F1** – Fluvially incised channels with steep side slopes. 7 ecosites (F1.1 – 1.7) **F2** – Fluvial landforms associated with the South Saskatchewan River. 15 ecosites (F2.1 – F2.15) **F3** – Secondary stream channels. 7 ecosites (F3.1 – F3.7)
	Glacio-Fluvial Landforms – Fluvial features created by flowing water at the time of deglaciation. (Map symbol – **G**)	**G1** – Glacio-fluvial channel banks. 11 ecosites (G1.1 – G1.11) **G2** – Glacio- and postglacio-fluvial terraces. 27 ecosites (G2.1 – G2.27) **G3** – Glacio-fluvial outwash. 13 ecosites (G3.1 – G3.12)
	Morainal Landforms – Unconsolidated deposits at time of glaciation. (Map symbol – **M**)	**M1** – Ground moraine. 8 ecosites (M1.1 – M1.8) **M2** – Morainal plain with eolian features. 1 ecosite (M2.1)
	Wetlands – (Map symbol – **W**)	**W1** – Ravine channels and drainages. **W2** – Slump basins and seepages. **W3** – River floodplains. **W4** – Morainal and glacio-fluvial basins, flats.

Example – map symbol for ecosite notation describing classification levels:

1 M 1.1 = ECOSITE NOTATION

```
| ---------------------------------------- Climatic Zone (Ecoregion)
   | ------------------------------------- Ecodistrict
      | ---------------------------------- Ecosection
        | -------------------------------- Individual Ecosite
```

Appendix 2: Radvanyi small mammal bait preparation.

Materials:

1.6 kg Beef suet. (Obtain fresh from butcher/meat market)
1.4-1.6 kg Smooth peanut butter. (Can use chunky)
1.8 kg Rolled oats.
1.4 kg Raisins - optional.
0.2 kg Walnut pieces.
1.8 cc Salt.
10 - 12 Drops of oil of aniseed.

Prepare bait in large aluminium pot:

1. Grind raisins and walnut pieces.
2. (a) Melt down beef suet over low heat.
   (b) Add smooth peanut butter.
3. Add in ground raisins, walnuts, salt and oil of aniseed. Stir until uniform consistency.
4. Add rolled oats while stirring until liquid no longer forms on surface. Should be a thick paste.
5. Remove from heat. Allow to cool. Store in jam or peanut butter tins in a cool place for 3-4 weeks, or freeze for later use.

Field use:

In live traps, use 3.5 cc in bait holder.
In snap traps, use up to 1 cc on bait lever.

In either case, traps should be sheltered from direct sun using 30 cm^2 piece of thin plywood supported with a wire shaped to fit the cover. Suspend the cover about 2 cm above the trap.

Appendix 3: Small mammal field data forms used in the CFB Suffield National Wildlife Area snap trap survey 1994-1996.

MICROTINE TRAPPING DATA - SUFFIELD N.W.A.

Observer ________________________ Day _____ Mo _____ Year 1995 Transect # __________

U.T.M (N).. U.T.M. (E).. Plot No __________

No. Pocket gopher mounds **(OLD)**____

No. Pocket gopher mounds **(FRESH)**____

Ground Squirrel Holes ....

DAY 1 Time ________

Trapline Dir................................**NORTH** Trapline Dir................................**SOUTH**

Com. Type	SPEC.		Sex - Age	Cond.	Col.	Com. Type	SPEC.		Sex - Age	Cond.	Col.
	01						19				
	02						20				
	03						21				
	04						22				
	05						23				
	06						24				
	07						25				
	08						26				
	09						27				
	10						28				
	11						29				
	12						30				
	13						31				
	14						32				
	15						33				
	16						34				
	17						35				
	18						36				

Comments:

Appendix 3: Continued.

Observer______________________________ Day______ Mo______ Year 1995

Transect(N)________________ Plot No.____________ Time________________

U.T.M.(N)__________________ U.T.M.(E)____________________

Day 2-North

	Spec.	Sex-Age	Cond.	Color
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				

Day 2-South

	Spec.	Sex-Age	Cond.	Color
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				

Comments:

Day 3-North Obs.______________Time______

	Spec.	Sex-Age	Cond.	Color
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				

Day 3-South Day______Mo______ Yr.1995

	Spec.	Sex-Age	Cond.	Color
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				

Comments:

Appendix 3: Continued.

MICROTINE TRAPPING DATA LEGEND SHEET

Data will be entered straight from this field form into the computer, so please stick to the coding for consistency. Please check field forms for completeness before proceeding to next site.

Observer	= Last name (Reynolds)
Day	= numeric (1......31)
Mo	= 3 first letters (JUL)
Transect	= Numeric, first 4 digits only (i.e. 5609)
UTM	= Complete easting and northing (543500 and 5615000)
Plot	= Numeric (1,2.........etc)
Trapline Dir	= Compass direction and bearing e.g. NW=165^0 (Only if it deviates from N & S)
No. P. gopher mounds	= number mounds in 2 meter wide strip with trap transect as median.
No. G. squirrel holes Comments Section).	= number of holes counted in 2 meter wide strip with trap transect as median (in
Com.T	= Vegetation community type (First name of Latin name, i.e. Rosa, Stipa etc.)

Please use the following codes under the heading of SPEC.

___	= Trap Not Sprung
C	= Trap Sprung, No Catch
BG	= Bait Gone
CBG	= Sprung & Bait Gone
D	= Specimen Discarded
R	= Specimen Released

Please use the following codes for species trapped .

SPTR	= Thirteen lined ground squirrel (*Spermophilus tridecemlineatus*)
THTA	= Northern pocket gopher (*Thomomys talpoides*)
DIOR	= Ord's kangaroo rat (*Dipodomys ordii*)
PEFA	= Olive backed pocket mouse (*Perognathus fasciatus*)
PEMA	= Deer mouse (*Peromyscus maniculatus*)
REME	= Western harvest mouse (*Reithrodontomys megalotis*)
ONLE	= Northern grasshopper mouse (*Onychomys leucogaster*)
MIPE	= Meadow vole (*Microtus pennsylvanicus*)
LACU	= Sagebrush vole (*Lagurus curtatus*)
MILO	= Long-tailed vole (*Microtus longicaudus*)
SOCI	= Masked shrew (*Sorex cinereus*)
SOHA	= Prairie shrew (*Sorex haydeni*)
SOMO	= Dusky shrew (*Sorex monticolus*)
MUMU	= House mouse (*Mus musculus*)
ZAPR	= Western jumping mouse (*Zapus princeps*)
UNVO	= Unidentified vole
UNMO	= Unidentified mouse
UNSH	= Unidentified shrew
TAMI	= Least chipmunk (*Tamias minimus*)

APPENDIX 4. Cover type composition of vegetation zones and ecosite composition of topographic habitats.

VEGETATION ZONES								
GRASSLANDS			**SHRUB GRASSLANDS**			**SHRUBS - TREES**		
Vegetation Cover Types Included	**Total Area (ha)**	**% of SNWA**	**Vegetation Cover Types Included**	**Total Area (ha)**	**% of SNWA**	**Vegetation Cover Types Included**	**Total Area (ha)**	**% of SNWA**
Upland grassland	15091.30	32.87	Grassland-mid/low shrubs	13717.60	29.88	Barren-mid/tall shrubs	829.50	1.81
Moist grassland	1355.00	2.95	Mid/low shrubs-grassland	6219.86	13.55	Tall/mid/low shrubs	128.97	0.28
Disturbed grassland	1090.31	2.37	Shrubs-trees-grassland	5435.40	11.84	Trees-tall/mid shrubs	62.56	0.14
Sedge-forb wetlands	174.15	0.38	Grassland-tall/mid/low shrubs	664.75	1.45	Barren	40.17	0.09
Barren-grass	144.70	0.32	Meadow-low shrubs	251.59	0.55	Tall trees	2.59	0.01
Seeded grassland	129.25	0.28	Tall shrubs-grassland	164.09	0.36			
Saline grassland	71.73	0.16	Mid/low shrubs	12.14	0.03			
Forb	17.82	0.04						
Subtotal	**18074.26**	**39.37**		**26465.43**	**57.66**		**1063.79**	**2.33**
COVER TYPES NOT SAMPLED BY SMALL MAMMAL TRAPPING NOR INCLUDED IN VEGETATION ZONE ANALYSIS:								
Wet meadow wetlands	55.30	0.12	Trees-grassland	109.38	0.24	Barren-trees	47.02	0.10
Saline wetlands	16.26	0.04						
Unclassified wetlands	9.13	0.02						
Ravine wetlands	7.64	0.02						
Dugouts	6.68	0.01						
Aquatic	54.30	0.12						
Subtotal	**149.31**	**0.33**		**109.38**	**0.24**		**47.02**	**0.10**
Total	**18223.57**	**39.70**		**26574.81**	**57.90**		**1110.81**	**2.43**
						Grand Total	**45909.19**	**100.03**

APPENDIX 4. Continued.

TOPOGRAPHIC HABITATS				
TOPOGRAPHIC HABITAT TYPE	**ECODISTRICT LANDFORMS**	**ECOSECTION**	**ECOSITES INCLUDED**	**# OF ECOSITES**
SAND DUNES	Eolian	E1-Sand dunes are dominant feature	E1.1,E1.3,E1.5,E1.8,E1.10	5
	Glacio-Fluvial	G2-Glacio-and postglacio-fluvial terraces	G2.1	1
	Morainal	M2-Morainal plain with eolian features	M2.1	1
(32.6 % of SNWA)				**7**
FLAT UPLANDS	Fluvial	F2-Fluvial landforms assoc. with S.S. River	F2.3, F2.4, F2.5, F2.6, F2.7, F2.8, F2.13, F2.15	8
	Glacio-Fluvial	G2-Glacio-and postglacio-fluvial terraces	G2.2, G2.3, G2.4, G2.5, G2.6, G2.7, G2.10, G2.13,	
	Glacio-Fluvial	G2-Glacio-and postglacio-fluvial terraces	G2.14, G2.15, G2.16, G2.17, G2.18, G2.19, G2.20,	22
	Glacio-Fluvial	G2-Glacio-and postglacio-fluvial terraces	G2.21, G2.22, G2.23, G2.24, G2.25, G2.26, G2.27	
	Glacio-Fluvial	G3-Glacio-fluvial outwash	G3.1, G3.2, G3.3, G3.5, G3.8, G3.9, G3.10,	
	Glacio-Fluvial	G3-Glacio-fluvial outwash	G3.11, G3.12, G3.13	10
	Morainal	M1-Ground moraine	M1.1, M1.3, M1.4, M1.5, M1.6, M1.8	6
(45.8 % of SNWA)				**46**
INTERDUNAL - MORAINAL	Eolian	E1-Sand dunes are dominant feature	E1.2, E1.4, E1.6, E1.7, E1.9	5
	Glacio-Fluvial	G3-Glacio-fluvial outwash	G3.4, G3.6, G3.7	3
	Morainal	M1-Ground moraine	M1.2, M1.7	2
(11.2 % of SNWA)				**10**
RAVINES	Fluvial	F1-Fluvial incised channels, steep side slopes	F1.1, F1.2, F1.3, F1.4, F1.5, F1.6, F1.7	7
	Fluvial	F2-Fluvial landforms assoc. with S.S. River	F2.1, F2.2, F2.9, F2.10, F2.11, F2.12, F2.14	7
	Glacio-Fluvial	G1-Glacio-fluvial channel banks	G1.1, G1.2, G1.3, G1.4, G1.5, G1.6, G1.7, G1.8,	
	Glacio-Fluvial	G1-Glacio-fluvial channel banks	G1.9, G1.10, G1.11	11
(9.8 % of SNWA)				**25**
WET AREAS	Fluvial	F3-Secondary stream channels	F3.1, F3.2, F3.3, F3.4, F3.5, F3.6, F3.7	7
	Glacio-Fluvial	G2-Glacio-and postglacio-fluvial terraces	G2.8, G2.9, G2.11, G2.12	4
(0.6 % of SNWA)				**11**
			Total	**99**

Appendix 5: Taxonomic order list of small mammal species trapped and observed in the CFB Suffield National Wildlife Area, 1994-1996.

ORDER/FAMILY/SPECIES	TRAPPED	OBSERVED
Order Insectivora		
Family Soricidae		
Prairie shrew (*Sorex haydeni*)	x	
Order Chiroptera		
Family Vespertilionidae		
Little brown bat (*Myotis lucifugus*)	x	
Long-eared bat (*Myotis evotis*)	x	
Long-legged bat (*Myotis volans*)	x	
Western small-footed bat (*Myotis ciliolabrum*)	x	
Big brown bat (*Eptesicus fuscus*)	x	
Hoary bat (*Lasiurus cinereus*)	x	
Order Lagomorpha		
Family Leporidae		
Nuttall's cottontail (*Sylvilagus nuttallii*)		x
White-tailed jack rabbit (*Lepus townsendii*)		x
Order Rodentia		
Family Sciuridae		
Richardson's ground squirrel (*Spermophilus richardsonii*)		x
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	x	
Family Geomyidae		
Northern pocket gopher (*Thomomys talpoides*)	x	
Family Heteromyidae		
Olive-backed pocket mouse (*Perognathus fasciatus*)	x	
Ord's kangaroo rat (*Dipodomys ordii*)	x	
Family Castoridae		
Beaver (*Castor canadensis*)		x
Family Cricetidae		
Western harvest mouse (*Reithrodontomys megalotis*)	x	
Deer mouse (*Peromyscus maniculatus*)	x	
Northern grasshopper mouse (*Onychomys leucogaster*)	x	
Bushy-tailed woodrat (*Neotoma cinerea*)[1]	x	
Meadow vole (*Microtus pennsylvanicus*)	x	
Sagebrush vole (*Lagurus curtatus*)	x	
Muskrat (*Ondatra zibethicus*)		x
Family Muridae		
House mouse (*Mus musculus*)	x	
Family Erethizontidae		
Porcupine (*Erethizon dorsatum*)		x

[1] found dead (freshly killed) within 2 m of a sprung snap trap in 1995

Appendix 6: General biological information for all small mammal species trapped and observed in the CFB Suffield National Wildlife Area, 1994-1996.

6.1 Species Accounts

Mammal guidebook-type descriptions on general biological information for each species of small mammal trapped and observed during the wildlife inventory of the CFB Suffield National Wildlife Area, 1994 to 1996, is included as a quick reference for non-technical readers. The list is arranged in taxonomic order. These species accounts include a summary of biological information on description, natural history, food habits, reproductive characteristics, predators, and economics data available on each species. Information on geographic distribution, status, and habitat descriptions for each species is provided in section 4.0 DISCUSSION, subsection 4.3 Species Distributions, Abundance, and Habitat Analysis in this report.

6.1.1 Prairie shrew (*Sorex haydeni*)

The prairie shrew was once considered to be a subspecies of the masked shrew (*S. cinereus*) as it is a barely distinguishable form of that group (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The prairie shrew is probably the smallest shrew in Alberta and is cinnamon brown to dark brown on the back with grayish underparts and a noticeably dark terminal tuft on the tail. Shrews have poor eyesight and depend upon their vibrissae or whiskers, long noses, and, to some degree, their auditory sense to detect prey. Insectivorous prey such as, beetles and grasshoppers are often initially decapitated, a diagnostic feature that can be used to determine the presence of prairie shrews. Alternate food items consumed by shrews may be carrion, small invertebrates, and some vegetation. Excess food is often stored. Many of the insectivorous prey food items of shrews are deleterious species to agriculture; therefore, prairie shrews can be beneficial to humans.

Reproductive activity in prairie shrews commences during spring and, after a midsummer break, continues until fall with females producing as many as 3 litters per year. Gestation lasts 18 to 20 days and litter size ranges from 4 to 10. The main predators of shrews are probably birds, especially owls (*Strigidae*) and shrikes (*Laniidae*), and to a lesser extent snakes, red foxes (*Vulpes velox*), long-tailed weasels (*Mustela frenata*), and coyotes (*Canis latrans*).

6.1.2 Little brown bat (*Myotis lucifugus*)

The little brown bat is a medium-sized bat (weighing up to 12 g) that has a dorsal pelage varying in colour from light to dark brown with a glossy sheen on the tips of the hairs, giving it a coppery appearance (Pattie and Hoffmann 1992; Smith 1993). The ventral side is generally much paler in a yellowish to grayish colour, and the ears and flight membranes are dark brown to black (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). Grassland dwelling members of this species are generally lighter-coloured than the forest dwelling individuals (Smith 1993). The ears when laid forward reach the nose (Pattie and Hoffmann 1992; Smith 1993).

The little brown bat is known to establish summer roosts within buildings (Riskin and Pybus 1998). It is the more commonly known bat in Alberta, often hanging in clusters from hallways of buildings, in attics, or in narrow crevices under bridges where they roost in solitary pairs or sometimes in colonies of up to a 1,000 individuals (Soper 1964; Pattie and Hoffmann 1992). In Alberta, little brown bats were usually found alone in exposed diurnal roosts, but groups of up to 6 individuals were sometimes observed (Riskin and Pybus 1998). Colonies that are occupied for a long time display the characteristic pungent odor of bat urine and feces. Little brown bat colonies are nearly always found near open water because when they leave their roosting sites in the early evening they travel to a water source where they drop down to the surface for a drink on the fly (Pattie and Hoffmann 1992). Most little brown bats migrate south in the fall, generally during September and early October, to hibernation sites that may be caves in southern Alberta, Montana, or North Dakota, where they are known to overwinter (Pattie and Hoffmann 1992). They usually hibernate in caves, hollow trees, or old buildings where temperatures range from just above freezing to as high as 15^{0}C (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). Little brown bats showed a preference for exposed diurnal roosting sites that provided security from predation and physiological stress, where temperature may be a critical factor in determining the use of these roosts (Riskin and Pybus 1998). Daytime roosts include hollow trees, attics of occupied buildings, abandoned buildings and cabins, and rock crevices (Soper 1964; Smith 1993). Members of this species frequently share day roosts and hibernacula with other species of bats (Pattie and Hoffmann 1992).

The food of little brown bats consists almost entirely of flying insects which they capture over and around waterbodies such as streams and ponds. When associated with cities, towns, or villages, they occasionally concentrate hunting activities around street lights where insects may be plentiful (Pattie and Hoffmann 1992). After leaving the roost, they may forage for periods of up to 5 h with a secondary peak of activity just before dawn. The consumption of large numbers of flying insects every night, many of which are deleterious species to agriculture, makes them beneficial to humans by providing some economic value to the agricultural industry.

Little brown bats normally mate in the fall, but have their young the following spring; however, mating also occurs in the hibernating colony and during spring (Pattie and Hoffmann 1992). With a fall mating, the sperm remains viable in the reproductive tract of the female until spring when ovulation occurs and the egg is fertilized with stored sperm. Gestation is believed to be 50 to 60 days after fertilization at which time a single young is born, usually in June (Pattie and Hoffmann 1992).

Known predators of little brown bats are raptors, especially owls, as well as long-tailed weasels, mink (*Mustela vison*), striped skunks (*Mephitis mephitis*), black-billed magpies (*Pica pica*), and domestic cats (*Felis catus*) (Pattie and Hoffmann 1992; Riskin and Pybus 1998). Unfortunately, bats are extremely sensitive to insecticides and many colonies have been drastically reduced or decimated by exterminators using insecticides on their food source or as a result of disturbance to wintering colonies.

6.1.3 Long-eared bat (*Myotis evotis*)

The long-eared bat is a pale, buffy yellowish, medium-sized bat (weighing up to 9 g) with much paler yellowish-white underparts, naked black ears, and blackish flight membranes (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). In Alberta, this bat is somewhat smaller than the little brown bat. The main distinguishing feature is its long black ears, the longest of all Alberta bats (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The ears, when laid forward, extend 6 to 7 mm beyond the nose, thereby distinguishing it from all other Alberta species. Its wing joins the foot at the base of the toes, unlike the little brown bat (Soper 1964; Pattie and Hoffmann 1992). Large colonies of long-eared bats are never as abundant as colonies of little brown bats (Pattie and Hoffmann 1992).

The main food of long-eared bats is flying insects. Foraging throughout forest openings and meadows begins when they emerge after dark and share feeding grounds with little brown bats, long-legged bats, silver-haired bats, and hoary bats.

Little is known about their breeding habits; however, it is believed that young are born in late June or early July because they have been observed flying during early August (Pattie and Hoffmann 1992). In summer, males use caves for roosts whereas colonies of females and young are often found in buildings (Pattie and Hoffmann 1992). Little is known about their hibernation sites. Long-eared bats molt in July and August.

6.1.4 Long-legged bat (*Myotis volans*)

The long-legged bat is a medium-sized brown bat (weighing up to 9 g) that is characterized by the presence of a keel on the calcar of the interformal membrane; short, rounded ears; and a light covering of fur extending onto the underside of the wing (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). It is one of the darkest small bats, having a uniform dark, chocolate brown hair coat with black ears and flight membranes (Pattie and Hoffmann 1992; Smith 1993). Although it closely resembles the little brown bat, its ears when laid forward barely reach the nose, a characteristic that distinguishes it from the little brown bat (Soper 1964; Pattie and Hoffmann 1992).

The long-legged bat forms large nursery colonies often under shingles of deserted buildings, in bank crevices along eroded watercourses, and in trees (Pattie and Hoffmann 1992). They do not use caves or mines for daytime roosts in summer, but enter these places at night (Pattie and Hoffmann 1992). They emerge quite early in the evening and fly high until dusk when they tend to decrease altitude and fly closer to the ground (Pattie and Hoffmann 1992). The molt appears to begin in mid-June and is usually completed during July. It is assumed that long-legged bats summering in the prairie region are migratory, but little is known about migration, hibernation sites, or general living habits (Soper 1964; Pattie and Hoffmann 1992).

Long-legged bats are often observed foraging among coniferous trees along the shores of lakes and streams where their main diet is flying insects (Pattie and Hoffmann 1992). In northern areas, young are probably born in July or early August, but in southern areas, researchers have suggested a longer birthing period that extends from June through August (Pattie and Hoffmann 1992). What wildlife species prey on long-legged bats is unknown. The density of long-legged bats throughout Alberta is sporadically common to sparse (Pattie and Hoffmann 1992; Smith 1993).

6.1.5 Western small-footed bat (*Myotis ciliolabrum*)

The western small-footed bat is a small-sized bat (weighing up to 7 g) that is light brown or tan above and almost white below with a dark band across the muzzle and eyes (Pattie and Hoffmann 1992; Smith 1993). It has dark brown to black ears and flight membranes, and is readily distinguishable from other Alberta bats by its small size (Pattie and Hoffmann 1992; Smith 1993). The calcar is strongly keeled, and as its name suggests its feet are small.

The western small-footed bat is found infrequently, even in parts of the range where it is common. Small numbers of bats (12 to 20) and their young have been found in nursery colonies in buildings (Pattie and Hoffmann 1992). Western small-footed bats often use caves and mines as winter hibernacula, where they may be located close to the entrance in much colder and draftier sites than would be selected by other species (Pattie and Hoffmann 1992). They are usually found alone or in small groups wedged into cracks in the roof. In California, births occur during late May, but in northern parts of the range young are probably born in July. In South Dakota, the molt occurs during June and July (Pattie and Hoffmann 1992). Banding records have shown that western small-footed bats have survived for at least 9 years in the wild (Pattie and Hoffmann 1992).

A food habits study in Kansas reported that western small-footed bats eat beetles, flies, bugs, and ants (Pattie and Hoffmann 1992). They appear to be an efficient feeder as evidenced by full stomachs in specimens that were collected early in the evening. They usually feed along cliffs and steep river valleys rather than over water (Pattie and Hoffmann 1992). What wildlife species prey on western small-footed bats is unknown. Their density in Alberta is too low for them to have any significant economic impact (Pattie and Hoffmann 1992).

6.1.6 Big brown bat (*Eptesicus fuscus*)

The big brown bat is a large brown bat (weighing up to 29 g) with a glossy pelage that varies in colour from brown to reddish brown with underparts that are lighter brown (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The flight membranes, face, and ears are black (Pattie and Hoffmann 1992; Smith 1993). The ovoid-shaped ears are relatively large, but do not reach the nose when laid forward (Smith 1993). The calcar is keeled, the muzzle is broad, and the blunt tragus is less than half the length of the ear (Pattie and Hoffmann 1992; Smith 1993).

Big brown bats are the most well-known of Canadian bats because of their association with man-made structures for roosts (Pattie and Hoffmann 1992). They are known to inhabit cities, boreal forests, and aspen parklands, but only at sites where daytime roosts are available. They primarily use buildings and roost behind boards and in attics; as well, they use hollow trees and rock fissures

(Pattie and Hoffmann 1992). Big brown bats hibernate in winter, mainly in caves, storm sewers, mines, and buildings within or near their summer range, and they generally are found singly or in groups of 2 to 3 (Soper 1964; Pattie and Hoffmann 1992). They tend to hibernate in locations where temperatures fluctuate and the body temperature decreases to near ambient temperature. However, if the ambient temperature drops to near 0°C, they awaken, become active, and move to warmer sites that may even be a different building or cave (Pattie and Hoffmann 1992). The annual molt is generally complete by late June or July except for lactating females where it is delayed until after the young are weaned. Mortality is highest during the first year; however, survival up to 19 years in the wild has been documented (Pattie and Hoffmann 1992). Big brown bats have a tremendous homing ability and can return distances in excess of 30 km per night (Pattie and Hoffmann 1992).

Big brown bats leave their roosts early in the evening, get a drink, and then feed on flying insects (Pattie and Hoffmann 1992). They usually feed at heights of less than 10 m above the ground, satisfy their appetite quickly, and then roost until near morning although some individuals continue to feed sporadically all night (Pattie and Hoffmann 1992). Big brown bats often use the same feeding areas and flight paths.

Breeding takes place in the fall or it occurs during hibernation. As in other species, the sperm remains viable in the reproductive tract of the female until spring when ovulation occurs and the egg is immediately fertilized with stored sperm (Pattie and Hoffmann 1992). After a 2-3 month gestation, 1 to 2 young are born, usually in June or July (Soper 1964; Pattie and Hoffmann 1992). Only about 10% of the big brown bats in Alberta bear twins (Pattie and Hoffmann 1992).

Known predators of big brown bats are owls, snakes, domestic cats, and sometimes other mammals (Pattie and Hoffmann 1992). The economic value of big brown bats is unknown, but they do eat flying insects many of which are deleterious species to agriculture; therefore, they may provide a benefit to this industry (Pattie and Hoffmann 1992).

6.1.7 Hoary bat (*Lasiurus cinereus*)

The hoary bat is the largest of the North American bats (weighing up to 35 g) and it is the most distinctively brownish-coloured bat in Alberta (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). It cannot be mistaken for any other species of bat because the tips of many hairs are white which gives it an overall frosted appearance (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The dorsal hairs often have white tips followed by a brown band, a yellowish band, and a black basal band (Pattie and Hoffmann 1992). The ventral pelage is yellowish-brown to nearly white. The ears of the hoary bat are short, rounded, black, and furred (Pattie and Hoffmann 1992; Smith 1993). The tail, the underside of the wings, and the dorsal surface of the feet are also well-furred (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). The calcar is modestly keeled and the tragus is triangular in shape, broad based, short, and blunt (Pattie and Hoffmann 1992).

The hoary bat is an arboreal species that roosts among the leaves of trees and tall shrubs where it hangs head-down all day (Soper 1964). These tree bats use both coniferous and deciduous trees as daytime roosts at heights from a few metres aboveground to several metres high up in the forest canopy (Pattie and Hoffmann 1992). They are generally solitary and seldom encountered by humans. In summer, the males travel further north and reach higher altitudes than do females as the sexes usually remain apart until the fall migration (Pattie and Hoffmann 1992). Adults molt during July while the young complete a post-juvenile molt prior to the fall migration (Pattie and Hoffmann 1992). Hoary bats are migratory and occasionally move together in a large group where they may first appear in Alberta during May, but disappear from the province between mid-August and late September (Pattie and Hoffmann 1992).

Hoary bats are known to feed on termites, beetles, grasshoppers, mosquitoes, flying ants, large stinkbugs, and other flying insects. They are also suspected of preying on smaller bat species (Pattie and Hoffmann 1992). They do not become active until well after sunset, and reach peak foraging about 3 to 7 h after dusk. After a lull period, they become active again prior to returning to the day roost (Pattie and Hoffmann 1992).

It is believed that hoary bats breed during fall. After fertilization and a 90-day gestation, twins are usually born between late May and early July (Soper 1964; Pattie and Hoffmann 1992). A female hoary bat was observed attaching her first born on her back while she continued to deliver the second young (Pattie and Hoffmann 1992). Although there are no documented reports of predation on hoary bats other than humans, owls may prey on them (Pattie and Hoffmann 1992). There is no known economic value for the hoary bat; however, aesthetically, it is probably the most pleasing of all Alberta bats.

6.1.8 Nuttall's cottontail (*Sylvilagus nuttallii*)

The Nuttall's cottontail is a small lagomorph (pikas, hares, and rabbits) with a sturdy body and relatively short ears and legs (Soper 1964). This little rabbit has long, soft, grayish fur that is darker on the sides, gray on the rump, white on the belly, and has a distinguishing rufus patch on the nape of the neck as well as on the lower thighs (Soper 1964; Smith 1993). The tail is short, gray on top, and white underneath. The Nuttall's cottontail does not display seasonal colour phase changes (Smith 1993). Unlike hares, rabbits usually live in burrows and have young that are born naked with the eyes closed (Soper 1964).

Nuttall's cottontail rabbits are most active during twilight and night, but their activity is severely reduced with inclement weather especially heavy rains or wind (Pattie and Hoffmann 1992). They are seldom seen far from cover whether that is brush, rugged and rocky terrain, or buildings. They traditionally follow the same trails, a trait that is evident after snowfall. Regional distribution is often spotty, but for no apparent reason they may be common in 1 area and absent or sparse in another area that appears similar (Soper 1964). In Alberta, the population of Nuttall's cottontail is considered to be sparse within a relatively small occupied territory in the southern prairies. There are numerous voids within its known range and even keen observers rarely catch a glimpse of these little plains rabbits. The female usually builds a nest by burrowing or digging out a cavity and lining it with grasses and fur. Occasionally, she conceals a surface nest under dense thickets or prepares her nest in a burrow, a rock crevice, or in a hole in a clay butte (Soper 1964).

The spring and summer diets of Nuttall's cottontails are mainly grasses and forbs, while in fall and winter, sagebrush and other shrubs form the bulk of the diet (Pattie and Hoffmann 1992). Breeding normally begins in April and 3 to 4 litters are produced each year. Nuttall's cottontails are prolific small mammals as the female usually enters estrus within a few hours of birthing (Soper 1964; Pattie and Hoffmann 1992). Litter sizes vary from 1 to 8 leverets with 4 to 5 being the norm. In more southern milder climates, young may be born during every month of the year, but in more northern colder latitudes, breeding usually does not occur during the winter months (Soper 1964). Females born in early spring usually breed later during their first summer.

Known predators of Nuttall's cottontails are red foxes, coyotes, and badgers (*Taxidea taxus*), as well as owls, hawks (*Accipitridae*), and eagles (*Accipitridae*) (Pattie and Hoffmann 1992). This species is of no economic consequence; however, they are extremely fun to watch because they are an aesthetically-pleasing small mammal.

6.1.9 White-tailed jack rabbit (*Lepus townsendii*)

The white-tailed jack rabbit, which is actually a hare, is the largest member of the hare and rabbit family (*Leporidae*) that inhabits the prairies, weighing up to 4 kg (Pattie and Hoffmann 1992; Smith 1993). This prairie hare has a fairly long white tail that is held rigidly when it runs, and hence the name arising from this peculiarity. The white-tailed jack rabbit is a big, open-country hare that has long, black-tipped ears, long strong hind legs, and long, soft, variable pelage that changes colour seasonally. In summer, the pelage is a grayish brown along the back and sides, the feet and belly are white, and the ears are brown with black tips (Pattie and Hoffmann 1992). In winter, the pelage is entirely white except for the grayish forehead and black-tipped ears (Smith 1993). Inclement weather is not likely to influence foraging or locomotion because the white-tailed jack rabbit has a highly insulative pelage (Rogowitz 1997). Unlike rabbits, hares are non-burrowing animals that live on the ground surface and have young that are born with their eyes open and a good coat of hair (Soper 1964).

White-tailed jack rabbits are most active during moonlit nights when locomotor activity begins about 1 h after sunset or near moonrise, continues throughout the night, and ceases near sunrise (Pattie and Hoffmann 1992; Rogowitz 1997). This animal is a remarkable runner where it quickly reaches speeds of up to 65 km/h and bounds across the prairie in leaps of up to 4.5 m (Soper 1964; Pattie and Hoffmann 1992). Its quick speed is attained by propulsion from its powerful hind legs. During daytime in summer, jack rabbits often seek shelter in a depression hollowed out in the lee of a rock, post, or a partially filled badger hole, whereas during winter they dig caverns in snow banks or excavate snow burrows (Pattie and Hoffmann 1992). They often sit in these "forms" during the day with only the eyes and the depressed ears showing above the surface so that, when alarmed, they catapult themselves out of hiding using their strong hind legs (Pattie and Hoffmann 1992). They run with their ears erect and tail extended. Interactions with conspecifics and the effects of predators can dramatically modify the behaviour of white-tailed jack rabbits (Rogowitz 1997).

Food of the white-tailed jack rabbit is usually green vegetation or a wide range of vegetable matter when available such as, native grasses and clover (*Trifolium spp.*), vascular and herbaceous plants, grain, legumes, and buds and leaves of native and cultivated shrubs (Soper 1964). However, during winter they are often forced to feed on bark or twigs of shrubs and they will raid farmer's alfalfa fields and stacks of hay or green feed, if these are available.

White-tailed jack rabbits usually breed from March to July, and at this time ovulation follows copulation. After an approximately 30-day gestation, 1 to 9 precocious leverets (the usual number being 3 to 4 per litter) are born in simple ground depressions (Soper 1964; Pattie and Hoffmann 1992). The quickly growing young are weaned at 5 to 6 weeks and by 95 to 125 days, they attain adult weight (Pattie and Hoffmann 1992). White-tailed jack rabbits are usually solitary, but in winter they may join together in groups of 3 to 50.

Avian and terrestrial species of wildlife are known predators of white-tailed jack rabbits such as, coyotes and eagles while red foxes and hawks are known to prey on leverets; however, its speed often allows it to outrun the enemy (Soper 1964; Pattie and Hoffmann 1992; Rogowitz 1997). During peak population densities, white-tailed jack rabbits can have a serious negative impact on agricultural fields and pastures as they compete directly with cattle and sheep by feeding on the same plants (Soper 1964; Pattie and Hoffmann 1992).

6.1.10 Richardson's ground squirrel (*Spermophilus richardsonii*)

The Richardson's ground squirrel is a medium-sized rodent (weighing up to 610 g) that is larger than a chipmunk but smaller than a marmot, and it characteristically sits up on its hind feet in an upright position as do all members of this genus (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). Richardson's ground squirrels are semi-fossorial, diurnally active, obligate hibernators that sleep underground but forage aboveground in prairie grasslands (Michener 1998). The general public inappropriately refer to these animals as "gophers". The pelage is a sandy, brown, rich, buffy yellow with indistinct brownish bars on the rump that give it a motley appearance on the back. The underparts are lighter than the back, varying from buffy to clay-coloured. The ears are small and roundish, the eyes are large and placed high on the head, and the short tail (about one-third of the body length) is flat, slim, and well-furred (Soper 1964; Pattie and Hoffmann 1992; Smith 1993).

Although Richardson's ground squirrels are not particularly sociable with each other, they form loose colonies in open, short and mixedgrass plains, and in sagebrush, semi-desert areas of suitable habitat throughout their distributional range. Cannibalistic tendencies are often evident along highways where they are attracted to the crushed remains of the unfortunate members that have been killed by passing vehicles (Soper 1964; Pattie and Hoffmann 1992). They construct an average of 8 entrances to their burrow system, most of which have a mound of earth to 1 side. Burrows dug from the inside have no external mounds of earth, but connect to the system and are used to escape from predators (Pattie and Hoffmann 1992). The home burrows are 4 to 10 m long, 75 to 85 mm in diameter, and often end in a grass-filled spherical nest chamber that is about 225 mm in diameter (Pattie and Hoffmann 1992). These burrows often provide cover for other prairie animals. Prairie shrews, voles, deer mice, and western harvest mice may seek refuge during prairie fires while snakes, frogs, and toads may use ground squirrel burrows as hibernation sites.

Richardson's ground squirrels are true hibernators, an activity that may commence as early as July with the older, fatter males disappearing first, followed by the younger males, females, and young of the year by mid August (Pattie and Hoffmann 1992). Adult males enter into hibernation earlier than adult females and generally are heavier and fatter at that time (Michener 1998). A few late stragglers may remain active until October. The reverse is true in the spring as males generally appear first during late March and early April, about a week prior to the females when they often brave chilly weather and snowy conditions aboveground (Soper 1964). Male Richardson's ground squirrels emerge from hibernation earlier than females and generally are heavier because of greater fat reserves (Michener 1998). The spring emergence is usually dependent upon temperature, but may vary by as much as 3 weeks. In Alberta, hibernation may not be continuous since Richardson's ground squirrels have been observed aboveground every month of the year and occasional winter emergence is often associated with a long, unusually mild spell of weather (Pattie and Hoffmann 1992). Males usually end torpor at least 1 week before they emerge, during which time they eat seeds cached in the burrow, replenish fat, and initiate spermatogenesis in preparation for the oncoming breeding season (Michener 1998). On the other hand, females do not store food in their burrows, they emerge from hibernation within 2 days of terminating torpor, and they are bred 2-4 days post-emergence when they are at their lowest body weight (Michener 1998). The emergence of females is timed to ensure access to lush green forage during the late stages of lactation, approximately 6 to 8 weeks after they emerge, whereas the males time their emergence to guarantee their access to breeding females and by being physically and physiologically ready when the estrous females first appear (Michener 1998).

The preferred food of Richardson's ground squirrels is grasses, succulent shoots, roots, leaves, and seeds of many prairie plants and when available, cultivated garden crops are favourites (Soper 1964; Pattie and Hoffmann 1992). Flowers, especially those of alfalfa and clover are consumed during the growing season and fruits and seeds are eaten as plants mature. Richardson's ground squirrels often store seeds or grain in some of their tunnels, a food source that is probably eaten when they awaken during winter or when they emerge in spring before the new growth of vegetation occurs.

Breeding usually takes place within a few days of the first emergence of females from their burrows (Soper 1964; Pattie and Hoffmann 1992). Both yearlings and adult females breed. After 23 days of gestation (Michener 1998), 3 to 11 (usually 6 to 8) altricial young are born during the second week in April (Pattie and Hoffmann 1992). Only about 25% of females born survive to emerge from hibernation the following year; only half as many males survive. Adult females tend to have a higher annual survival rate than adult males, mainly because females are more likely to survive during the breeding season (Michener 1998). Longevity appears to be about a maximum of 4 years in the wild (Pattie and Hoffmann 1992).

The most significant predators of Richardson's ground squirrels are humans, domestic dogs (*Canis familiaris*), and domestic cats. Native predators include hawks, prairie falcons (*Falco mexicanus*), golden eagles (*Aquila chrysaetos*), long-tailed weasels, badgers, coyotes, red foxes, bullsnakes (*Pituophis melanoleucus*), and prairie rattlesnakes (Soper 1964; Pattie and Hoffmann 1992).

The Richardson's ground squirrel is considered to be a pest in the agricultural community because of its depredation of crops and physical disruption to the range. There are many areas of low numbers within their distributional range, mainly because of severe control measures (Smith 1993). However, in spite of high mortality, these grassland inhabitants are quite common to abundant throughout their distributional range, probably a result of high fecundity and because they disappear underground in hibernation for about 6 months of each year (Soper 1964).

6.1.11 Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)

The thirteen-lined ground squirrel is a slim-bodied, short-legged ground squirrel with alternating dark and light lines of pelage arranged as seven wide, dark, brown longitudinal dorsal stripes dotted with buffy white spots and six narrow whitish-buff stripes (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). It possesses a well-furred but thin tail, a pale-coloured, broken eye ring as well as buff-coloured cheeks, nose, feet, and underparts.

Thirteen-lined ground squirrels are strictly diurnal (Kirsch 1997) and are most often seen around midday during warm sunny weather. In the east and central portion of their range, they establish definite colonies, but on the west side they are essentially solitary; therefore, they do not appear to be common (Pattie and Hoffmann 1992). They utter distinctive call notes of a shrill "seek-seek" or high pitched bubbling trills when alarmed. Generally, thirteen-lined ground squirrels do not construct earthen mounds at burrow entrances as do Richardson's ground squirrels; however, they do have permanent burrow systems with several entrances. Burrows of 50 to 65 mm in diameter descend steeply, extend 100 to 1,000 mm below the surface, and then level off often at right angles. They lead into a well-developed nest chamber which is usually filled with dried grasses and roots and is approximately 225 mm in diameter (Pattie and Hoffmann 1992).

Thirteen-lined ground squirrels are omnivorous as they tend to be more carnivorous than most other species of North American ground squirrels; however, they adjust their food habits seasonally. They eat stored seeds in the spring immediately after they emerge from hibernation, then they switch to grass, leaves, and roots as new plants grow. Later in the season, they consume adult and larval insects, eggs and nestling birds, as well as mice and carrion, which collectively often comprise 50% or more of their diet (Pattie and Hoffmann 1992).

Thirteen-lined ground squirrels emerge from hibernation during late March or early April when the males surface about 2 weeks prior to the females. Once the females emerge, mating begins, and after a 27 to 28 day gestation, 4 to 14 (usually 8 to 10) altricial young are born. Thirteen-lined ground squirrels display multiple paternity with females playing an active role in selection of mates (Berteaux *et al.* 1999). Usually only 1 litter per year is born in the more northern areas of their distributional range. By late September or early October, most thirteen-liners have plugged their burrow entrances with soil and have entered hibernation.

Even though thirteen-lined ground squirrels produce high numbers of offspring, predation and disease are factors that maintain these prolific populations in check. The main predators are hawks, badgers, long-tailed weasels, and domestic cats. Occasionally, coyotes, snakes, and humans take some.

6.1.12 Northern pocket gopher (*Thomomys talpoides*)

The northern pocket gopher is a stout-bodied, short-tailed, short-legged, burrowing rodent with a large head, small ears, and small beady eyes (Pattie and Hoffmann 1992; Smith 1993). It has a whitish, nearly hairless tail that is short and stocky and ends in a blunt tip; it has large forefeet with long claws. The northern pocket gopher possesses external, large, fur-lined cheek pouches which extend back to its shoulders. The most diagnostic characteristic of this animal is presence of these cheek pouches. The northern pocket gopher has a soft, dense steel-gray pelage varying in colour to match the soils they inhabit from extremely light, buffy, brown in sandy areas, as in the SNWA, to extremely dark brown to almost black in other areas of loamy soils (Pattie and Hoffmann 1992).

Northern pocket gophers do not hibernate and remain solitary most of the year, spending much of their time digging new 50 mm diameter tunnels. Their strong foreclaws and incisor teeth are used to dig the tunnels, with most of the work occurring at night (Soper 1964). The burrow exits are kept plugged with soil except during aboveground excursions which normally occur at night. Excavated burrows may extend up to 150 m laterally and are found anywhere between a few centimetres and 3 m below the surface. Adults are pugnacious and are always ready to inflict severe wounds on their enemies with their long sharp incisor teeth and long-clawed toes.

The staple diet consists mainly of succulent underground plant parts, which they feed on as they continue to dig new tunnels. However, they often consume aboveground green vegetation in summer which is usually 70% to 90% forbs while the remainder is grass. Favourite foods include clover, yarrow, penstemon, and anemone. Aboveground foraging almost always occurs at night when they are vulnerable to predation and trapping (Soper 1964).

Northern pocket gophers usually breed in April or early May when males roam over the surface and enter the burrows of estrous females. After 19 to 20 days of gestation, 1 to 8 (usually 3 to 6) altricial young are born in a grass-lined burrow nest. Northern pocket gophers have only 1 litter per year and they reach adult weight in about 6 months; however, they do not mature sexually until the following spring. Longevity is about 4 years in the wild.

The main predators of northern pocket gophers are weasels and owls. Occasionally, badgers, snakes, coyotes, and foxes prey on them. They are generally considered to be an agricultural nuisance because of the physical disruption to the range caused by the familiar mounds they create aboveground. Northern pocket gophers are common to exceedingly abundant in some parts of their distributional range, while for no obvious reason they are scarce or absent in other extensive areas of similar habitat.

6.1.13 Olive-backed pocket mouse (*Perognathus fasciatus*)

The olive-backed pocket mouse, one of the smallest mice in Alberta, is a tiny, attractive, docile rodent (Pattie and Hoffmann 1992; Smith 1993). The pelage is short, dark, sandy-brown on the back with white or buffy-white feet and underparts. There is a thin cream-coloured or buffy line along the side, providing a distinct contrast between the darker pelage on the back and the lighter pelage on the down and underside. There are also distinguishing yellow buffy patches on and behind each ear (Soper 1964). The tail is long and thin. External cheek pouches are located on each side of the mouth which provide the main diagnostic feature of this species.

These nocturnal, solitary, mild-mannered mice exhibit a fondness for sand bathing; however, during the day they retire to 20 mm diameter tunnels in the sandy substrate. The burrow entrances are usually plugged with soil, which maintains a higher humidity in the burrow system and reduces water loss, an important strategy to a mammal living in an arid environment. The summer tunnel system contains storage and shelter burrows as well as a resting chamber at about the 300 to 450 mm depth. The winter system may be at least 2 m below the ground surface and has a grass-lined nest chamber.

The diet of the olive-backed pocket mouse consists of seeds of Russian thistle (*Salsola kali*), needle-and-thread, knotweed (*Polygonum spp.*), tumbling mustard (*Sisymbrium altissimum*), butterfly weed (*Gaura sp.*), lamb's-quarters (*Chenopodium album*), pigweed (*Chenopodium spp.*), common blue-eyed grass (*Sisyrinchium montanum*), and foxtail barley (*Hordeum jubatum*), and occasionally green vegetation is consumed if available (Pattie and Hoffmann 1992). Food storing is a major activity during late summer and early fall when olive-backed pocket mice use their cheek pouches to gather seeds and insect eggs and transport this collected food to underground nest chambers to hoard it for use overwinter.

Olive-backed pocket mice do not appear to put on layers of fat as do most hibernating rodents, but between mid-October and mid-April they enter into alternating periods of torpor and feeding activity in what is believed to be a state of semi-hibernation to full hibernation (Pattie and Hoffmann 1992). Breeding commences shortly after they emerge in spring. Two to 9 (usually 4 to 6) altricial young are born after a gestation of approximately 28 days. Two litters are generally produced each season. Known predators of the olive-backed pocket mouse are owls, snakes, northern grasshopper mice, deer mice, long-tailed weasels, and domestic cats.

6.1.14 Ord's kangaroo rat (*Dipodomys ordii*)

The Ord's kangaroo rat is an attractive rodent that is readily identified by several distinctive features. It has powerful kangaroo-like hind legs, large prominent eyes, an extremely long, well-furred and tufted tail, external hair-lined cheek pouches, and a proportionately large head (Soper 1964; Smith 1993). Its soft, shiny, and sleek fur is yellowish-buff on the back with some black hairs on the uppermost portion, buffy sides, and a white belly (Pattie and Hoffmann 1992). The Ord's kangaroo rat has long prominent vibrissae that originate from both sides of its nose, and it has densely haired soles on greatly elongated hind feet. The auditory bullae at the posterior-lateral margins of the skull are extremely expanded, a characteristic of desert-dwelling rodents which provides them with acute hearing. The forelegs are greatly reduced and are just barely visible when the animal is viewed from the side as it sits hunched over on its extended hind feet, exhibiting a kangaroo-like appearance (Pattie and Hoffmann 1992).

Ord's kangaroo rats are granivorous nocturnal rodents that collect seeds and nest material in their cheek pouches. They are highly fossorial (adapted to digging) and cache food items in their underground burrow systems of complex tunnels and chambers. Burrows are about 75 mm in diameter, descending gradually from the face of a sand slope and usually extending to within 300 mm of the surface. Ord's kangaroo rats are not colonial but are solitary and highly territorial because they defend their burrows, food cache, and surrounding area from any intruders (Gummer 1997a). They kick sand at slow-moving predators such as prairie rattlesnakes, and evade fast-moving predators by catapulting themselves with their hind legs in jumps that extend up to 2 m in length (Pattie and Hoffmann 1992). The tail serves to balance the body, as it does in kangaroos, and is used to change direction by moving it laterally. Their well-developed senses of hearing, sight, and smell help them survive in desert-like environments. Gummer (1997b) determined that the majority of Ord's kangaroo rats in southeast Alberta use shallow, daily torpor during periods of cold temperatures and continuous snow cover as a unique physiological ability to conserve metabolic resources during winter. The result is an increased overwinter survival.

Seeds comprise up to 77% of the diet of Ord's kangaroo rats, but they also collect green vegetation and insects, including ants, butterfly pupa, adult carabid beetles, larval antlions, and grasshoppers (Pattie and Hoffmann 1992; Gummer 1995). In the SNWA, they are known to eat cactus and wheatgrass seeds, choke cherry (*Prunus virginiana*), scurf pea, ground-plum (*Astragalus crassicarpus*), and Russian thistle (Gummer 1997b). They often forage up to 25 m from their burrows, transporting food back to their nests using their cheek pouches.

Breeding in the Canadian northern populations of Ord's kangaroo rats occurs from April through August, and individual females may have up to 4 litters per season compared with only 1 or 2 litters per season in locations south of the Canada-United States border (Gummer 1997b). After a gestation of 29 to 30 days, 1 to 6 (usually 3 to 5) altricial young are born in the burrow nest cavity. In the SNWA, females reached sexual maturity earlier than males (41 days vs. 61 days) and juvenile Ord's kangaroo rats bred during their first season (Gummer 1997b).

These northern populations of Ord's kangaroo rats have extremely low survival rates, averaging 8.3% per year, which appears to be related to starvation and hypothermia during winter, predation, and botfly larvae parasitism (Gummer 1997b; Gummer *et al.* 1997; Gummer 1999). Direct evidence of predation on Ord's kangaroo rats in southeast Alberta included observations of burrowing owls (*Speotyto cunicularia*), great horned owls (*Bubo virginanus*), prairie rattlesnakes, bullsnakes, coyotes, and badgers (Pattie and Hoffmann 1992; Gummer 1997a).

6.1.15 Beaver (*Castor canadensis*)

The beaver, the most massive and powerful of the North American rodents, is semi-aquatic (Soper 1964). It has short legs, a short neck, a large, broad head, small eyes and ears, large webbed hind feet, a broad, flattened scaly tail, and massive, protruding orange-faced incisors (Pattie and Hoffmann 1992). The skull is massive, but has a relatively narrow braincase, large zygomatic arches, and large teeth (Smith 1993). The pelage is long, thick, dense and water-resistant with soft grayish underfur and long, dark brown guard hairs varying from reddish brown to dark brown (Soper 1964; Smith 1993). Beavers possess large anal scent glands called castors, which are present in both sexes and produce a waxy secretion that is used to mark territories (Pattie and Hoffmann 1992). Both the ears and nostrils can be closed voluntarily and the lips remain closed behind the incisor teeth so they can gnaw tree branches after they submerge underwater.

Most North Americans can generally identify beavers. The beaver was the centre of the Canadian fur trade during the early part of the 20th century and is second only to the bison as the most influential mammal in the historical and economical development of the North American continent. It has had an impressive ecological, economical, and social impact on human populations as a result of its valuable fur, the tremendous physical impact it can have on the environment, and its widespread distribution (Pattie and Hoffmann 1992).

Beavers are mainly nocturnal although they can be active during daylight hours. They do not hibernate and they are best known for their engineering skills in dam building (Soper 1964; Pattie and Hoffmann 1992). Dams may be constructed of mud, rocks, sticks, and even unusual materials such as cornstalks and sagebrush. Dams are quite variable in length, height, and in their location relative to other dams. They serve to maintain pools of water beneath the ice in winter so beavers can store bark-covered branches and tree stems for winter food (Pattie and Hoffmann 1992). Beavers usually construct lodges, large dome-shaped piles of mud and sticks in which they create a den. The entrance to the den is usually about 1 m below the water surface, but the chamber inside the pile of sticks is always above the level of the water. Sometimes beavers do not construct lodges, but create dens by burrowing into river banks. Obvious signs of beavers are dams, lodges, and conical stumps and wood chips at the site of fallen trees.

The summer food of beavers consists of bark and cambium of aspen, willow, alder (*Alnus sp.*), and paper birch (*Betula papyrifera*), as well as succulent stream-side plants and other aquatic vegetation (Soper 1964; Pattie and Hoffmann 1992). The winter food cache consists of willows and branches of deciduous trees that have been felled for construction of dams. These woody components are piled in big deep-water feed beds next to the lodge or bank den (Soper 1964). An adult beaver consumes approximately 662 g of woody vegetation each day, and depending on tree size may cut from 200 to 1,700 deciduous trees a year (Pattie and Hoffmann 1992).

Breeding normally occurs in January or February, and after a gestation of about 120 days, 1 to 6 (usually 4) kits are born during April or May (Pattie and Hoffmann 1992). Adult pairs are reported to mate until the death of a partner. They generally produce 1 litter per year, although a second litter may be produced in some Alberta populations. In the wild, the longevity of beavers is believed to be at least 19 years (Pattie and Hoffmann 1992).

Historically, the beaver has been preyed on by wolves (*Canis lupus*), wolverines (*Gulo gulo*), coyotes, cougar/mountain lions (*Felis concolor*), lynx (*Lynx canadensis*), bears (*Ursus spp.*), and fisher (*Martes pennanti*), but these predators all need to catch the beaver away from water in a surprise attack (Pattie and Hoffmann 1992). In recent times, populations of these wild predators have generally declined, with the exception of coyotes, and now exercise only minimal impact on beaver populations. However, humans have been and probably still are the major predator of beavers where they exercise total control over some populations, especially in areas of land-use conflicts.

6.1.16 Western harvest mouse (*Reithrodontomys megalotis*)

The western harvest mouse is a small gray-coloured mouse with a long bicoloured tail (Smith 1993). The pelage is short, slate-gray on the back with a grayish belly and a contrasting dark stripe along the back from head to tail. The western harvest mouse is 1 of the 3 smallest species of mice in the prairies region. It is easily distinguished from the other 2 types because the olive-backed pocket mouse has large external cheek pouches and the house mouse has a gray underside and a nearly naked scaly tail (Pattie and Hoffmann 1992). Furthermore, the western harvest mouse differs from the house mouse by having buffy patches on its cheeks and flanks instead of gray. The 2 most distinctive and diagnostic features of the western harvest mouse are a longitudinal groove on the front of each upper incisor and the sharply bicoloured tail, which is light gray on the underside (Soper 1964; Pattie and Hoffmann 1992; Smith 1993).

Western harvest mice are nocturnal and remain active from shortly after sunset until dawn. They are omnivorous aboveground nesters that do not hibernate (Peterson *et al.* 1985; Kaufman *et al.* 1988). A distinctive sign of the presence of the western harvest mouse is to find a globular nest constructed on or near ground level. Their nest generally consists of grasses woven into a 75 mm-diameter ball, that is often lined with soft materials such as cattail fluff or milkweed (*Asclepias spp.*) down. Since western harvest mice are extremely tolerant of neighbors of the same species and even other species of mice, these nests may house from 2 to 10 mice. Sociability of this magnitude often promotes high ectoparasite loads including ticks, mites, fleas, lice, and chiggers. A recent study in tallgrass prairies found a low trapability of western harvest mice using live traps (Getz and Hofmann 1999). However, snap trapping in the SNWA did not appear to be affected as the western harvest mouse was the second highest caught species.

Food of the western harvest mouse consists of seeds of grasses, legumes (*Leguminosae*), mustards (*Cruciferae*), and grain, as well as considerable quantities of insects such as grasshoppers, beetles, weevils, and moth larvae (Soper 1964; Fleharty and Navo 1983; Pattie and Hoffmann 1992). During spring and early summer, they are known to eat succulent green matter from a variety of native plants. Western harvest mice do not appear to store much food although sometimes in fall they will cache seeds in underground cavities near their nests for use during severe spells of bad weather. They form runways as they constantly travel from the nest site in search of food, and during these travels they often leave piles of grass cuttings in their runways from eating. This is yet another clue indicating their presence.

Reproduction in the western harvest mouse generally occurs during warmer summer months. In the wild they produce from 1 to 9 litters per year, averaging 4.1 young per litter. After a gestation of 23 to 24 days, from 2 to 7 altricial young are born. Females mature at 4 to 5 months of age and exhibit postpartum estrus, further substantiating the potential for high productivity. Major predators of western harvest mice are owls, long-tailed weasels, red foxes, badgers, coyotes, and striped skunks.

6.1.17 Deer mouse (*Peromyscus maniculatus*)

The deer mouse has large ears, a pointed nose, long vibrissae, protruding large black eyes, white underside and feet, and a long, well-furred, sharply bicoloured tail that is dark on top and white underneath (Pattie and Hoffmann 1992; Smith 1993). The colour of the pelage ranges from slate-gray to golden-brown on the back, but the belly is always white. Deer mice display 3 main pelage colour phases: the juvenile slate gray to black coat which is molted in 30 to 45 days; the subadult mixed dark brown to gray coat; and the adult gray coat.

This mainly nocturnal mouse generally remains active throughout the year. It does not hibernate, but may become torpid and inactive during extremely cold periods (Soper 1964; Pattie and Hoffmann 1992). Deer mice tend to be more arboreal than voles and often climb into rose bushes for fruits. Dens usually contain a 100 mm-diameter nest that is lined with almost any kind of material that can be shredded, including grasses, papers, cotton rags, newspapers, mattress stuffing, and insulation. In prairie environments, deer mice may use burrows of other rodents for dens. They are noted for long distance treks during the night, where one-way distances of 400 m through soft snow and homing travels of more than 3 km have been reported (Pattie and Hoffmann 1992). A long distance movement of 1000 m by a deer mouse in southeast Alberta was reported by Klausz (1997). Recently, a new record non-homing movement distance of 1,768 m by a deer mouse, which was suspected to be a dispersal movement caused by high density, was reported by Bowman *et al.* (1999). Deer mice are tremendously perceptive and extremely inquisitive, a trait that may explain the ease at which they can be trapped.

Deer mice possess internal cheek pouches which they often fill with seeds from grasses, grains, choke cherries, wild buckwheat (*Persicaria convulvulus*), lamb's-quarters, or other vegetation that they transport back to their burrows (Pattie and Hoffmann 1992). They may hoard quantities of up to 3 litres of seeds. Additional food items they may consume are grasshoppers, larval moths and other insects, carrion, an occasional egg or nestling of a ground-nesting bird, and even other small mammals, including members of their own genus. In arid grasslands such as the SNWA, water is obtained by eating green vegetation.

Breeding in deer mice normally occurs between March and October. They average 3 litters per year in the wild, up to a maximum of 4 (Pattie and Hoffmann 1992). After a variable gestation of 22 to 35 days, 1 to 9 (usually 4 to 5) altricial young are born. The female enters postpartum estrus soon after the birth of its young, a characteristic that contributes to high fecundity. Young females become sexually mature at 32 to 35 days, whereas males mature a little later at 40 to 45 days. Deer mice have the ability for rapid annual turnovers and populations usually fluctuate between scarcity, where minimum densities occur in early spring, and abundance, where maximum densities occur in the fall. These fluctuations can be sudden and severe, as evidenced by a decline of 86% within 1 year (from 17.5 to 0.25 individuals per ha) in a northern tundra population (Pattie and Hoffmann 1992).

Major wildlife predators of deer mice are long-tailed weasels, raccoons (*Procyon lotor*), red foxes, coyotes, and owls. Other occasional predators such as, snakes, domestic cats, and hawks, may use deer mice as an alternate source of food, especially when populations are high. Deer mice are not known to cause serious agricultural losses, but can negatively impact beekeepers by entering hives and feeding on overwintering bees (Pattie and Hoffmann 1992). However, they are better known as pests because of their tendency to enter homes and other buildings occupied by humans, especially during the fall season.

6.1.18 Northern grasshopper mouse (*Onychomys leucogaster*)

The northern grasshopper mouse resembles the deer mouse, but is much larger with broader shoulders and a chunky body that ends in a short, thick, tapering tail (Pattie and Hoffmann 1992; Smith 1993). The silky body pelage is bicoloured with a pale sandy-brown colour on the back, a grayish head and nose, a white tuft at the base of the ears, and a white belly (Soper 1964; Smith 1993). The tail is white underneath except over the last third of its length it is all white. Short legs and broad feet tend to accent its stockiness. One of the main diagnostic characteristics of the northern grasshopper mouse is the proportionately short tail which is less than twice the length of the hind foot.

The northern grasshopper mouse has 2 unique features, a distinctive scent that is pungent and an ability to vocalize which is both frequent and variable (Pattie and Hoffmann 1992). Adults can emit 4 different types of vocalizations. They occupy well-defined scent-marked territories of 2 to 3 ha in size. Males occupied larger home ranges than females during all seasons and male home range size is basically determined by mate-searching behaviour (Stapp 1999). Nest burrows are U-shaped, about 40 mm in diameter, and are usually located about 15 cm belowground. They may be located on the ground surface under vegetation and debris or in holes dug by other animals. The entrance to their burrow system is plugged during the day. Northern grasshopper mice are considered to be predatory carnivores, attacking other vertebrates by proceeding with a slow deliberate approach followed with a sudden rush that usually knocks the prey onto its back. Then, they direct powerful bites toward the base of the prey's skull and kill it by driving their needle-sharp lower incisors into the brain on which they feed first (Pattie and Hoffmann 1992).

Northern grasshopper mice are different from most North American rodents in that their diet is mainly animal matter, including arthropods and small vertebrates (Stapp 1999). About 90% of the summer diet of the northern grasshopper mouse consists of a variety of vertebrates and invertebrates, with approximately 40% of this diet being its favoured grasshoppers (hence its name), crickets, and other Orthopterans, while beetles contribute another 20%. Lepidopterans were a preferred food item of northern grasshopper mice in the Colorado shortgrass prairie (Fleharty and Navo 1983). Only about 10% of the summer diet is vegetation, which is comprised mainly of seeds of grasses and forbs, whereas the winter diet is about 40% vegetation. Plant material, including seeds, comprised more than 37% of the winter diet of northern grasshopper mice in the Colorado shortgrass prairie (Fleharty and Navo 1983). Northern grasshopper mice usually build up layers of fat on their bodies during fall; however, they do not hibernate.

Northern grasshopper mice breed from March through August with females exhibiting postpartum estrus. They can produce 2 to 3 litters per season where 1 to 6 (Sikes 1998), but usually 3 or 4 altricial young are born. Although litter size showed a significant effect on mean mass of offspring early in lactation, young showed compensatory growth as soon as they began eating solid food such that by weaning and adult age there was no apparent difference in body size (Sikes 1998). Gestation is variable, extending from about 29 to 32 days up to 47 or 48 days, and it may involve delayed implantation. During the non-breeding season, members of the same sex share nests indicating a reduced intra-sexual aggression which allows northern grasshopper mice to conserve energy by communal nesting (Stapp 1999). Longevity of 2 to 3 years is possible, but probably is not attained in the wild.

The main predators of northern grasshopper mice are owls, red foxes, coyotes, long-tailed weasels, prairie rattlesnakes, and domestic cats. Occasionally, red-tailed hawks (*Buteo jamaicensis*) prey on northern grasshopper mice although their nocturnal habits generally protect them from a number of diurnally active predators. It is unlikely that northern grasshopper mice constitute a major prey of any predator because they are at low density throughout the distributional range.

6.1.19 Bushy-tailed woodrat (*Neotoma cinerea*)

The bushy-tailed woodrat is a medium-sized rodent weighing up to 530 g with buffy, long, soft pelage that is silver-gray on the back and sides and white on the belly and feet (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). They have large protruding black eyes, large fur-covered ears, long vibrissae, a face that tapers sharply into the nose, and a long, well-furred bushy tail (Pattie and Hoffmann 1992; Smith 1993). The long bushy tail is the main diagnostic feature used to identify this species. The bushy-tailed woodrat is skilled at climbing because of 4 long-clawed toes on each front foot and 5 on each rear foot (Pattie and Hoffmann 1992).

The bushy-tailed woodrat is the infamous "packrat" or "trade rat", a name that was given to it because of its characteristic habit of carrying something in its teeth until the item is dropped in favour of a more attractive object that is found next along the route (Pattie and Hoffmann 1992). The bushy-tailed woodrat is predominantly nocturnal and does not hibernate (Soper 1964; Pattie and Hoffmann 1992). A clue to its presence is the detection of a bulky nest structure that is usually constructed of vegetation, sticks, and rubbish, and which is often located in crevices of sandstone cliffs, rock outcrops, or in abandoned buildings (Soper 1964; Pattie and Hoffmann 1992). These nests provide both cover and protection from enemies. The bushy-tailed woodrat is an extremely curious animal that is somewhat more bold than shy (Soper 1964). Longevity in the wild is at least 4 years (Pattie and Hoffmann 1992).

The bushy-tailed woodrat is mainly herbivorous, where spring and summer food consists of green vegetation, including buds and leaves of shrubs, conifer needles, cacti, mushrooms, forbs, fruits, nuts and bulbs, and seeds (Soper 1964; Pattie and Hoffmann 1992). In the fall, woodrats collect vegetative cuttings and starchy corms and roots which they often build into cache piles near the nest, similar to the haystacks made by pikas (Pattie and Hoffmann 1992). A food cache will average about 8 litres in volume and a single animal may collect more than 1 pile for overwinter use (Pattie and Hoffmann 1992).

Breeding may occur in early February but generally peaks somewhere between March and June (Pattie and Hoffmann 1992). After 27 to 32 days of gestation, 1 to 6 (usually 3 to 4) altricial young are born. Newborn bushy-tailed woodrats grow rapidly and are usually weaned by 30 days; however, they do not mature sexually until the following spring (Pattie and Hoffmann 1992). Females exhibit postpartum estrus, and in some parts of the range 2 litters per season are produced; it is not known if this is the case in Alberta (Soper 1964; Pattie and Hoffmann 1992).

The preferred habitat of the bushy-tailed woodrat is rocky outcrops, rock slides, talus slopes, badlands, ledges, caves, forested banks of streams, and in cavities under rocks and boulders. Cabins and a variety of buildings are also used even if they are not abandoned (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). This type of habitat has crevices and other nooks and crannies where woodrats can construct large stick nests. Bushy-tailed woodrats frequently occupy vacant buildings in the mountains and foothills range of Alberta (Smith 1993).

Predators of the bushy-tailed woodrat include coyotes, bobcats (*Lynx rufus*), owls, long-tailed weasels, marten (*Martes americana*), wolverines, red foxes, wolves, snakes, and humans (Pattie and Hoffmann 1992). Humans eliminate woodrats from buildings each fall and are likely a major predator. Based on live trapping results in buildings around an abandoned coal mine in central Alberta, densities of 7 to 14 bushy-tailed woodrats per hectare were recorded (Pattie and Hoffmann 1992). Woodrats do not pose any economic threat to agriculture; however, they are a nuisance in cabins and ranch buildings where they are pests, although they are easy to remove by trapping (Pattie and Hoffmann 1992).

6.1.20 Meadow vole (*Microtus pennsylvanicus*)

The meadow vole is a relatively large vole, measuring up to 175 mm in total length and weighing up to 50 g. It has an overall grayish to reddish brown colour that varies from brown to blackish-brown above and gray below (Smith 1993). The distinguishing features of meadow voles are small protruding black eyes, rounded small ears that are partially hidden in long loose fur, rounded heads, and long bicoloured tails that are twice the length of the hind foot (Pattie and Hoffmann 1992). It is the most common of the 3 species of microtine rodents (meadow vole, sagebrush vole, and muskrat) that were found in the SNWA.

Meadow voles characteristically build and maintain a complicated system of runways and trails as they cut vegetation in linear foraging patterns radiating from their nest. The home plots are often located on steep slopes facing north and northeast (Soper 1964). Although they are mainly nocturnal, it is not unusual to catch a glimpse of these aggressive and somewhat territorial voles scurrying along a runway in broad daylight, an event that was observed during the SNWA study. At least 1 runway leads to a short burrow in the soil or under some litter, where a 150 mm-diameter nest is usually found (Soper 1964; Pattie and Hoffmann 1992). Winter nests will often be constructed aboveground but under the cover of snow once it arrives. In prairie habitats, old ground squirrel holes or other holes at the base of a sagebrush are often used for the nest burrow.

Males are generally aggressive to other members of their somewhat loosely-formed colonies, as evidenced by numerous back wounds and scars. Spacing of breeding males is basically regulated by the availability of sexually receptive females, whereas female meadow voles appear to be spatially regulated by population density rather than simple food availability (Fortier and Tamarin 1998).

The main spring and summer diet of meadow voles consists of green sedges (*Carex spp.*) and grasses, buds and leaves of sagebrush, and some forbs, whereas the bulk of the winter diet is seeds, roots, and some bark (Soper 1964; Pattie and Hoffmann 1992). They are known to store large quantities of seeds of various plants, tubers of the wild artichoke (*Helianthus tuberosa*), and surplus unharvested grain left in farm fields.

Spring breeding in meadow voles may be stimulated by the first new plant growth which generally commences in April, but may start during late March, depending upon the latitude and local weather conditions. Berteaux *et al.* (1999) showed experimentally that 79% of female meadow voles chose to mate with more than 1 male, which indicates that females play an active role in multiple paternity. Ovulation is induced by copulation and after a gestation of 20 to 21 days, 1 to 11 (usually 4 to 8) altricial young are born. Litter size appears to be directly related to food abundance and multiple litters are generally produced. Females exhibit postpartum estrus and breeding continues through until the end of October, as long as fresh green vegetative shoots are available. Female meadow voles are territorial during the breeding season whereas males are non-territorial (Pugh and Ostfeld 1998). Adults usually bear their young in the spring and die before winter, leaving the summer or fall-produced generation to overwinter and breed the following spring. Spring-born females mate when they become 25 days of age and bear their first young at 45 to 46 days. The longevity of voles is approximately 2 years, but the majority do not survive that long in the wild.

Population size of meadow voles varies greatly from year to year with low densities of about 35/ha in the spring and maximum densities peaking at more than 1,000/ha in the fall of each year (Pattie and Hoffmann 1992; Merwin *et al.* 1999). In tallgrass prairie in central Illinois, mean and maximum densities of 27.2/ha and 128/ha were significantly different than in bluegrass prairie (12.7/ha and 83/ha) and in an alfalfa field (7.2/ha and 71/ha), respectively (Getz and Hofmann 1999). During years of high densities, economic losses can result from bark being chewed from tree roots, the girdling of shrubs and seedling trees in forest nurseries, the destruction of ornamental plants, shrubs, bulbs, and vegetables, and from gnawing damage to granaries and other farm sheds. Through feeding activity, meadow voles often cause serious damage in North American orchards especially to young apple (*Malus domestica*) trees (Merwin *et al.* 1999). They can also cause severe depredation of unharvested grain left in farm fields overwinter.

The main predators of meadow voles are hawks and owls, snakes, long-tailed weasels, domestic cats, crows (*Corvus brachyrhynchos*), gulls (*Laridae*), herons (*Ardeidae*), coyotes, wolves, and red foxes, some of which often depend on meadow voles for their own survival. Shrews will prey on nestling meadow voles and fish will devour swimming voles.

6.1.21 Sagebrush vole (*Lagurus curtatus*)

The sagebrush vole is the palest-coloured vole inhabiting North America. It is easily recognized by its small size, light ashy colouration, and its short furry tail, which is just slightly longer than the hind foot (Soper 1964). The pelage has a tinge of buff about the nose and ears, but overall it is a pale sandy colour that is darker on the back and lighter on the belly (Smith 1993). The stubby body, short legs, and long lax hair, together with short round ears that are nearly hidden by head fur, create an impression of compactness (Pattie and Hoffmann 1992).

Sagebrush voles are generally uncommon, occur in extremely spotty or localized areas where they are seldom seen or captured, and are highly variable in numbers between years; however, local populations can sometimes be quite dense (Pattie and Hoffmann 1992; Smith 1993). In sandy areas, these voles excavate shallow tunnels that can be 100 to 400 mm deep and 1 to 2 m long. These elaborate runway systems often cover an area of more than 80 m in diameter and include a multitude of burrows and scattered sage clumps. Several burrows may lead to an underground nest chamber that may be lined with shredded sage bark. Burrows and runways that are littered with grass cuttings are usually a clue to the presence of sagebrush voles.

Sagebrush voles obtain water from their food, which consists of flowers and seeds, leaves of sage plants, rabbit-brush (*Chrysothamus nauseosus*), and dotted blazing star (*Liatris sp.*), winter-fat (*Eurotia lanata*) seeds and heads, spores and sporophylls of prairie selaginella, and many other forbs and some grasses. Also, bulbs and roots are consumed. Winter food generally consists of bark and cambium of sagebrush and the roots of several prairie plants.

In Canada, the duration of the breeding season for sagebrush voles is longer than for most other voles, extending from May until August or September, whereas in more southern populations breeding occurs throughout the year. After a gestation of 24 to 26 days, 1 to 11 (usually 5 to 8) altricial young are born in the underground nest chamber (Pattie and Hoffmann 1992). The female exhibits postpartum estrus, a characteristic that contributes to high fecundity.

Known predators of the sagebrush vole are bullsnakes, burrowing owls, and short-eared owls (*Asio flammeus*). Potential and suspected predators are other species of wildlife that live in the same habitat, such as prairie rattlesnakes, long-tailed weasels, grasshopper mice, hawks, owls, red foxes, coyotes, and badgers.

6.1.22 Muskrat (*Ondatra zibethicus*)

The muskrat is a highly-specialized aquatic vole that is the largest microtine rodent in Alberta (Pattie and Hoffmann 1992; Smith 1993). The pelage has long, lustrous, reddish brown to almost black guard hairs and a dense water repellent underfur that is brownish-gray (Pattie and Hoffmann 1992; Smith 1993). The tail is long, scaly, sparsely haired and laterally compressed (Soper 1964; Smith 1993). The muskrat has prominent, orange-faced incisors, short legs, small weak front paws, broad, powerful, partially webbed hind feet that are adapted for swimming, short ears, and protruding small, black, beady eyes (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). It has the ability, like the beaver, to close its lips behind the incisors thus allowing it to gnaw tree branches while submerged without water entering the mouth cavity (Pattie and Hoffmann 1992). Both sexes have perineal scent glands that enlarge and produce a distinctively scented discharge during the breeding season, a trait that has resulted in its vernacular name (Pattie and Hoffmann 1992).

Muskrats do not hibernate, but they do store winter food (Pattie and Hoffmann 1992). In a study in Manitoba, muskrats accrued substantial lipid stores during winter which reached peak values in February but varied significantly between years (Campbell and MacArthur 1998). They are active day and night, but activity peaks around dusk and dawn. Most of their activity is in the aquatic environment of a marsh or slough where densities of 8 to 85 per hectare are normal and houses are constructed with accumulations of herbaceous vegetation (Pattie and Hoffmann 1992). Muskrat houses are dome-shaped piles of cattails and rushes, but unlike beaver lodges, mud and sticks are not included. In southern locations, muskrats tend to inhabit bank dens along rivers and creeks; therefore, houses are much less common (Soper 1964; Pattie and Hoffmann 1992). Family units usually occupy 1 house.

A characteristic of northern muskrats is to build "push ups", which are holes dug through the surface of newly formed ice to where vegetation is hauled up on top of the ice. Eventually the site becomes converted to a hollow dome of frozen vegetation that serves as a shelter from the cold (Pattie and Hoffmann 1992). These push ups are maintained by the muskrats continuously bringing bottom plants up into the site and using it as a sheltered feeding location. In winter, caribou often paw apart push ups and consume the green vegetation as an easy source of food (Pattie and Hoffmann 1992).

The dominant food of muskrats in prairie marshes is the broadleaf cattail (Campbell and MacArthur 1998). Summer food of the muskrat includes the succulent and juicy shoots, stems and leaves of cattails, rushes (*Juncus spp.*), sedges, common blue-eyed grass, water lilies (*Nymphaea tetragona*), and pond weeds that form part of the shoreline and emergent herbaceous vegetation in their habitat (Soper 1964; Pattie and Hoffmann 1992). Occasionally, they eat animal matter including frogs, turtles, mussels, salamanders, snails, crayfish, and sometimes small fish (Pattie and Hoffmann 1992). During winter, their diet consists mainly of the submerged vegetation that was cached earlier in the year. In a study in Manitoba, annual changes in forage quality and energy intake were accompanied by changes in basal energy expenditure, serum thyroxine concentration, body lipid stores, and organ sizes of seasonally acclimatized muskrats (Campbell and MacArthur 1998).

The breeding season of muskrats lasts from March to September. After a gestation of 25 to 30 days, between 1 and 11 (usually 6 or 7) altricial young are born (Soper 1964; Pattie and Hoffmann 1992). At least 2 litters per year are produced; sometimes under favourable conditions 3 litters may be successfully raised (Pattie and Hoffmann 1992). Young of both sexes do not mature until the spring following their birth.

The major wild predator of muskrats is mink; however, humans are the most important cause of mortality as a result of fur trapping. During spring and fall, which are peak periods of dispersion, muskrats are often killed by owls, coyotes, domestic dogs, red foxes, wolves, and badgers as they travel overland looking for new habitat to colonize (Pattie and Hoffmann 1992). This is the time of year when highway mortalities commonly occur. These extremely prolific rodents are sought after as an important source of fur because of its good insulating properties, attractiveness, and durability. Muskrats have been important to the trapping community of Alberta as a source of income throughout the 20th century; however, fluctuating and dwindling fur prices during the last decade have reduced its economic importance.

6.1.23 House mouse (*Mus musculus*)

The house mouse is a small, uniformly gray mouse with a long pointed nose and associated abundant vibrissae that are situated in front of large, lustrous, and protruding black eyes (Pattie and Hoffmann 1992; Smith 1993). It possesses a long, sparsely haired, scaly tail, and large, almost hairless, ears. The pelage is darker on the back and lighter gray on the sides with a slight yellow wash; the underparts are ashy gray (Soper 1964; Smith 1993). The feet are brown with whitish tips (Soper 1964; Pattie and Hoffmann 1992). The house mouse is similar to the deer mouse and the western harvest mouse; however, it differs from the deer mouse by its larger size and its molars have 3 longitudinal rows of cusps instead of 2 rows, and it differs from the western harvest mouse by not having grooves on its upper incisors and its tail is not bicoloured (Pattie and Hoffmann 1992; Smith 1993). The albino strain of the house mouse is the standard laboratory mouse used throughout North America, primarily in medical research.

House mice are most abundant in ungrazed and unmowed habitats that have a well-developed litter layer or a complex vertical structure of forbs, grasses, and shrubs (Clark *et al.* 1998). Highest densities are often in fencerows rather than adjacent pastures and lowest densities occur in upland prairies or mowed areas (Clark *et al.* 1998). House mice do not hibernate, and sustenance and shelter is provided by stacks of hay or straw bales, granaries, feedlots, poultry barns, and houses (Pattie and Hoffmann 1992). They construct nests of vegetation, shredded paper and rags, often rolled up into a 100 mm-diameter ball that can be found underneath litter, inside a wall, or hidden away almost anywhere (Pattie and Hoffmann 1992). In native habitats, house mice require more cover than deer mice (Kirsch 1997). House mice inhabit buildings on any level not just on the lower levels, and although many mice may live together they are not truly colonial. Small, oval fecal pellets are a good indicator of their presence (Pattie and Hoffmann 1992). The smell of muriatic acid accompanies high-density populations; the acid being named because of its resemblance to their smell (Pattie and Hoffmann 1992). The house mouse is the target of more traps and poison than any other rodent because of its fondness to live in close association with human habitations. In an experimental test, age and sex class capture rates of the house mouse were significantly affected by intrinsic factors which in turn were modified by external factors (Drickamer *et al.* 1999). Adult house mice had a significant difference in trap-response; males were caught significantly more than females (Drickamer *et al.* 1999).

The food of the house mouse is primarily vegetation although insect parts comprised 15% to 88% of stomach samples analyzed from 2 studies (Pattie and Hoffmann 1992). The house mouse is omnivorous and eats food items of corn, lepidopterous larvae, and seeds of *Setaria sp.* (Fleharty and Navo 1983). Carrion and meats that are preserved by humans are often consumed by house mice and they will readily drink milk and water.

Breeding normally takes place between May and October, but occurs throughout the year if ideal conditions prevail since females are spontaneous ovulators (Pattie and Hoffmann 1992). The gestation period is 19 to 21 days after which 1 to 12 (usually 4 to 8) altricial young are born. Generally, sexual maturity is reached in 40 to 56 days although a few females may breed earlier (Pattie and Hoffmann 1992).

In areas of human habitation, the domestic cat is a known predator; however, in areas away from dwellings, long-tailed weasels, owls, hawks, striped skunks, and loggerhead shrikes (*Lanus ludovicianus*) are wildlife species that are known to prey on house mice (Pattie and Hoffmann 1992).

6.1.24 Porcupine (*Erethizon dorsatum*)

The porcupine is a large (weighing up to 12 kg), clumsy, slow-moving rodent that is known for its long, sharply pointed and barbed-tipped quills that cover the head, back, sides, and tail (Soper 1964; Pattie and Hoffmann 1992; Smith 1993). Long and coarse pale yellow guard hairs cause an overall colour of brownish-yellow in adults, whereas juveniles are blackish (Pattie and Hoffmann 1992). Gray patches appear between the eyes and cheeks while the underside ranges in colour from black to dark buffy brown (Pattie and Hoffmann 1992; Smith 1993). The porcupine has dense and woolly underfur that is a dark brown or black colour. Its limbs are short, and the forelimbs each bear 4 toes with sharp, powerful, curved claws. On each hindfoot, there are 5 toes with claws that are shorter and not as curved as those on the forelimbs (Pattie and Hoffmann 1992). The soles of the feet are bare but have a thick, black, denticulate skin that helps them in climbing, a skill at which they excel in contrast to their clumsy slow movement on the ground (Pattie and Hoffmann 1992). The tail is stout and muscular with quills on the sides and top. It may be used as a prop while the porcupine stands upright on lightweight branches and uses its forepaws to pull twigs into its mouth (Pattie and Hoffmann 1992; Smith 1993). Proportionately, the porcupine has a small head, but its skull is heavily constructed with broad nasals and a blunt muzzle (Banfield 1974; Pattie and Hoffmann 1992). The skull has a large infra-orbital foramina and the upper incisors are long, orange-coloured, and extend well past the nasal bones (Smith 1993).

Porcupines neither hibernate nor store food (Pattie and Hoffmann 1992). Their top speed is 3-5 km/h on land or in the water (Pattie and Hoffmann 1992). Adults consume approximately 430 g of vegetation daily, and since they deposit 75 to 180 fecal pellets per day, an estimate of the time they have occupied a site can be made by counting pellets (Pattie and Hoffmann 1992). The porcupine is essentially the arboreal counterpart of the beaver, as both are large, stout-bodied, bark-eating rodents (Pattie and Hoffmann 1992). A major difference in pelage readily distinguishes the 2 species. The beaver defends itself from predators by retreating to an aquatic environment, whereas the porcupine's defence from predators is its unique coat composed of defensive quills (Pattie and Hoffmann 1992). The quills are easily shed because of light attachment, and when they penetrate muscle tissue they are not easily withdrawn because of barbed tips which also causes the quills to slowly work their way inwards (Banfield 1974). Quills can penetrate muscle tissue at the rate of up to 6 mm/h. The porcupine can deliver a fast hard blow with its tail which leaves the easily-detached lateral quills impaled in the attacker (Banfield 1974). Contrary to popular belief, porcupines cannot throw quills. There are an estimated 30,000 quills on an adult porcupine (Banfield 1974). Lost quills are replaced in 10 days to 6 months and the annual molt which occurs between spring and mid-summer serves to replace broken quills, old quills, underfur, and guard hairs (Pattie and Hoffmann 1992).

Porcupines are herbivores that feed on grass and succulent plants and on leaves, buds, twigs, and especially young bark or the cambium layer of deciduous and coniferous trees (Pattie and Hoffmann 1992). Because they can cause damage to merchantable timber by girdling and killing trees outright, porcupines are considered to be forestry pests (Banfield 1974). In the southern prairies, porcupines are known to feed on a variety of green vegetation including alfalfa, clover, and grain in agricultural areas, and on the bark and twigs of willow, wild rose, choke cherry, and silver-berry (Soper 1964). Their affinity for salt has resulted in them gnawing on leather boots, a saddle cinch, and hammer, shovel, and axe handles where human sweat has accumulated.

Breeding normally takes place in November and December where copulation is achieved by a very careful rear mounting of the female by the male (Pattie and Hoffmann 1992). After a 205 to 217 day gestation only 1 young, known as a porcupette, is produced (Pattie and Hoffmann 1992). The precocious young porcupette has its eyes open at birth and is covered with long black hair that hides functional quills that are already about 2.5 cm long. Longevity in the wild is at least 9 years (Banfield 1974; Pattie and Hoffmann 1992).

Undoubtedly, many large predators try to kill porcupines and sometimes succeed. Known wildlife predators are fishers, wolverines, and bobcats, and they regularly kill porcupines by repeatedly attacking and biting the head, during which time they often receive a large quantity of quills (Pattie and Hoffmann 1992). However, porcupines have a unique mode of defence in which they find a log or stone to protect their heads, they turn their backs to their adversary, and they elevate their quills (Banfield 1974). Then, they lash out with their club-like spiny tail in lightening fast blows, which usually ends with the attacker getting impaled as the contact quills detach (Banfield 1974). They also respond to threats by crouching instead of running which results in high mortality along highways, and they also will climb trees to escape an attack.

Appendix 7: Status of Suffield small mammal species in the SNWA, on the Committee On The Status Of Endangered Wildlife In Canada (COSEWIC); total numbers of animals caught; whether or not the species is a grassland endemic; and whether or not the species is at risk of extirpation in Alberta.

SPECIES	NO[1]	GE[2]	STATUS AND LISTING			AT RISK IN AB
			SNWA	ALBERTA[3]	COSEWIC[4]	
Prairie shrew	45	yes	Medium	UNDETERMINED		Unknown
Little brown bat	4	no	Low	GREEN		No
Long-eared bat	28	no	Medium	UNDETERMINED		Unknown
Long-legged bat	1	no	Low	UNDETERMINED		Unknown
Western small-footed bat	**43**	yes	**High**	YELLOW B		No
Big brown bat	6	no	Low	GREEN		No
Hoary bat	4	no	Low	UNDETERMINED		Unknown
Nuttall's cottontail	-	yes	Medium	YELLOW B	NOT AT RISK	No
White-tailed jack rabbit	-	yes	Medium	GREEN		No
Richardson's ground squirrel	-	yes	Low	YELLOW A		No
Thirteen-lined ground squirrel	46	yes	Medium	YELLOW A		No
Northern pocket gopher	9	yes	Medium	GREEN		No
Olive-backed pocket mouse	14	yes	Low	YELLOW B		No
Ord's kangaroo rat	42	yes	Medium	BLUE	VULNERABLE	Yes
Beaver	-	no	Low	GREEN		No
Western harvest mouse	**95**	yes	**High**	YELLOW B	INDETERMINATE	No
Deer mouse	**1694**	no	**High**	GREEN		No
Northern grasshopper mouse	14	yes	Low	YELLOW B		No
Bushy-tailed wood rat	1	no	Low	GREEN		No
Meadow vole	**84**	no	**High**	GREEN		No
Sagebrush vole	3	yes	Low	UNDETERMINED	INDETERMINATE	Unknown
Muskrat	-	no	Low	GREEN		No
House mouse	1	no	Low	GREEN		No
Porcupine	-	no	Low	GREEN		No

[1] = Total number of animals caught from 1994 to 1996.
[2] = Grassland Endemic.
[3] = BLUE LIST= May be at risk because of vulnerability and limited information.
YELLOW LIST= Sensitive species that may have naturally low populations, limited provincial distributions, or demographics that make them vulnerable to human-caused environmental changes. YELLOW A= concern over long-term declines in numbers. YELLOW B= naturally rare but not in decline, naturally rare with clumped breeding distribution, or associated with deteriorating habitats.
GREEN LIST= Not considered at risk as their populations are stable and their key habitats are generally secure at present.
UNDETERMINED LIST= Not known to be at risk but insufficient information available to determine present status.
[4] = VULNERABLE= A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
INDETERMINATE= A species for which there is insufficient scientific information to support status designation.
NOT AT RISK= A species that has been evaluated and found to be not at risk.

Appendix 8: Species, numbers, date, Figure 21 site numbers, UTM co-ordinates, and location name for bats captured and observed in the CFB Suffield National Wildlife Area, 1994-1996.

BAT SPECIES Captured	#	DATE	Fig19 Site #	UTM CO-ORDINATES	LOCATION NAME
Western small-footed	10	5/7/95	1	550500 5607300	East Boundary by river
(*Myotis ciliolabrum*)	9	15/7/95	13	550800 5607250	East Boundary by river
	5	12/7/95	11	531520 5590460	East Sherwood Forest
	4	8/7/95	5	542140 5603960	Whitco Springs
	4	22/7/95	25	541250 5603310	Whitco Springs
	4	6/8/95	36	541360 5596210	South Hantavirus Coulee
	2	16/7/95	14	535290 5590150	S. Sask.River, 4 km east of Sherwood Forest
	1	9/7/95	6	536400 5590650	Bat Springs
	1	13/7/95	12	544690 5605790	Ravine off Butler's Trail
	1	20/7/95	21/22	531200 5590680	Sherwood Forest
	1	27/7/95	29	527110 5567100	Bull Pen at river (South Block)
Long-eared	9	8/7/95	5	542140 5603960	Whitco Springs
(*Myotis evotis*)	5	15/7/95	13	550800 5607250	East Boundary by river
	3	13/7/95	12	544690 5605790	Ravine off Butler's Trail
	3	20/7/95	21/22	531200 5590680	Sherwood Forest
	3	22/7/95	25	541250 5603310	South Whitco Springs
	3	6/8/95	36	541360 5596210	South Hantavirus Coulee
	1	19/7/95	19/20	548740 5606100	Aspen Grove, South Butler Trail
	1	24/7/95	26	540950 5587960	East Coulee, Murphy's Horn
Big brown	2	29/7/95	31	527820 5579610	Coulee Edge SW of river flats (South Block)
(*Eptesicus fuscus*)	2	31/7/95	32	525820 5575340	North Dugway Forest (South Block)
	1	9/7/95	6	536400 5590650	Bat Springs
	1	13/7/95	12	544690 5605790	Ravine off Butler's Trail
Little brown	4	8/7/95	5	542140 5603960	Whitco Springs
(*Myotis lucifugus*)					
Hoary	3	6/8/95	36	541360 5596210	South Hantavirus Coulee
(*Lasiurus cinereus*)	1	12/7/95	11	531520 5590460	East Sherwood Forest

Appendix 8: Continued.

BAT SPECIES Observed	#	DATE	Fig19 Site #	UTM CO-ORDINATES	LOCATION NAME
Long-legged	1	8/7/95	5	542140 5603960	Whitco Springs
(*Myotis volans*)					
Western small-footed	1	9/8/96	a	550040 5608060	East boundary trail
(*Myotis ciliolabrum*)	3	22/7/96	c	542150 5603630	Whitco Springs
	1	6/6/95	d	538070 5605930	Double Wide Fireguard
	2	14/7/96	f	536450 5590760	Bat Springs
Long-eared	5	4/7/96	b	550580 5607040	East boundary by river
(*Myotis evotis*)					
Big brown	1	4/7/96	b	550580 5607040	East boundary by river
(*Eptesicus fuscus*)	1	28/8/94	c	542100 5604000	Whitco Springs
	1	30/8/94	e	541000 5597800	Hantavirus coulee
	1	14/7/96	f	536450 5590760	Bat Springs
Little brown	1	22/7/96	c	542150 5603630	Whitco Springs
(*Myotis lucifugus*)					
Hoary	1	28/8/94	c	542100 5604000	Whitco Springs
(*Lasiurus cinereus*)	1	30/8/94	e	541000 5597800	Hantavirus coulee