Small Mammal Survey of Fish Springs National Wildlife Refuge: Final Report to the United States Fish and Wildlife Service

by
Shannen L. Robson, M.S.
and
Eric A. Rickart, Ph.D

Utah Museum of Natural History
University of Utah
1390 East Presidents Circle
Salt Lake City UT 84112

September 2004

Table of Contents:

Figures and Tables:

Appendices:

Project Description and Summary

Systematic sampling of the small mammals within Fish Springs National Wildlife Refuge (FSNWR) was undertaken to provide the Refuge with data to evaluate the effects of Refuge management practices on small mammal habitat and monitor the presence and distribution of invasive species within the Refuge boundaries.

The small mammal populations at Fish Springs National Wildlife Refuge were informally surveyed in the early 1960's, shortly after Fish Springs was granted national wildlife status, providing a baseline inventory of the small mammal species at FSNWR. Thirty years later, in 1992, BYU mammalogist Clyde Pritchard conducted a brief three day sampling effort in and around the Refuge and recorded the first instance of the invasive species *Mus musculus* (house mouse) at the campground spring edge. In his report he voiced a concern that this species may be competing with other naturally occurring small mammal species. A rigorous resampling effort had not been conducted since these cursory surveys to monitor the expansion of *Mus musculus*, to identify the presence of additional invasive species, or to evaluate the effects of refuge management on small mammal diversity and densities.

This project was designed to address these management needs by (1) resampling previously surveyed localities within FSNWR to validate the current presence of small mammal species known to occur in the Refuge; (2) documenting the population density and extent of the invasive species *Mus musculus* and its effects on other small mammal species; (3) systematically sample ecological habitats in the Refuge yet unsurveyed; (4) identify critical habitat locations within FSNWR that contain high species diversity or rare species and may be sensitive to management practices; (5) update the FSNWR small mammal species inventory list.

This project also addresses several ecological research hypotheses. Small, terrestrial mammals are excellent indicators of the effects of human disturbance or modifications on ecological communities (Zou et al. 1989). When habitat is altered for management purposes, a subsequent response is expected within small mammal communities (Fitzgerald et al. 2001). Numerous studies indicate that habitat manipulation (Mitchell et al. 1995, Zou et al. 1989), wildfire (Groves and Steenhof 1988, Yensen et al. 1992), and prescribed fire (Fitzgerald 2001) impact small mammal populations. However, because temporal scale can influence ecological interpretation, the impacts reported in these studies may only reflect short-term effects and not the long-term response of small mammal populations (Brady and Slade 2001; Swihart and Slade 1990). Fish Springs National Wildlife Refuge (FSNWR) was awarded national wildlife refuge status in 1959 and since then wildlife managers have significantly modified the area to optimize the habitat for waterfowl. Habitat alterations have included the dissection of the spring slews into nine sections by dikes and gravel roads, annually conducted burns to promote bird-preferred plant species, and periodic flooding of meadow areas. Bloczyński et al. (2000) suggest that wetlands optimized for one faunal guild can not be optimal for another. Therefore, the management practices employed at FSNWR that favor avian species are expected to have negatively impacted the species richness and relative abundances of its small mammal species.

Comparisons with previous survey efforts allow us to examine the long-term effects of ecological disturbance on small mammal populations within the Refuge. We predict that (1) small mammal species richness will vary by microhabitat type with the lowest number of species expected in the marsh meadow areas as a result of annually managed burns and flooding events; (2) species abundances will be highest in the unmanaged sand dune and floral rich wetland habitats and lowest in the naturally harsher salt flat and foothill, and heavily managed marsh meadow, habitats; (3) an increase in the abundance and range of the invasive species *Mus musculus* since it was first detected in 1992; (4) a short-term decline or the local extinction of some small mammals since the Refuge was established and its management related habitat disturbances were initiated.

To test these predictions, we (1) identified five general microhabitat types within FSNWR and sampled the small mammal population within each; (2) calculated the species richness and abundances between those habitats expecting that highly modified habitats will reflect lower species diversity and abundances; (3) compared the current species diversity and relative abundances to historic data expecting a loss of native species, the appearance of exotic species, and an overall loss in species abundances.

This project was directed by Dr. Eric Rickart, Curator of Vertebrates at the Utah Museum of Natural History (UMNH), and UMNH Vertebrates Project Manager, Shannen Robson between September 2002 and October 2003. Twenty-one sites were sampled using multiple trapping methods (see Methods section below) for a total of 1198 trap nights, yielding 184 specimens of 12 different species. These data were compiled, interpreted, and recommendations formulated and presented in the next sections of this report.

Methods

The FSNWR study area

Fish Springs National Wildlife Refuge lies in West Desert of Juab County in west-central Utah. The Refuge boundaries encompass 17,992 acres situated between the Fish Springs and Thomas mountain ranges (Figure 1). This area is generally flat with less than 30 feet variation in elevation except for a small area of the northeastern foothills of the Fish Spring mountains. Here elevation increases an additional 500 feet. Five major geothermal springs and several lesser springs seep from a faultline at the base of the eastern front of the Fish Springs Range (Oliveiria 1975) creating a 10,000 acres marsh system that has been divided into nine pools by elevated gravel roads and dikes.

Microhabitat descriptions

To determine small mammal-habitat associations and how small mammal communities vary by habitat within the Refuge, five general microhabitat types were identified: wetland, marsh meadow, salt flat, foothill, and sand dune. Microhabitats were identified by distinct plant communities (see Table 1) and edaphic features.

1. Wetland microhabitat. Spring edges have a distinct wetland habitat dominated by the common reed (*Phragmites austalis*), cattail (Typha latifolia), rushes (*Scirpus maritimus, S. acutus, S. americanus*, and *Juncus balticus*), and salt grass (*Disticulus spicata spicata*).
2. Marsh meadow microhabitat. Approximately 25-50 feet from the spring edges the wetland habitat abruptly shifts to marsh meadow habitat. The marsh meadow areas are heavily managed and experience periodic flooding, prescribed burns, and pesticide sprays. The meadows are clearly identifiable as homogenous swaths of reed (*Phragmites austalis*) and the ubiquitously present salt grass (*Disticulus spicata spicata*).
3. Salt flat microhabitat. Highly saline, desert salt flat habitat surrounds the marsh meadows. These areas rarely experience flooding and therefore remain extremely

dry with a high soil salt content. This habitat dominates the refuge and is characterized by salt tolerant plants such as greasewood (*Sarcobatus vermiculatus*), iodine bush (*Allenrolfea occidentalis*), halogeton (*Halogeton glomeratus*), shadscale (*Atriplex tridentate*), salt grass (*Distichlis spicta spicata*), and various annual chenopod species.

4. Foothill microhabitat. A small portion of the rocky, talus slopes of the Fish Spring Mountains are within the refuge boundaries. These foothills are higher in elevation than the Refuge playa, escaping the high saline concentrations that the plant communities in the other microhabitat types face. The foothills are characterized by mormon tea (*Ephedra nevadensis*), shadscale (*Atriplex confirtifolia* and *A. canescens*), rabbit brush (*Aracamarea nauseosa*), horse brush (*Tetrodynea spinosa* and *T. spp.*), and Indian rice grass (*Stipa hymonoides*). Importantly, this is the only habitat with significant amounts of invasive cheat grass (*Bromus tectorum*).
5. Sand dune microhabitat. Along the refuge boundaries there are several groups of permanent sand dunes. The deep sandy soil provides critical habitat for burrowing and tunneling mammal species and is dominated by greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex tridentata*), iodine bush (*Allenrolfea occidentalis*), and salt grass (*Disticulus spicata spicata*).

Trapping methods and sampling localities

Twenty-one directed trapping locations were established and sampled using multiple trap types between September 2002 and October 2003 for a total of 1198 trap nights. Trapping locations were chosen opportunistically depending on constraints of management practices (for instance, strategic flooding greatly affected site choice). As a result not all microhabitats were sampled equally (see Table 2 for site summary data). Site localities within the Refuge are identified in Figure 1. There were 3 wetland sites totaling 149 trap nights, 5 marsh meadow sites totaling 257 trap nights, 4 foothill sites totaling 231 trap nights, 6 dune sites totaling 382 trap nights, and 3 salt flat sites totaling 179 trap nights (see Appendix 2 for a detailed chronology of trapping effort). Relative values were used for comparison to control for unequal sampling.

Both Sherman live traps and snap traps (museum specials and victor rat traps) were utilized in the wetland, salt flat, foothill, and sand dune habitat sites and aluminum can pitfall traps were placed in the wetland and marsh meadow habitat sites to target shrew species. At each trap site, appropriate traps were positioned in locations most likely to result in the successful capture of a small mammal. All of the snap and live traps were baited before sunset, checked the following morning within 2 hours of sunrise, and closed during the day. Fifty-eight of the 184 captured animals were released alive. The remainder were prepared as voucher specimens and curated at the Utah Museum of Natural History (UMNH). Species identity, age class, and sex was recorded for each captured animal and additional standard measurements were recorded for each voucher specimen. The entire raw data set is provided in Appendix 1.

Analyses

Relative species abundances (percent of the total captures represented by each species) and species richness (number of different species) for the entire Refuge were calculated and compared to data from earlier studies (Ecology and Epizoology Research Group 1964, 1965, 1966, 1967, 1968, 1969; EcoDynamics 1971, 1972) to determine if species abundances or richness declined after the introduction of management practices in 1959. This survey was also compared to unpublished data collected by Brigham Young University mammalogist Clyde Pritchard during 3 nights of trapping at 5 different trap sites in 1992 (BYU sites A-G on Map, Figure 1). Pritchard's field notes report that all of the specimens collected during 1992 were live trapped and released except for a few voucher specimens curated at the Monte L. Beane Museum at BYU. We examined those voucher specimens at BYU in Spring 2003 to verify species identifications and locality data. The actual and relative number of specimens collected during each survey effort is provided in Table 5.

Results

One hundred eighty-four individuals of twelve different species were captured during 1198 trap nights. Table 3 compares the actual and relative species richness and abundances for the entire Refuge and for each individual microhabitat type. Relative abudance (calculated as a percent of captures in that habitat out of the total captured in the Refuge) was highest in the sand dunes (33.2%), followed by the foothills (28.3%) and the wetland (21.7%) habitats. Abundances decreased to 9.8% in the marsh meadow and, not surprisingly, was lowest in the salt flats (7.1%). No species dominated more than twenty percent of the total number of captures. The foothills contain the greatest number of different species (8), followed by the wetlands and dunes (5 each), and the marsh and salt flats (4 each). In addition to containing the greatest number of species, the foothills also contain most of the species specialists. Four of the five species found in only one habitat types were documented in the foothills (see Table 4) indicating that this is an especially critical area for small mammal species. The deer mouse (*Peromyscus maniculatus*), a widespread habitat generalist, was documented in all five habitats. The house mouse (*Mus musculus*), an invasive species, was documented in three of the five habitat types indicating that this species has expanded it's habitat, range, and abundance since it was first recorded at the campground in 1992, most likely the result of migration from the FSNWR headquarters and surrounding buildings. The house mouse is a 'weedy' species and particularly adept at colonizing disturbed habitats. Management within the refuge may be contributing to its expansion.

The actual and relative abundances of small mammal species collected were compared to data reported from previous studies at FSNWR and the surrounding area (Table 5, Figure 2, and Appendix 3). Only one historically recorded species, the little pocket mouse (*Perognathus longimembris),* was absent in the 2002/2003 resampling effort. Two species, *Sorex vagrans* and *Mus musculus*, are first recorded in 1992 and increase in relative abundance in 2002. While not represented in the historical data, the vagrant shrew was known to exist in the FSNWR area (Egoscoe 1961, 1965) and is probably absent from the Ecology and Epizoology records due to differing trapping methodologies. Assuming the historical presence of *Sorex vagrans*, species richness at FSNWR (Figure 3) has declined by 1 species and increased by one additional exotic species.

Discussion

This project is particularly informative because the records of historical survey efforts were available allowing the rare opportunity to examine small mammal community dynamics over time. Poor locality description and methodological reporting in previous studies make precise historical comparison tenuous. However, comparison with the results of this study indicate that species diversity and relative abundance of most small mammal species have remained remarkably constant over time. The general habitat types that suffer the lowest species richness and relative abundances are those that experience the greatest management-related alterations. While nearly all of the species present historically were recorded during this resampling effort, capture frequencies of several species in the FSNWR small mammal community fluctuated over time and the peaks in abundances did not occur simultaneously (Figure 2).

Grayson (1993) highlights two species of rodent, Ord's kangaroo rat (*Dipodomys ordii*) and the chisel-toothed kangaroo rat (*Dipodomys microps*) as particularly refined indicators of local habitat conditions. These two species are found together, but are non-competing because they target different plant resources. The "chisel" like incisors of *D. microps* allows this species to strip off the high salt outer layer of shadscale leaves to eat the low salt interior while *D. ordii* targets seed bearing resources (Durrant 1952). A decline in either over time would reflect the dynamics of the local plant community. The relative abundance of Ord's kangaroo rat was documented as high as 28.4% in 1967 and steadily declined to 16.0% om 1969, 5.8% in 1971, to less than 1% in 1972. These low numbers were sustained with only 3.5% abundance in 1992 and 1.6% in 2002/2003. The abundances of both species of kangaroo rat were positively associated (but not significantly, $p=0.254$) suggesting that these species populations may experience temporal population density changes in tandem. The decline in *D. ordii* may be attributable to competition with another seed-eating species, the harvest mouse (*Reithrodontomys megalotis*), whose relative abundance increased. These data suggest a historical change has occurred in the local vegetation. Kangaroo rats have short forelimbs, large hind limbs, and a strong tail making them excellent jumping species in open desert habitats. Invasive grasses, such as cheat grass, colonize the spaces between endemic bunch grasses reducing the open pavement saltorial species require for locomotion. Closed grassy habitat favors small murids (like *Reithrodontomys spp.*) and such a change in plant ecology may account for the shifting small mammal populations. Additional studies investigating normal seasonal and cyclic populations fluctuations, changes in vegetation, and intraspecies competition would help explain this pattern.

The elevation and geomorphological advantage of the foothill microhabitat is likely to account for its high number of species specialists. However, it's possible that the minimal management practices in this habitat also contribute to its disproportionately high relative species abundances and richness. Regardless, the data show that this is a critical small mammal microhabitat within the Refuge and the most likely habitat for documenting yet unrecorded species. The sand dune habitat also experienced high species diversity and abundance and, importantly, was the only habitat to contain Ord's kangaroo rat. The sand dunes also benefit from low management-related modifications, so the robust sand dune small mammal community may be the result of habitat stability over time. The marsh meadow habitat yielded four species, all nested within the wetland habitat assemblege. However, two of the four species were represented by only one specimen. The relatively low species abundance in this grass habitat could be the result of targeted annual prescribed burns and deliberate periodic flooding by the Refuge management. However, since only pitfall traps were set in two of the marsh meadow sites, specifically targeting shrew species, the low abundances of non-shrew species may reflect a bias trapping protocol.

The invasive species, *Mus musculus*, first appeared in the sampling record in 1992. These specimens were collected at the local campground not far from the Refuge headquarters and buildings. In 2002 three house mouse specimens were collected in the northwestern corner of the Refuge and in 2003 high abundances were recorded in the central portion of the Refuge. In the resampling effort *Mus* was the 5th most abundant species, representing almost 10% of the Refuge's relative species abundance (see Table 3). These data indicate that this exotic species is both expanding its range and increasing in population, competing with native species. Future studies should investigate the habitat selection of *Mus* and its influence on the abundances of endemic small mammal species and overall species richness.

The unique chemical composition of the geothermal ponds may also be an important factor for small mammal communities. The geothermal heat from a warm spring has been known to sustain marsh plants year-round allowing microtines the opportunity to increase reproduction (Negus et al.1986). Negus et al. (1986) have shown that vole reproduction may be initiated by a chemical factor in salt grass, 6-methoxybenzoxazolinone (6-MBOA). Young sprouts of salt grass in late February were high in 6-MBOA while the late June samples were lower and there was no detectable 6-MBOA in the salt grass samples from August. The seasonal onset of breeding coincides with the appearance of 6-MBOA in the newly sprouted salt grass and they showed that supplemental 6-MBOA can initiate breeding in a non-breeding winter population. Future investigations should examine the impact of warm springs on the chemical factors of plant resources around warm springs and both their effects on vole reproductive patterns and possibly sustaining the *Mus* populations over winter.

The isolation of the FSNWR fauna may be reflected in the genetics of the voucher specimens collected. Grayson (1993) has illustrated how climate change during the late Pleistocene and early Holocene has constricted faunal populations to localized 'oases', separated by long distances of harsh, nonmigratable distances. Tissue samples from each voucher specimen in the 2002/2003 resampling project were taken for future DNA analysis to compare the genetic signature of the FSNWR fauna with that of other Great Basin small mammal populations. Such analyses would reveal how long ago the FSNWR mammals became remnant populations and determine their genetic uniqueness.

A complete, updated, and revised species list for FSNWR can be found in Appendix 3. This list also includes the location, species, and abundance of voucher specimens held in zoological collections in. Several additional species either known from this region or typical of habitat within the Refuge, (*Tamias minimus, Paragnathus parvus, Microdipodops megacephalus, Sorex preblei, Lemmiscus curtatus* and *Microtus longicaudus*), were added to the list because they may be present in FSNWR but not yet recorded. None of the previous sampling efforts at FSNWR to date have been rigorous or systematic. FSNWR fauna may prove to be more diverse if a persistent, longitudinal collecting effort was conducted throughout the entire Refuge.

Project Objectives Summary

(1) Resampling efforts within FSNWR targeted previously sampled and yet to be sampled areas of the Refuge. This effort validated the current presence of all but one small mammal species previously documented in the Refuge.

(2) The invasive species *Mus musculus* has increased in number and expanded its range since it was first vouchered in the Refuge in 1992 and presents a serious competitive disadvantage for existing species.

(3) Five ecological microhabitats were identified in the Refuge and were systematically sampled.

(4) Sampling efforts suggest that the dune areas and foothills along the periphery of the refuge are the most species rich and diverse habitats probably due to the minimal management impacts in these localities. These critical areas within FSNWR may be sensitive to management practices and should be protected from future alteration.
(5) The FSNWR small mammal species inventory list (Appendix 3) has been updated and revised to include species known to the region and potentially existing in the Refuge, as well as removing the pygmy rabbit (*Brachylagus idahoensis*).

Ecological Hypotheses Summary

(1) We predicted that small mammal species richness would vary by microhabitat type with the lowest number of species expected in the marsh meadow areas as a result of annually managed burns and flooding events. We found both predictions to be supported by our data. Species were richest in low management habitats, highest in the foothills followed by (in order) the dune, wetland, salt flat, and marsh habitats (see Table 3). However, the low abundance and richness of the marsh habitat may be confounded by unequal and biased sampling methods.
(2) We predicted that species abundances would be highest in the unmanaged sand dune and floral rich wetland habitats and lowest in the naturally harsher salt flat, foothill, and heavily managed marsh meadow, habitats. The dune habitat contained more than one-third (33.2%) of the total number of individuals captured followed by the foothill habitat (28.3%). Together, these two habitats yielded over 60% of the relative abundance in the Refuge further emphasizing their importance as critical habitat deserving special consideration. The wetland habitat also had significant abundance (21.7% of the total sample) while the marsh and salt flat habitats suffered low abundances, as expected (9.8% and 7.1%, respectively).
(3) We predicted an increase in the abundance and range of the invasive species *Mus musculus* since it was first detected in 1992 and found this to be the case. The expansion of *Mus* from the human occupied areas into the interior of the Refuge is disconcerting and will likely place additional stress on the local species. Continued monitoring of this species is highly recommended.
(4) We predicted a short-term decline or the local extinction of some small mammals since the Refuge was established and its management related habitat disturbances were initiated. However, our resampling effort showed the opposite. The species present historically proved to be resilient over the past 40 years despite significant habitat modification and shifting plant communities. The warm springs may provide a unique and consistent source of food to small mammals (such as microtines) which sustains small mammal community structures over time. Future studies should investigate the unique aspects of geothermal springs in small mammal dynamics.

Acknowledgements

We would like to thank Jay Banta for encouragement and support of this project and Frances Banta for her generous hospitality. We would like to thank Sam Rickart, Wendi King, Leslie Slater, and Steve Gronemeyer for field assistance and Ann Kelsey for her expert plant identifications.

References

Brady, M. J. and N. A. Slade. 2001. Diversity of a grassland rodent community at varying temporal scales: the role of ecologically dominant species. *Journal of Mammalogy* 82: 974-983.

Bloczynski, J. A., W. T. Bogart, B. F. Hobbs, and J. F. Koonce. 2000. Irreversible investment in wetlands preservation: Optimal ecosystem restoration under uncertainty. *Environmental Management* 26: 175-193.

Durrant, S. 1959. Mammals of Utah. University of Kansas publication, volume 6: 1-549. Lawrence, Kansas.

Ecology and Epidemiology Research Group. 1964. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 117.

Ecology and Epidemiology Research Group. 1965. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 123.

Ecology and Epidemiology Research Group. 1966. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 141.

Ecology and Epidemiology Research Group. 1967. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 144.

Ecology and Epidemiology Research Group. 1968. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 145.

Ecology and Epidemiology Research Group. 1969. A study of the ecology and epizoology of the native fauna of the Great Salt Lake desert. University of Utah, Ecology and Epizoology series no. 154.

EcoDynamics, Inc. 1971. Ecological studies in western Utah. EcoDynamics series no. 72-1.

EcoDynamics, Inc. 1972. Ecological studies in western Utah. EcoDynamics series no. 73-1.

Egoscoe, H. J. 1961. Small mammal records from western Utah. *Journal of Mammalogy* 42: 122-124.

Egoscoe, H. J. 1965. Records of shrews, voles, chipmunks, cottontails and mountain sheep. *Journal of Mammalogy* 46: 685-686.

Fitzgerald, C. S., P. R. Krausman, and M. L. Morrison. 2001. Short-term impacts of prescribed fire on a rodent community in desert grasslands. *The Southwestern Naturalist* 46: 332-337.

Geier, A. R. and L. B. Best. 1980. Habitat selection by small mammals. *Journal of Wildlife Management* 44: 16-24.

Grayson, D. 1993. The Desert's Past. Washington D.C.: Smithsonian Institution Press.

Groves, C. and K. Streenhof. 1988. Responses of small mammals and vegetation to wildfire in shadscale communities of southwestern Idaho. *Northwest Science* 62: 205-210.

Mitchell, M. S., K. S. Karriker, E. J. Jones, and R. A. Lancia. 1995. Small mammal communities associated with pine plantation management of pocosins. *Journal of Wildlife Management* 59: 875-881.

Negus, N., P. J. Berger, and B. W. Brown. 1986. Microtine population dynamics in a predictble environment. *Canadian Journal of Zoology* 64(3): 785-792

Oliveiria, M. E. 1975. Geology of the Fish Springs mining district, Fish Springs Range, Utah. *Brigham Young University Geology Series* 22: 69-104.

Shippee, E. A. and H. J. Egoscoe. 1958. Additional mammal records from the Bonneville Basin, Utah. *Journal of Mammalogy* 39: 275-277.

Swihart R. K. and N. A. Slade. 1990. Long-term dynamics of an early successional small mammal community. *American Midland Naturalist* 123: 372-382.

Yensen, E., D. L. Quinney, K. Johnson, K. Timmerman and K. Steenhof. 1992. Fire, vegetation changes, and population fluctuations of Townsend's ground squirrels. *American Midland Naturalist* 128: 299-312.

Zou, J., J. T. Flinders, H. L. Black, and S. G. Whisenant. 1989. Influence of experimental habitat manipulations on a desert rodent population in southern Utah. *Great Basin Naturalist* 49: 435-448.

Figure 1: Map of FSNWR Region with BYU and UMNH Trap Sites

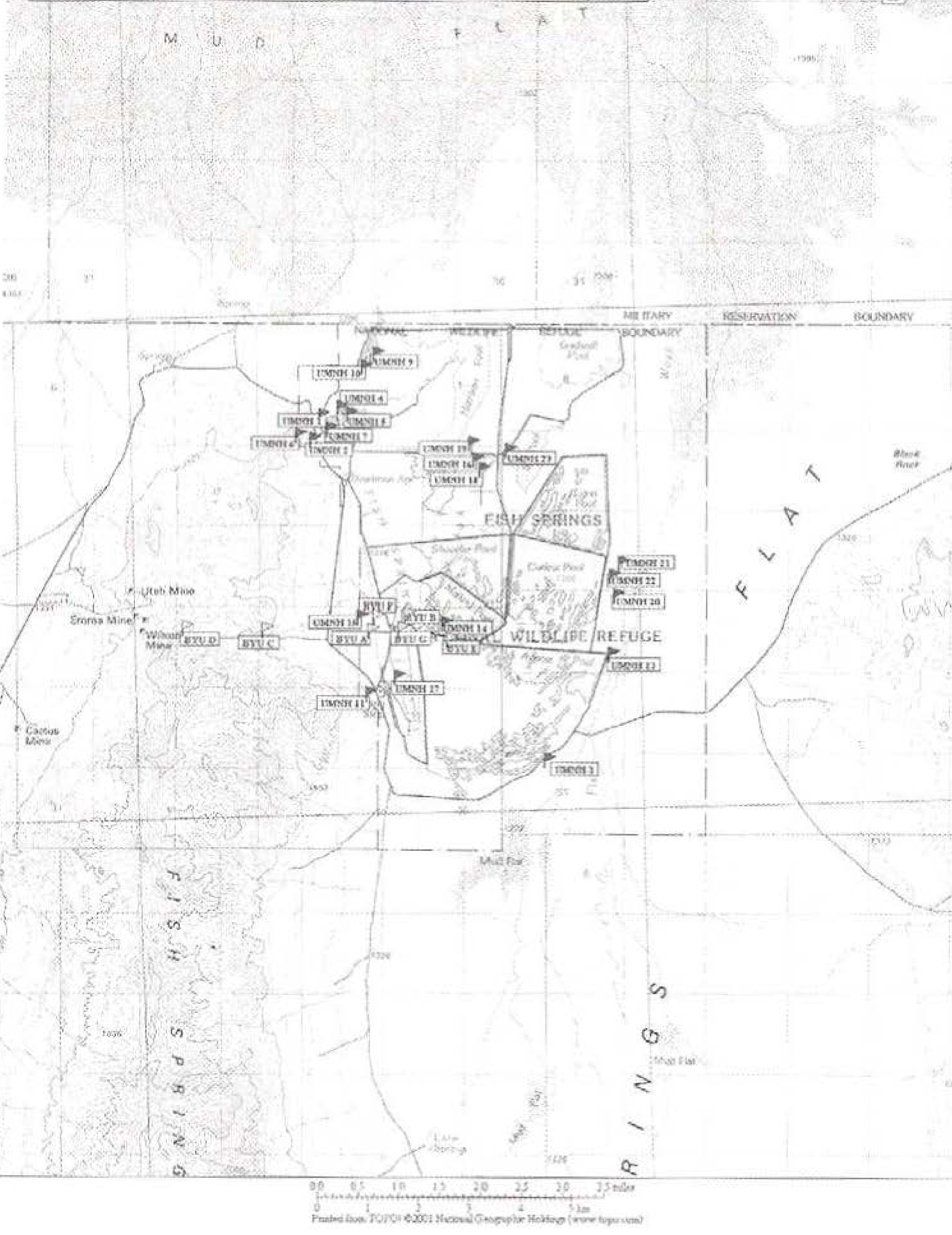

Figure 2: Relative abundances of small mammal species captured at FSNWR over time.

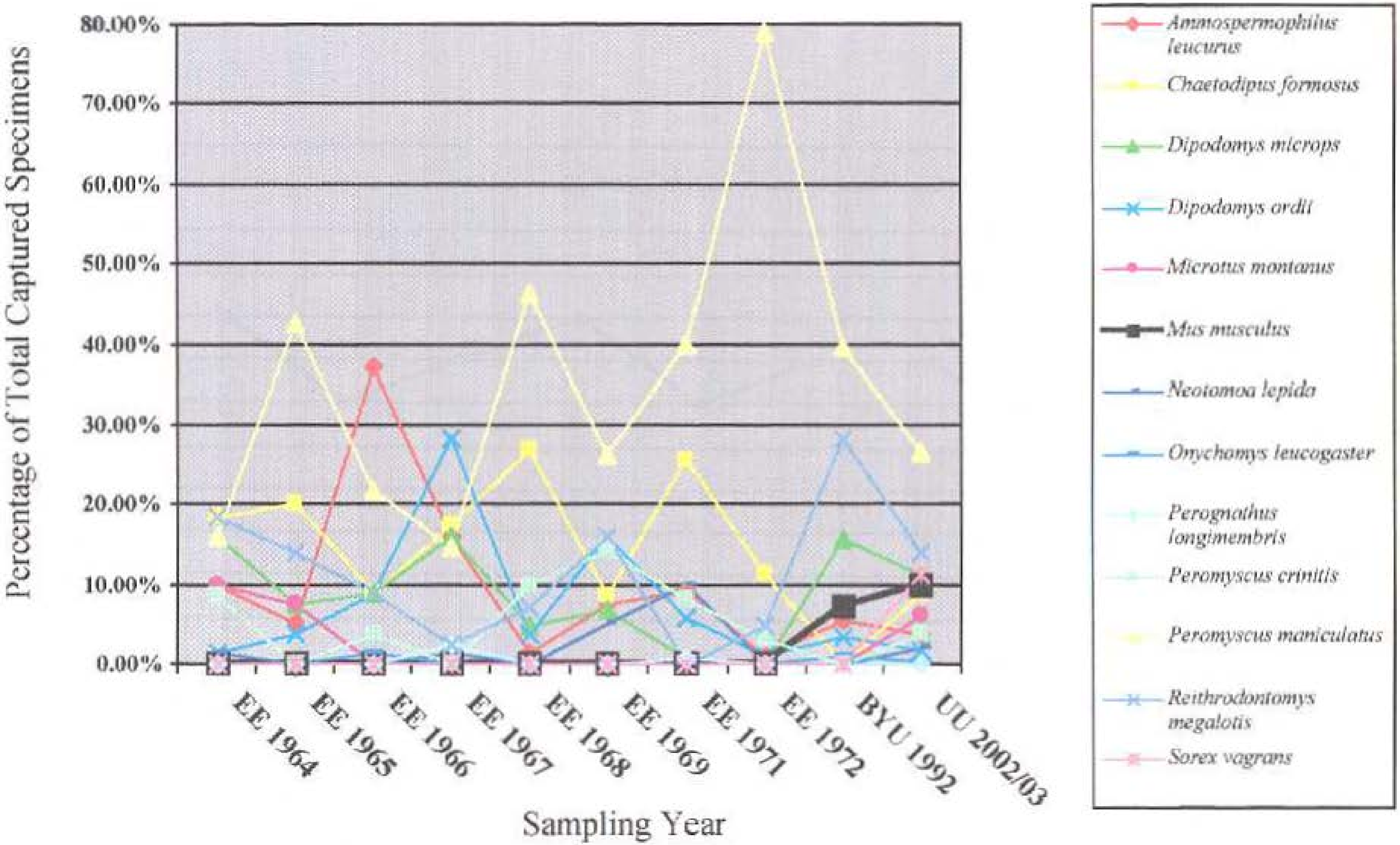

Figure 3: Species Richness of small mammal species over time at FSNWR

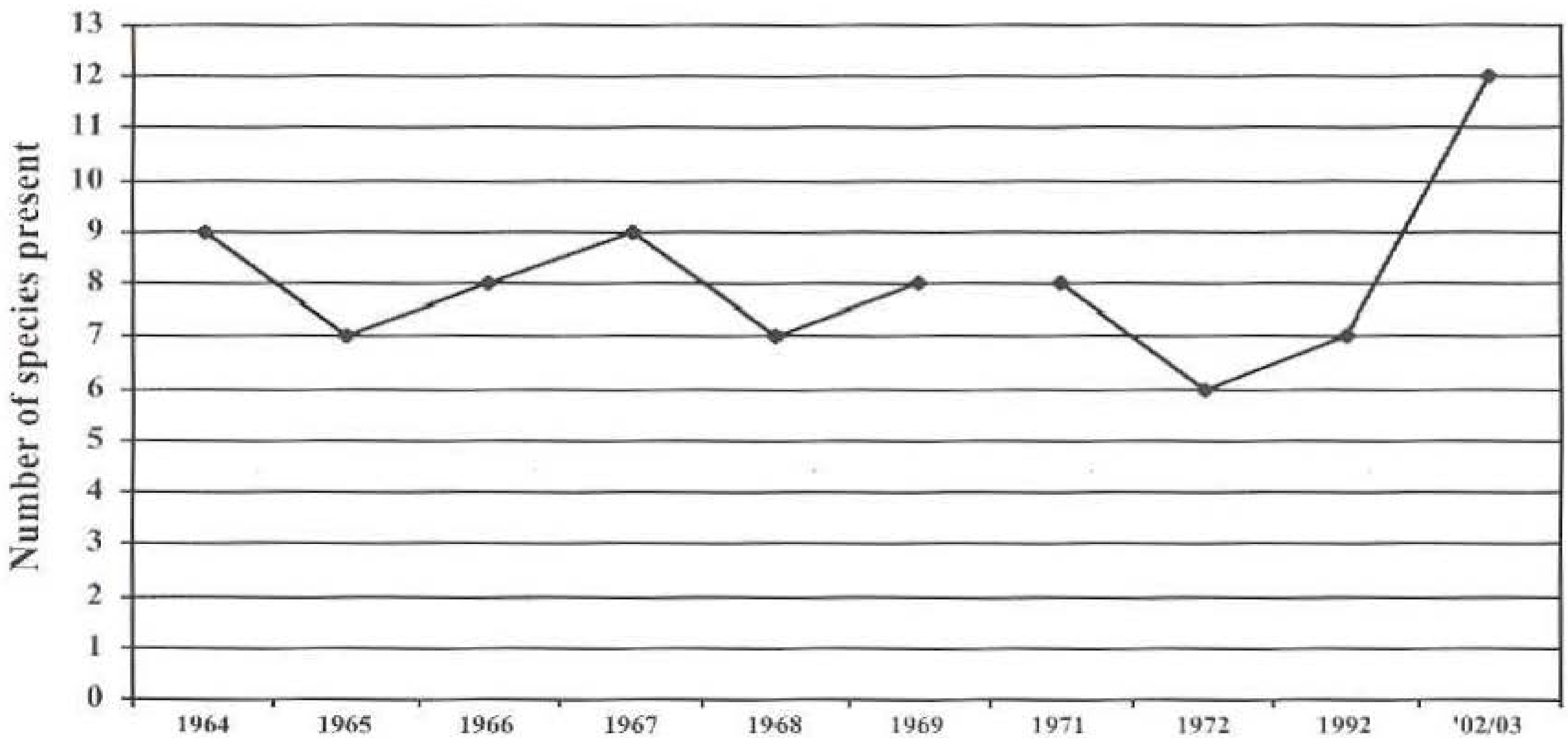

Table 1: Microhabitat plant communities

Habitat type	Genus species of plant	Common name
Spring Edge		
	Phragmites astraius	
	Typha latifolia	Cattail
	Scirpus maritimus	Alkalai bullrush
	Juncus bellicus	
	Sciprus americanus	Olney threesquare
	Scirpus acutus	Hardstem bullrush
	Disticulus spicata spicata	
	Glaux maritima	Sea milkwort
	Crossa truxillensis	
	Nitrophila occidentalis	Winterwort
	Sporobolius airoides	(feathery grass)
Marsh		
	Disticulus spicata spicata	
	Phragmites astralus	
Salt Flat		
	Atriplex tridentata	Shadscale
	Sarcobatus vermiculatus	Greasewood
	Allenrolfea occidentalis	Iodine bush
	Halogeton glomoratus	
	Suaeda moquinii	Seepweed
	Kochia americana	Gray molly
	other annual chenopod sp.	
Dune		
	Sarcobatus vermiculatus	Greasewood
	Atriplex tridenta	Shadscale
	Disticulus spicata spicata	
	Allenrolfea occidentalis	Iodine bush
	Sarocomia utahensis	pickleweed
	Erogium deflexum	buckwheat
Foothill		
	Ephedra nevadensis	Mormon tea
	Atriplex confirtifolia	Shadscale
	Atriplex canescens	
	Aracamarea nauseosa	Rabbitbrush
	Tetrodynea spinosa	Horsebrush
	Tetrodynea sp.	
	Stipa hymenoides	Indian rice grass
	Lyceum sp.	
	Bromus toctorum	Cheat grass
	Gutierrezia sarothrae	Broomshake weed

Table 2: FSNWR small mammal survey site information sorted by microhabitat groups.

Site Number	Microhabitat type	Site Description	DECLAT/ NAD 1927	DECLONG/ NAD 1927	ELEV	Total trap nights	Total captures	Total released	Site trap success (%)
3	DUNE	South Sand Dunes	39.82750	113.35964	4311	80	9	0	11.25
9	DUNE	North Sand Dunes	39.90428	113.40133	4314	100	24	15	24.00
13	DUNE	Southeast dunes	39.84546	113.34512	4306	60	3	0	5.00
17	DUNE	Middle spring roadside dune	39.84134	113.39370	4319	30	11	8	36.67
20	DUNE	East Dunes	39.85662	113.34330	4295	38	7	4	18.42
21	DUNE	NE Dunes	39.85969	113.34217	4293	74	7	3	9.46
						382	61	30	
2	FOOTHILL	Lower North Spring foothills	39.86458	113.41361	4300	20	3	0	15.00
6	FOOTHILL	Upper North Spring Foothills	39.86389	113.41447	4370	91	11	0	12.09
11	FOOTHILL	Foothills West of Headquarters	39.83839	113.39954	4346	80	26	18	32.50
15	FOOTHILL	Landfill	39.84927	113.39965	4350	40	12	4	30.00
						231	52	22	
4	MARSH	North Spring marsh meadow #1	39.88725	113.40827	4305	112	1	0	0.89
5	MARSH	North Spring marsh meadow #2	39.88758	113.41237	4281	90	7	1	7.78
14	MARSH	Picnic marsh	39.84967	113.38392	4301	30	3	0	10.00
18	MARSH	Pintail marsh meadow	39.87877	113.37532	4276	15	6	0	40.00
22	MARSH	NE Dune disticlis	39.85872	113.34547	4296	10	1	0	10.00
						257	18	1	
7	SALT	North Spring salt flats	39.88449	113.41314	4250	89	6	0	6.74
19	SALT	Pintail saltflat scrub	39.87907	113.37540	4278	30	4	3	13.33
23	SALT	Ibis Flat	39.88207	113.36974	4302	60	3	1	5.00
						179	13	4	
1	WET	North Spring edge	39.88758	113.41237	4281	57	8	0	14.04
10	WET	North Dune spring	39.90414	113.40073	4281	62	14	0	22.58
16	WET	Pintail spring edge	39.87831	113.37464	4280	30	18	1	60.00
						149	40	1	
				Total for all sites:		1198	184	58	

Table 3: Actual and relative species richness and abundances of captured animals for entire refuge and in each of the microhabitats.

	Wetland	Marsh	Salt flat	Foothills	Dune		Total captures/ species	species abundance [2]	# habitats species occurs
Ammospermophilus leucurus			3	4			7	3.8%	2
Chaetodipus formosus				16			16	8.7%	1
Dipodomys microps			3	7	11		21	11.4%	3
Dipodomys ordii					3		3	1.6%	3
Microtus montanus	9	1			1		11	6.0%	3
Mus musculus	11	6		1			18	9.8%	3
Neotomoa lepida				4			4	2.2%	1
Onychomys leucogaster				1			1	0.5%	1
Peromyscus crinitis				7			7	3.8%	1
Peromyscus maniculatus	5	1	1	12	30		49	26.6%	5
Reithrodontomys megalotis	4		6		16		26	14.1%	3
Sorex vagrans	11	10					21	11.4%	2
Species abudances/habitat	40	18	13	52	61	Total	184	100.0%	
Number of trap nights/habitat	149	257	179	231	382				
Trap success/habitat (%)	26.8%	7.0%	7.3%	22.5%	16.0%				
Relative abundance (% total sample)[1]	21.7%	9.8%	7.1%	28.3%	33.2%				
Species richness/habitat (max 12)	5	4	4	8	5				

[1] Calculated as the percent of all FSNWR captures (n=184) represented by each habitat.

[2] Calculated as the percent of all FSNWR captures (n=184) represented by each species.

Table 4: Species habitat specialization.

	Wetland	Marsh	Salt flat	Foothills	Dune	# of habitats
Peromyscus maniculatus	5	1	1	12	30	5
Dipodomys microps			3	7	11	3
Microtus montanus	9	1			1	3
Reithrodontomys megalotis	4		6		16	3
Mus musculus	11	6		1		3
Ammospermophilus leucurus			3	4		2
Sorex vagrans	11	10				2
Chaetodipus formosus				16		1
Dipodomys ordii					3	1
Neotomoa lepida				4		1
Onychomys leucogaster				1		1
Peromyscus crinitis				7		1

Table 5: Actual and relative number of specimens collected by survey.

	EE 1964		EE 1965		EE 1966		EE 1967		EE 1968	
	Captures	% Total	Captures	% Total	Captures	% Total	Captures	% Total	Captures	% Total
Ammospermophilus leucurus	8	9.88%	4	5.0%	28	37.2%	13	16.0%	1	1.2%
Chaetodipus formosus	15	18.52%	16	20.0%	7	9.0%	14	17.3%	22	26.8%
Dipodomys microps	13	16.05%	6	7.5%	7	9.0%	13	16.0%	4	4.9%
Dipodomys ordii	1	1.23%	3	3.8%	7	9.0%	23	28.4%	3	3.7%
Microtus montanus	8	9.88%	6	7.5%	0	0.0%	1	1.2%	0	0.0%
Mus musculus	0	0.00%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Neotoma lepida	1	1.23%	0	0.0%	0	0.0%	1	1.2%	0	0.0%
Onychomys leucogaster	0	0.00%	0	0.0%	1	1.3%	0	0.0%	0	0.0%
Perognathus longimembris	0	0.00%	0	0.0%	0	0.0%	2	2.5%	0	0.0%
Peromyscus crinitis	7	8.64%	0	0.0%	3	3.8%	0	0.0%	8	9.8%
Peromyscus maniculatus	13	16.05%	34	42.5%	17	21.8%	12	14.8%	38	46.3%
Reithrodontomys megalotis	15	18.52%	11	13.8%	7	9.0%	2	2.5%	6	7.3%
Sorex vagrans	0	0.00%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	81	100.0%	80	100.0%	78	100.0%	81	100.0%	82	100.0%

	EE 1969		EE 1971		EE 1972		1992 (in refuge)		SLR 2003/2003	
	Captures	% Total	Captures	% Total	Captures	% Total	Captures	% Total	Captures	% Total
Ammospermophilus leucurss	9	7.6%	11	9.1%	1	1.0%	6	5.3%	7	3.8%
Chaetodipus formosus	10	8.4%	31	25.6%	12	11.4%	0	0.0%	16	8.7%
Dipodomys microps	8	6.7%	1	0.8%	0	0.0%	18	15.8%	21	11.4%
Dipodomys ordii	19	16.0%	7	5.8%	1	1.0%	4	3.5%	3	1.6%
Microtus montanus	0	0.0%	0	0.0%	0	0.0%	0	0.0%	11	6.0%
Mus musculus	0	0.0%	0	0.0%	0	0.0%	8	7.0%	18	9.8%
Neotoma lepida	6	5.0%	12	9.9%	0	0.0%	0	0.0%	4	2.2%
Onychomys leucogaster	0	0.0%	0	0.0%	0	0.0%	1	0.8%	1	0.5%
Perognathus longimembris	0	0.0%	1	0.8%	0	0.0%	0	0.0%	0	0.0%
Peromyscus crinitis	17	14.3%	10	8.3%	3	2.9%	0	0.0%	7	3.8%
Peromyscus maniculatus	31	26.1%	48	39.7%	83	79.0%	45	39.5%	49	26.6%
Reithrodontomys megalotis	19	16.0%	0	0.0%	5	4.8%	32	28.1%	26	14.1%
Sorex vagrans	0	0.0%	0	0.0%	0	0.0%	0	0.0%	21	11.4%
	119	100.0%	121	100.0%	105	100.0%	114	100.0%	184	100.0%

Appendix 1: Raw data sorted by species.

GENUS SPECIES	SITE #	HABITAT TYPE	LOCALITY DESCRIPTION	COLLECT DATE	UMNH ACCESN NUMBER	UMNH CATALOG NUMBER	DECLAT	DECLONG	ELEV (FT)	FIELDEX NUMBER	COLLECT METHOD	PREP TYPE	SEX	AGE	TL (mm)	TV (mm)	HF (mm)	EAR (mm)	WT (g)	TISSUE SAMPLE
Ammospermophilus leucurus	007	SALT	North Spring salt flats	20020928	2002.50	30623	39.88449	113.41334	4250	SLR158	rat	fluid	M	ADULT	227	69	38	13	100	Y
	007	SALT	North Spring salt flats	20020928	2002.50	30624	39.88449	113.41334	4250	SLR155	rat	fluid	M	ADULT	226	70	38	13	100	Y
	007	SALT	North Spring salt flats	20020928	2002.50	30625	39.88449	113.41334	4250	SLR150	rat	fluid	M	ADULT	223	63	40	15	100	Y
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	F	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	unk	unk						
	015	FOOTHILL	Landfill	20030705			39.84927	113.39965	4350		sherman	released	unk	ADULT						
	015	FOOTHILL	Landfill	20030705			39.84927	113.39965	4250		sherman	released	unk	ADULT						
Chaetodipus formosus	002	FOOTHILL	Lower North Spring foothills	20020908	2002.50	30579	39.88455	113.41361	4300	SLR105	snap	fluid	M	ADULT	192	108	28	12	18	Y
	008	FOOTHILL	Upper North Spring Foothills	20020923	2002.50	30642	39.88380	113.41447	4370	SLR113	rat	fluid	F	ADULT	183	103	23	0	18	Y
	008	FOOTHILL	Upper North Spring Foothills	20020929	2002.50	30643	39.88089	113.41447	4370	SLR137	snap	fluid	F	ADULT	183	100	24	7	23.5	Y
	011	FOOTHILL	Foothills West of Headquarters	20030704	2003.21	30807	39.83839	113.39954	4346	SLR177	snap	fluid	M	ADULT	192	105	28	12	20	Y
	011	FOOTHILL	Foothills West of Headquarters	20030704	2003.21	30752	39.83839	113.39954	4346	SLR179	sherman	fluid	M	ADULT	198	104	26	12	15	Y
	011	FOOTHILL	Foothills West of Headquarters	20030705	2003.21	30767	39.83839	113.39954	4346	SLR184	snap	fluid	M	ADULT	188	110	28	11	16	Y
	011	FOOTHILL	Foothills West of Headquarters	20030705	2003.21	30768	39.83839	113.39954	4346	SLR190	snap	fluid	M	ADULT	188	112	25	12	17	Y
	011	FOOTHILL	Foothills West of Headquarters	20030705			39.83839	113.39954	4346		sherman	released	unk	unk						
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	unk	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	M	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	M	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	F	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	M	YG ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	M	YG ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	M	YG ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	M	ADULT						
Dipodomys microps	003	DUNE	South Sand Dunes	20020922	2002.50	30629	39.82753	113.35964	4311	SLR134	sherman	fluid	M	JUV	218	121	39	12	36	Y
	003	DUNE	South Sand Dunes	20020922	2002.50	30630	39.82753	113.35964	4311	SLR113	sherman	fluid	M	ADULT	275	158	41	13	70	Y
	003	DUNE	South Sand Dunes	20020923	2002.50	30631	39.82753	113.35964	4311	SLR120	sherman	fluid	F	ADULT	267	155	42	13	39	Y
	009	DUNE	North Sand Dunes	20020928	2002.50	30596	39.90425	113.40133	4314	SLR141	snap	fluid	F	ADULT	252	156	42	12	33	Y
	009	DUNE	North Sand Dunes	20020930	2002.50	30597	39.90425	113.40133	4314	SLR142	sherman	fluid	M	ADULT	257	150	41	14	35	Y
	009	DUNE	North Sand Dunes	20020930	2002.50	30598	39.90425	113.40133	4314	SLR143	sherman	fluid	M	ADULT	268	153	41	14	38	Y
	009	DUNE	North Sand Dunes	20030510			39.90425	113.40133	4314		sherman	released	F	ADULT						
	020	DUNE	East Dunes	20031008	2003.21	30797	39.85062	113.34330	4293	SLR224	sherman	fluid	M	YG ADULT	282	168	41	15	66	Y
	021	DUNE	NE Dunes	20031012			39.85969	113.34217	4293		sherman	released	F	ADULT						
	021	DUNE	NE Dunes	20031011	2003.21	30801	39.85868	113.34213	4293	SLR223	sherman	fluid	F	ADULT	280	175	43	14	61	Y
	021	DUNE	NE Dunes	20031011			39.85969	113.34217	4293		sherman	released	F	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030511	2003.21	30577	39.83839	113.39954	4346	SLR133	sherman	fluid	M	ADULT	248	155	41	15	39	N
	011	FOOTHILL	Foothills West of Headquarters	20030705	2003.21	30766	39.83839	113.39954	4346	SLR180	sherman	fluid	M	ADULT	272	158	42	14	38	Y
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	F	YG ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	M	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	M	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	F	ADULT						
	015	FOOTHILL	Landfill	20030704	2003.21	30756	39.84927	113.39965	4350	SLR183	sherman	fluid	F	ADULT	279	160	43	13	61	Y
	007	SALT	North Spring salt flats	20020928	2002.50	30620	39.88449	113.41314	4250	SLR127	snap	fluid	M	ADULT	278	160	40	14	72	Y
	007	SALT	North Spring salt flats	20020928	2002.50	30621	39.88445	113.41314	4250	SLR153	snap	fluid	M	ADULT	272	156	42	14	66	Y
	023	SALT	Salt Flat	20031012			39.88207	113.38874	4302		sherman	released	F	ADULT						
Dipodomys ordii	017	DUNE	Middle spring roadside dune	20031004	2003.21	30776	39.84134	113.38020	4316	SLR203	sherman	fluid	F	ADULT	248	130	40	15	33	Y
	017	DUNE	Middle spring roadside dune	20031004	2003.21	30777	39.84134	113.38020	4316	SLR204	sherman	fluid	F	ADULT	243	133	39	15	47	Y
	017	DUNE	Middle spring roadside dune	20031005	2003.21	30781	39.84134	113.38020	4316	SLR205	sherman	fluid	M	ADULT	244	136	39	14	34	Y
Microtus montanus	009	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		pitfal	released	unk	unk						
	022	MARSH	NE Dune outlet	20031012	2003.21	30806	39.85872	113.34547	4296	SLR232	snap	fluid	F	YG ADULT	163	42	21	15	46	Y
	001	WET	North Spring edge	20020908	2002.50	30611	39.88758	113.41257	4251	SLR101	snap	fluid	M	ADULT	169	37	22	15	53	Y
	001	WET	North Spring edge	20020920	2002.50	30612	39.88758	113.41257	4251	SLR121	snap	fluid	M	ADULT	172	42	21	15	52.5	Y
	012	WET	North Dune spring	20030510	2003.21	30588	39.90414	113.40073	4251	SLR150	pitfal	fluid	F	JUV	90	25	17	8	11	N
	012	WET	North Dune spring	20030510	2003.21	30589	39.90414	113.40073	4251	SLR151	pitfal	fluid	F	SUBAD	136	38	21	12	21	N
	012	WET	North Dune spring	20030511	2003.21	30590	39.90414	113.40073	4251	SLR158	snap	fluid	M	JUV	108	28	19	8	17	N
	012	WET	North Dune spring	20030511	2003.21	30591	39.90414	113.40073	4251	SLR171	snap	fluid	F	JUV	116	27	20	9	18	N
	013	WET	Pintail spring edge	20031004	2003.21	30769	39.87831	113.37484	4250	SLR196	snap	skeleton	F	SUBAD	116	38	19	13	18	Y
	013	WET	Pintail spring edge	20031004	2003.21	30770	39.87831	113.37484	4250	SLR197	snap	fluid	F	ADULT	136	26	22	12	28	Y
	013	WET	Pintail spring edge	20031005	2003.21	30782	39.87831	113.37484	4250	SLR209	snap	fluid	F	ADULT	170	48	22	14	60	Y
Mus musculus	015	FOOTHILL	Landfill	20030705	2003.21	30762	39.84927	113.39965	4350	SLR189	sherman	fluid	M	ADULT	144	76	19	13	10	Y
	018	MARSH	Pintail marsh meadow	20031005	2003.21	30778	39.87877	113.37932	4295	SLR206	snap	fluid	M	JUV	133	68	15	12	11	Y
	018	MARSH	Pintail marsh meadow	20031005	2003.21	30779	39.87877	113.37932	4295	SLR208	snap	fluid	M	ADULT	171	84	18	13	23.5	N
	018	MARSH	Pintail marsh meadow	20031005	2003.21	30780	39.87877	113.37932	4295	SLR207	snap	fluid	F	ADULT	151	71	17	14	15	N
	018	MARSH	Pintail marsh meadow	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix 1: Raw data sorted by species.

GENUS SPECIES	SITE #	HABITAT TYPE	LOCALITY DESCRIPTION	COLLCT DATE	UMNH ACC'SN NUMBER	UMNH CATALOG NUMBER	DECLAT	DECLONG	ELEV (FT)	FIELD8K NUMBER	COLLECT METHOD	PREP TYPE	SEX	AGE	TL (mm)	TV (mm)	HF (mm)	EAR (mm)	WT (g)	TISSUE SAMPLE
	018	MARSH	Pintail marsh meadow	20031006	2003.21	30794	39.87877	113.37332	4276	SLR221	snap	fluid	M	SUBAD	137	55	16	13	10	Y
	018	MARSH	Pintail marsh meadow	20031005	2003.21	30790	39.87877	113.37332	4276	SLR222	snap	fluid	M	SUBAD	137	58	17	13	11	Y
	001	WET	North Spring edge	20020929	2002.50	30613	39.88758	113.46237	4281	SLR119	snap	fluid	M	ADULT	140	55	18	15	14	Y
	001	WET	North Spring edge	20020928	2002.50	30619	39.88758	113.46237	4281	SLR126	snap	fluid	M	ADULT	155	74	18	13	17	Y
	016	WET	Pintail spring edge	20031004	2003.21	30771	39.87551	113.37464	4280	SLR198	snap	skeleton	F	ADULT	133	58	18	14	15	Y
	016	WET	Pintail spring edge	20031004	2003.21	30772	39.87551	113.37464	4280	SLR199	snap	fluid	F	SUBAD	136	65	18	14	10	Y
	016	WET	Pintail spring edge	20031005	2003.21	30784	39.87551	113.37464	4280	SLR211	snap	fluid	F	ADULT	174	80	19	15	25.3	N
	016	WET	Pintail spring edge	20031005	2003.21	30785	39.87551	113.37464	4280	SLR212	snap	fluid	M	ADULT	155	79	18	14	19	Y
	016	WET	Pintail spring edge	20031005	2003.21	30786	39.87551	113.37464	4280	SLR213	snap	fluid	F	ADULT	154	75	19	14	18	N
	016	WET	Pintail spring edge	20031005	2003.21	30787	39.87551	113.37464	4280	SLR214	snap	fluid	M	SUBAD	142	68	18	13	13	Y
Mus musculus cont'd	016	WET	Pintail spring edge	20031006	2003.21	30791	39.87551	113.37464	4280	SLR215	snap	fluid	F	YG ADULT	144	68	19	13	15	Y
	016	WET	Pintail spring edge	20031006	2003.21	30792	39.87551	113.37464	4280	SLR216	snap	fluid	F	ADULT	134	77	18	14	19	Y
	016	WET	Pintail spring edge	20031005			39.87551	113.37464	4280		snap	released	M	SUBAD						
Neotoma lepida	006	FOOTHILL	Upper North Spring Foothills	20020925	2002.50	30638	39.88359	113.41447	4370	SLR115	rat	fluid	M	ADULT	295	125	32	30	100	Y
	006	FOOTHILL	Upper North Spring Foothills	20020925	2002.50	30639	39.88359	113.41447	4370	SLR131	rat	fluid	M	ADULT	300	120	31	32	110	Y
	006	FOOTHILL	Upper North Spring Foothills	20020930	2002.50	30640	39.88359	113.41447	4370	SLR151	snap	fluid	M	ADULT	310	136	32	29	120	Y
	006	FOOTHILL	Upper North Spring Foothills	20020930	2002.50	30641	39.88359	113.41447	4370	SLR152	snap	fluid	M	ADULT	250	108	32	30	100	Y
Onychomys leucogaster	011	FOOTHILL	Foothills West of Headquarters	20030511	2003.21	30578	39.83839	113.39954	4346	SLR135	sherman	fluid	F	ADULT	138	39	19	20	24	Y
Peromyscus crinitus	006	FOOTHILL	Upper North Spring Foothills	20020925	2002.50	30644	39.88359	113.41447	4370	SLR114	snap	fluid	M	ADULT	175	94	21	20	18	Y
	006	FOOTHILL	Upper North Spring Foothills	20020928	2002.50	30645	39.88359	113.41447	4370	SLR129	snap	fluid	F	ADULT	159	85	19	21	13	Y
	006	FOOTHILL	Upper North Spring Foothills	20020928	2002.50	30646	39.88359	113.41447	4370	SLR130	snap	fluid	F	SUBAD	165	88	21	19	11	Y
	006	FOOTHILL	Upper North Spring Foothills	20020929	2002.50	30647	39.88359	113.41447	4370	SLR138	snap	fluid	M	ADULT	157	81	20	19	13.5	Y
	006	FOOTHILL	Upper North Spring Foothills	20020930	2002.50	30648	39.88359	113.41447	4370	SLR150	snap	fluid	M	ADULT	168	87	20	20	17	Y
	002	FOOTHILL	Lower North Spring foothills	20020908	2002.50	30580	39.88458	113.41387	4330	SLR103	snap	fluid	F	SUBAD	150	80	21	19	14	Y
	002	FOOTHILL	Lower North Spring foothills	20020908	2002.50	30581	39.88458	113.41387	4330	SLR104	snap	fluid	F	SUBAD	159	88	21	19	14	Y
Peromyscus maniculatus	003	DUNE	South Sand Dunes	20020927	2002.50	30636	39.82750	113.39964	4311	SLR107	snap	fluid	M	ADULT	0	0	22	18	20	Y
	003	DUNE	South Sand Dunes	20020923	2002.50	30637	39.82750	113.39964	4311	SLR119	sherman	fluid	F	SUBAD	149	66	21	18	11	N
	009	DUNE	North Sand Dunes	20020929	2002.50	30661	39.90428	113.40133	4314	SLR139	snap	fluid	M	ADULT	160	70	21	18	21	Y
	009	DUNE	North Sand Dunes	20020929	2002.50	30662	39.90428	113.40133	4314	SLR140	snap	fluid	F	ADULT	155	70	20	18	21	Y
	009	DUNE	North Sand Dunes	20020930	2002.50	30663	39.90428	113.40133	4314	SLR144	sherman	fluid	M	ADULT	153	73	21	18	15	Y
	009	DUNE	North Sand Dunes	20030510	2003.21	30604	39.90428	113.40133	4314	SLR164	sherman	fluid	M	SUBAD	144	65	20	18	13	N
	009	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	M	YG ADULT						
	009	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	unk	ADULT						
	009	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	F	ADULT						
	009	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	M	ADULT						
	009	DUNE	North Sand Dunes	20030510			39.90428	113.40133	4314		sherman	released	M	ADULT						
	009	DUNE	North Sand Dunes	20030510			39.90428	113.40133	4314		sherman	released	M	SUBAD						
	009	DUNE	North Sand Dunes	20030510			39.90428	113.40133	4314		sherman	released	F	YG ADULT						
	013	DUNE	Southeast dunes	20030703	2003.21	30606	39.84546	113.34612	4306	SLR176	snap	skeleton	F	JUV	123	53	17	11	8.4	Y
	013	DUNE	Southeast dunes	20030704	2003.21	30713	39.84546	113.34612	4306	SLR180	snap	fluid	M	ADULT	129	55	17	11	12.5	N
	013	DUNE	Southeast dunes	20030704	2003.21	30714	39.84546	113.34612	4306	SLR181	snap	fluid	M	ADULT	123	55	17	11	10	N
	017	DUNE	Middle spring roadside dune	20031006			39.84134	113.35970	4319		sherman	released	unk	JUV						
	017	DUNE	Middle spring roadside dune	20031005			39.84134	113.35970	4319		sherman	released	F	ADULT						
	017	DUNE	Middle spring roadside dune	20031005			39.84134	113.35970	4319		sherman	released	M	YG ADULT						
	017	DUNE	Middle spring roadside dune	20031005			39.84134	113.35970	4319		sherman	released	unk	ADULT						
	020	DUNE	East Dunes	20031006	2003.21	30796	39.85682	113.34330	4296	SLR223	sherman	fluid	F	YG ADULT	142	54	21	13	14.5	Y
	020	DUNE	East Dunes	20031006	2003.21	30795	39.85682	113.34330	4296	SLR222	sherman	fluid	M	YG ADULT	148	72	20	13	15	Y
	020	DUNE	East Dunes	20031005			39.85682	113.34330	4296		sherman	released	unk	ADULT						
	020	DUNE	East Dunes	20031005			39.85682	113.34330	4296		sherman	released	unk	SUBAD						
	020	DUNE	East Dunes	20031005			39.85682	113.34330	4296		sherman	released	unk	ADULT						
	020	DUNE	East Dunes	20031005			39.85682	113.34330	4296		sherman	released	unk	ADULT						
	021	DUNE	NE Dunes	20031011	2003.21	30802	39.85566	113.34217	4293	SLR230	snap	fluid	M	JUV	127	55	19	17	10	Y
	021	DUNE	NE Dunes	20031011	2003.21	30803	39.85566	113.34217	4293	SLR236	snap	fluid	M	ADULT	160	74	21	20	19	Y
	021	DUNE	NE Dunes	20031012	2003.21	30804	39.85566	113.34217	4293	SLR237	snap	fluid	M	JUV	123	52	20	15	11.1	Y
	021	DUNE	NE Dunes	20031012			39.85566	113.34217	4293		sherman	released	M	JUV						
	011	FOOTHILL	Foothills West of Headquarters	20030704	2003.21	30751	39.83839	113.39954	4346	SLR172	snap	fluid	F	ADULT	149	73	21	15	18.3	Y
	011	FOOTHILL	Foothills West of Headquarters	20030511			39.83839	113.39954	4346		sherman	released	F	ADULT						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	unk	SUBAD						
	011	FOOTHILL	Foothills West of Headquarters	20030510			39.83839	113.39954	4346		sherman	released	F	ADULT						
	015	FOOTHILL	Landfill	20030704	2003.21	30757	39.84927	113.39965	4330	SLR154	snap	fluid	M	ADULT	142	82	21	20	21	Y
	015	FOOTHILL	Landfill	20030704	2003.21	30758	39.84927	113.39965	4330	SLR155	snap	fluid	F	ADULT	152	71	20	17	22.3	Y
	015	FOOTHILL	Landfill	20030704	2003.21	30759	39.84927	113.39965	4330	SLR150	snap	fluid	M	ADULT	150	84	20	18	16	Y
	015	FOOTHILL	Landfill	20030705	2003.21	30763	39.84927	113.39965	4330	SLR190	sherman	fluid	M	ADULT	157	74	21	18	14	N
	015	FOOTHILL	Landfill	20030705	2003.21	30764	39.84927	113.39965	4330	SLR191	snap	fluid	M	ADULT	150	75	21	19	19	N
	015	FOOTHILL	Landfill	20030705	2003.21	30765	39.84927	113.39965	4330	SLR192	snap	fluid	F	ADULT	151	80	20	18	18	N

GENUS SPECIES	SITE #	HABITAT TYPE	LOCALITY DESCRIPTION	COLLCT DATE	UMNH ACC'SN NUMBER	UMNH CATALOG NUMBER	DECLAT	DECLONG	ELEV (FT)	FIELDBK NUMBER	COLLECT METHOD	PREP TYPE	SEX	AGE	TL (mm)	TV (mm)	HF (mm)	EAR (mm)	WT (g)	TISSUE SAMPLE
	015	FOOTHILL	Landfill	20030704			39.84327	113.32069	4350		sherman	released	UN	ADULT						
	015	FOOTHILL	Landfill	20030704			39.84327	113.38969	4350		sherman	released	M	ADULT						
	014	MARSH	Picnic marsh	20030705	2003.21	30760	39.84367	113.38852	4301	SLR157	snap	fluid	M	ADULT	138	70	18	15	13	N
	023	SALT	Ibis Flat	20031011	2003.21	30800	39.85207	113.36974	4302	SLR227	sherman	fluid	M	SUBAD	150	76	21	20	17	Y
	010	WET	North Dune spring	20030511	2003.21	30595	39.90414	113.40073	4281	SLR160	snap	fluid	M	ADULT	165	70	21	18	22	N
	016	WET	Pintail spring edge	20031004	2003.21	30773	39.57331	113.37464	4280	SLR220	snap	fluid	F	JUV	123	57	16	13	14	Y
	016	WET	Pintail spring edge	20031004	2003.21	30774	39.57331	113.37464	4280	SLR204	snap	skeleton	M	SUBAD	90		19	18	13	Y
	016	WET	Pintail spring edge	20031004	2003.21	30775	39.57331	113.37464	4280	SLR222	snap	skeleton	M	ADULT	139	68	20	20	24	Y
	016	WET	Pintail spring edge	20031005	2003.21	30783	39.57331	113.37464	4280	SLR210	snap	fluid	F	ADULT	154	68	20	19	19	Y

GENUS SPECIES	SITE #	HABITAT TYPE	LOCALITY DESCRIPTION	COLLCT DATE	UMNH ACC'SN NUMBER	UMNH CATALOG NUMBER	DECLAT	DECLONG	ELEV (FT)	FIELDBK NUMBER	COLLECT METHOD	PREP TYPE	SEX	AGE	TL (mm)	TV (mm)	HF (mm)	EAR (mm)	WT (g)	TISSUE SAMPLE
Reithrodontomys megalotis	003	DUNE	South Sand Dunes	20020922	2002.50	30602	39.82730	113.33964	4311	SLR103	sherman	fluid	F	JUV	148	70	18	18	13	Y
	003	DUNE	South Sand Dunes	20020923	2002.50	30603	39.82730	113.33964	4311	SLR114	snap	fluid	M	ADULT	135	70	18	15	10	Y
	003	DUNE	South Sand Dunes	20020923	2002.50	30604	39.82730	113.33964	4311	SLR117	snap	fluid	F	ADULT	134	60	18	15	13	Y
	003	DUNE	South Sand Dunes	20020923	2002.50	30605	39.82730	113.33964	4311	SLR113	sherman	fluid	M	ADULT	143	68	18	15	13	Y
	005	DUNE	North Sand Dunes	20020930	2002.50	30599	39.90428	113.40133	4314	SLR143	snap	fluid	M	SUBAD	125	60	18	14	8	Y
	005	DUNE	North Sand Dunes	20020930	2002.50	30600	39.90428	113.40133	4314	SLR140	snap	fluid	M	SUBAD	121	56	17	13	7.8	Y
	005	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	F	ADULT						
	005	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	M	ADULT						
	005	DUNE	North Sand Dunes	20030511			39.90428	113.40133	4314		sherman	released	F	ADULT						
Reithrodontomys megalotis cont'd	005	DUNE	North Sand Dunes	20030519			39.90428	113.40133	4314		sherman	released	F	ADULT						
	005	DUNE	North Sand Dunes	20030519			39.90428	113.40133	4314		sherman	released	M	ADULT						
	005	DUNE	North Sand Dunes	20030519			39.90428	113.40133	4314		sherman	released	M	YG ADULT						
	017	DUNE	Middle spring roadside dune	20031004			39.54134	113.33376	4319		sherman	released	UN	SUBAD						
	017	DUNE	Middle spring roadside dune	20031004			39.54134	113.33376	4319		sherman	released	UN	YG ADULT						
	017	DUNE	Middle spring roadside dune	20031004			39.54134	113.33376	4319		sherman	released	UN	ADULT						
	017	DUNE	Middle spring roadside dune	20031004			39.54134	113.33376	4319		sherman	released	UN	ADULT						
	027	SALT	North Spring salt flats	20020928	2002.50	30622	39.55440	113.43314	4250	SLR127	snap	fluid	M	ADULT	135	68	18	15	10.3	Y
	018	SALT	Pintail saltflat scrub	20031005	2003.21	30785	39.57307	113.37540	4278	SLR211	sherman	fluid	F	ADULT	150	73	18	15	13	Y
	018	SALT	Pintail saltflat scrub	20031005			39.57307	113.37540	4278		sherman	released	UN	YG ADULT						
	018	SALT	Pintail saltflat scrub	20031005			39.57307	113.37540	4278		sherman	released	UN	ADULT						
	018	SALT	Pintail saltflat scrub	20031005			39.57307	113.37540	4278		sherman	released	UN	ADULT						
	023	SALT	Ibis Flat	20031011	2003.21	30799	39.85207	113.36974	4302	SLR226	snap	fluid	F	ADULT	156	79	18	15	13	Y
	010	WET	North Dune spring	20030510	2003.21	30592	39.90414	113.40073	4281	SLR152	snap	fluid	F	ADULT	135	63	18	15	11	N
	010	WET	North Dune spring	20030510	2003.21	30593	39.90414	113.40073	4281	SLR153	snap	fluid	M	ADULT	147	74	19	15	14	N
	010	WET	North Dune spring	20030511	2003.21	30594	39.90414	113.40073	4281	SLR172	snap	fluid	F	ADULT	127	60	17	15	11	N
	016	WET	Pintail spring edge	20031005	2003.21	30790	39.57331	113.37464	4280	SLR217	snap	fluid	F	ADULT	155	75	17	15	17	Y

GENUS SPECIES	SITE #	HABITAT TYPE	LOCALITY DESCRIPTION	COLLCT DATE	UMNH ACC'SN NUMBER	UMNH CATALOG NUMBER	DECLAT	DECLONG	ELEV (FT)	FIELDBK NUMBER	COLLECT METHOD	PREP TYPE	SEX	AGE	TL (mm)	TV (mm)	HF (mm)	EAR (mm)	WT (g)	TISSUE SAMPLE
Sorex vagrans	004	MARSH	North Spring marsh meadow #1	20020922	2002.50	30613	39.55735	113.40627	4305	SLR111	pitfall	fluid	F	ADULT	105	37	13	5	4.8	Y
	001	MARSH	North Spring marsh meadow #2	20020908	2002.50	30605	39.55758	113.43237	4281	SLR102	pitfall	fluid	F	ADULT	96	32	13	5	4.2	Y
	001	MARSH	North Spring marsh meadow #2	20020928	2002.50	30609	39.55758	113.43237	4281	SLR123	pitfall	fluid	F	ADULT	96	37	18	5	4.7	Y
	001	MARSH	North Spring marsh meadow #2	20020922	2002.50	30614	39.55758	113.43237	4281	SLR112	pitfall	fluid	M	ADULT	114	36	13	5	7.1	Y
	001	MARSH	North Spring marsh meadow #2	20020930	2002.50	30616	39.55758	113.43237	4281	SLR142	pitfall	fluid	F	ADULT	97	40	14	7	4.7	Y
	001	MARSH	North Spring marsh meadow #2	20020930	2002.50	30617	39.55758	113.43237	4281	SLR143	pitfall	fluid	F	ADULT	105	40	13	5	3.1	Y
	001	MARSH	North Spring marsh meadow #2	20020930	2002.50	30618	39.55758	113.43237	4281	SLR141	pitfall	fluid	F	ADULT	134	41	13	5	4.6	Y
	001	MARSH	North Spring marsh meadow #2	20020923			39.55758	113.43237	4281		pitfall	released	UN	unk						
	014	MARSH	Picnic marsh	20030704	2003.21	30755	39.84367	113.38392	4301	SLR152	snap	fluid	F	ADULT	92	36	13	5	4.8	N
	014	MARSH	Picnic marsh	20030705	2003.21	30761	39.84367	113.38392	4301	SLR158	snap	fluid	IND	ADULT	100	32	12	12	4.4	N
	001	WET	North Spring edge	20020923	2002.50	30606	39.55758	113.43237	4281	SLR122	snap	fluid	F	IND	99	36	12	5	4.3	Y
	001	WET	North Spring edge	20020928	2002.50	30607	39.55758	113.43237	4281	SLR123	snap	fluid	F	ADULT	99	39	12	6	4.8	Y
	001	WET	North Spring edge	20020928	2002.50	30608	39.55758	113.43237	4281	SLR124	snap	fluid	F	ADULT	102	38	13	7	4.8	Y
	001	WET	North Spring edge	20020929	2002.50	30615	39.55758	113.43237	4281	SLR136	snap	fluid	M	SUBAD	84	25	12	5	2.7	Y
	010	WET	North Dune spring	20030510	2003.21	30582	39.90414	113.40073	4281	SLR153	pitfall	fluid	F	ADULT	99	37	13	5	4	Y
	010	WET	North Dune spring	20030510	2003.21	30583	39.90414	113.40073	4281	SLR133	pitfall	fluid	IND	ADULT	100	39	10	7	4.2	Y
	010	WET	North Dune spring	20030510	2003.21	30584	39.90414	113.40073	4281	SLR156	pitfall	fluid	IND	ADULT	100	40	13	6	4	Y
	010	WET	North Dune spring	20030511	2003.21	30585	39.90414	113.40073	4281	SLR167	pitfall	fluid	IND	ADULT	96	35	12	5	4.5	N
	010	WET	North Dune spring	20030511	2003.21	30586	39.90414	113.40073	4281	SLR172	pitfall	fluid	M	ADULT	108	37	12	5	5	N
	010	WET	North Dune spring	20030511	2003.21	30587	39.90414	113.40073	4281	SLR173	pitfall	fluid	IND	ADULT	95	47	13	7	4.5	N
	016	WET	Pintail spring edge	20031005	2003.21	30789	39.57331	113.37464	4280	SLR216	snap	fluid	F	ADULT	91	40	12	6	3.7	Y

Appendix 2: Trapping data sorted chronologically by site number.

Site #	Habitat	Site Description		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Totals	[illegible] total	[illegible] total	[illegible] total
001	WET	North Spring edge																						
			snaps		12	3	3	9	9	9											57	57		
			captures		1	0	2	3	2	0											8		8	
002	FOOTHILL	Lower North Spring foothills																						
			snaps		20																20	20		
			captures		3																3		3	
003	DUNE	South Sand Dunes																						
			snaps			20	20														40	[illegible]		
			shermans			20	20														40			
			captures			3	3														9		9	
004	MARSH	North Spring marsh meadow #1																						
			pitfalls	21	21	14	14	14	14	14											112	112		
			captures	0	0	1	0	0	0	0											1		1	
005	MARSH	North Spring marsh meadow #2																						
			pitfalls		15	15	15	15	15	15											90	90		
			captures		1	1	1	1	0	2											[illegible]		[illegible]	
			released				1														1			1
006	FOOTHILL	Upper North Spring Foothills																						
			snaps				20	20	20	20											80	91		
			rat				2	3	3	3											11			
			captures				3	3	2	3											11		11	
007	SALT	North Spring salt flats																						
			snaps		20			20	20	20											80	89		
			rat					3	3	3											9			
			captures		5			2	0	4											8		8	
009	DUNE	North Sand Dunes																						
			snaps						15	15											30	100		
			shermans						15	15	20	20									70			
			captures						3	5	8	8									24		24	
			released								7	8									15			15
010	MARSH	North Dune spring marsh																						
			pitfalls								10	10									38	62		
			snaps								12	12									24			
			captures								7	7									14		14	
011	FOOTHILL	Foothills West of Headquarters																						
			shermans								30	30		10	10						60	80		
			snaps											10	10						20			
			captures								10	3		3	4						20		20	
			released								5	8		3	1						18			18
013	DUNE	Southeast dunes																						
			snaps										10	10	10						30	60		
			shermans										10	10	10						30			
			captures										1	2	4						7		7	
014	MARSH	Picnic marsh																						
			snaps											15	15						30	30		
			captures											1	2						3		3	
015	FOOTHILL	Landfill																						
			shermans											10	10						20	40		
			snaps											10	10						20			
			captures											6	6						12		12	
			released											2	2						4			4
016	WET	Pintail spring edge																						
			snaps													10	10	10			30	30		
			captures													1	7	8			15		11	
			released													0	1	0			1			1
017	DUNE	Middle spring roadside dune																						
			shermans													10	10	10			30	30		
			captures													6	4	2			11		11	
			released													4	3	2			[illegible]			8
018	MARSH	Pintail marsh meadow																						
			snaps													5	5	5			15	15		
			captures													0	3	3			6		6	
019	SALT	Pintail saltflat scrub																						
			shermans													10	10	10			30	30		
			captures													0	4	0			4		4	
			released													0	3	0			3			3
020	DUNE	East Dunes																						
			shermans														19	19			38	38		
			captures														4	3			7		7	
			released														4	3			7			4
021	DUNE	NE Dunes																						
			shermans																17	17	34	74		
			snaps																20	20	40			
			captures																4	3	7		7	
			released																1	2	3			3
022	MARSH	NE Dune [illegible]																						
			snaps																	10	10	10		
			captures																	1	1		1	
025	SALT	Ibis Flat																						
			shermans																10	10	20	60		
			snaps																20	20	40			
			captures																2	1	3		3	
			released																0	1	1			1
																						1108	146	88

VOUCHERED SPECIES

Location and Number of Voucher Specimens

Species	Common name	BYU	UMNH Historical	UMNH 2002-03 project
Ammospermophilus leucurus	White-tailed antelope ground squirrel	8	5	3
Bassicariscus astutus	Ringtail		1	
Chaetodipus formosus	Long-tailed pocket mouse	6	29	7
Dipodomys microps	Chisel toothed kangaroo rat	16	10	13
Dipodomys ordii	Ord's kangaroo rat	3	14	3
Lepus californicus	Black tailed jack rabbit	1		
Lynx rufus	Bobcat		8	
Mephitis mephitis	Striped skunk		4	
*Microdipodops megacephalus***	Dark kangaroo mouse		1	
Microtus montanus	Montane vole	2	15	10
Mus musculus	House mouse	5		17
Mustela frenata	Long-tailed weasel		1	
Neotoma lepida	Desert woodrat	2	6	4
Ondatra zibethicus	Common muskrat	3	61	
Onychomys leucogaster	Northern grasshopper mouse	1	1	1
*Perognathus longimembrus***	Little pocket mouse		2	
Peromyscus crinitus	Canyon mouse	10	4	7
Peromyscus maniculatus	Deer mouse	6	41	28
Peromyscus truei	Pinyon mouse	1		
Reithrodontomys megalotis	Western harvest mouse	9	6	13
Sorex vagrans	Vagrant shrew		1	20
Spermophilus townsendii (mollis)	Piute ground squirrel		2	
Spilogale gracilis	Western spotted skunk		3	
Sylvilagus audubondii	Desert cottontail	2		
Taxidea taxus	American badger		2	
Thomomys bottae	Botta's pocket gopher	2	17	
Vulpes macrotis	Kit fox		5	

(** species vouchered in the FSNWR region rarely and historically)

SIGHTED OR HYPOTHETICAL SPECIES

Species	Common name	Sighted/hypothetical
Vulpes vulpes	red fox	sighted
Canis latrans	coyote	sighted
Tamias minimus	Least chipmunk	hypothetical
Perognathus parvus	Great Basin pocket mouse	hypothetical
Lemmiscus curtatus	Sagebrush vole	hypothetical
Microtus longicaudus	Long-tailed vole	hypothetical