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The Contribution of environmental variables on small mammal species richness and relative abundance in Eastern Nevada

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The Contribution of Environmental Variables on Small Mammal Species Richness and Relative Abundance in Eastern Nevada.

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Abstract

The purpose of this study is to determine how four environmental variables: elevation, latitude, soil type, and vegetation impact the relative abundance of *Peromyscus maniculatus* and the species richness of small mammal populations in Eastern Nevada. In order to complete this study, a survey of small mammals was completed in the following 8 Eastern Nevada valleys: Delamar, Dry Lake, Dry Lake- Muleshoe,Cave, Lake, Snake, Spring, White River. In each valley, transects of Sherman live traps will be set up for 3 consecutive nights (O'Farrell et al 1977). Data on elevation, latitude, soil type, and vegetation were taken at each trap site. Non-parametric PLR was then used to assess which variables were significant in determining *P.maniculatus* relative abundance and overall species richness. Polytomous logistic regression showed that soil was the only significant variable in determining species richness and relative abundance with a P-value of $< .001$.

Acknowledgments

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Introduction

The purpose of this study is to determine how four environmental variables: elevation, latitude, soil type, and vegetation impact the relative abundance of *Peromyscus maniculatus* and the species richness of small mammal populations in Eastern Nevada. For this study a small mammal includes species within the Order Rodentia. Previous studies have determined that latitude and elevation are the two most universal ecological gradients (McCain 1994). In other words, it is likely that latitude and elevation will be driving forces for both species richness and relative abundance. On a global scale it has been shown that biodiversity decreases with increased latitude and elevation (Lomolino et al 2005). Soil and vegetation were chosen because large-scale features of habitats can affect the distribution of small mammals (Wolff et al 1997). In particular, some small mammals are favored by changes in resource availability (Tabeni and Ojeda 2005). This is reflected in the increased abundance of small mammals in areas disturbed by ranching activities (Jones and Longland 1999).

Species richness of small mammals is an important conservation issue for many reasons. Biological diversity encompasses the infinite variety of life and living processes that have and will occur in the biosphere (Child 2003). In this particular study, determining what factors drive the species richness of small mammal populations in Eastern Nevada is important because it will help conservation efforts in that particular area. For instance, it may help determine appropriate land use designations. Through this study, I will be able to provide the factors determined to be significant for small mammal habitat so that land managers can make informed decisions.

Small mammal relative abundance is the other critical component of this study. Relative abundance is an important concept when applied to diversity. For example, a particular area may have a low diversity or low species richness, meaning there are not very many different types of small mammals found there. However, if this same area has a high relative abundance for a particular species, perhaps that species is well suited for that habitat or the habitat itself is beneficial to the species (Anderson and Gutzwiller 1996). This concept often happens in disturbed habitats. In the Great Basin, a study determined that habitats with feral horse grazing had less community completeness and 1.1- 7.4 times greater *P. maniculatus* than sites without feral horse grazing (Beever and Brussard 2004). *Peromyscus maniculatus* was chosen for the relative abundance study for many reasons. In most areas of Nevada *P. maniculatus* is the most abundant mammal (Hall 1946). *Peromyscus maniculatus* is also known to inhabit a tremendous number of environments, from deserts to grasslands to woodlands (Zeveloff 1988). Furthermore, they are active throughout the year (Zeveloff 1988).

This particular study is only aimed at determining the driving factors for relative abundance of *P. maniculatus* and species richness in small mammals of Eastern Nevada. Future research can be done to compare these factors and determine how to improve the biodiversity of this particular area. This study will therefore contribute to the future research of Northeastern Nevada's ecological gradients and biodiversity.

Similar studies involving environmental variables and small mammals have been completed in the past. A study done on species diversity of seed eating desert rodents in sand dune habitats concluded that the diversity of shrubs has no direct effect on the diversity of rodents (Brown 1973). However, according to Price et al, Heteromyid distributions were correlated to vegetation in earlier studies (1978). Similarly, O'Farrell and Clark (1986) found that there was a tendency for higher small mammal species diversity in more diverse habitat types.

Questions/Hypothesis

Two specific questions will be asked regarding the four factors. First, which factors: elevation, latitude, soil type, or vegetation, affect the relative abundance of small mammal populations in Eastern Nevada? To answer this question, *P. maniculatus*, a widely occurring deer mouse in Nevada, will be used to estimate relative abundance (Hall 1946). The factors will then be analyzed using a principle component analysis. This analysis will determine which factors are most important for the relative abundance of *P. maniculatus* in Eastern Nevada. The second question will ask which of these factors; elevation, latitude, temperature, or habitat, affect the species richness of small mammal populations in Eastern Nevada. During trapping, 15 different species of small mammals were caught in a number of different Eastern Nevada valleys. These species along with the driving factors will be analyzed with the principle component analysis, thus determining which factors are the most important for the relative abundance and species richness of these particular communities.

In this study, I hypothesize that the relative abundance of *P. maniculatus* and species richness of small mammals in Eastern Nevada will be affected by change in elevation, latitude, soil type, and vegetation. Due to the relatively narrow geographic area encompassed by this study it is possible that latitude will have little to no affect on species richness and relative abundance. Furthermore, past research indicates that soil type and vegetation will be the determining factors for relative abundance and species richness of small mammals in Eastern Nevada.

In order to complete this study, a survey of small mammals will be completed in the following 8 Eastern Nevada valleys: Delamar, Dry Lake, Dry Lake- Muleshoe,Cave, Lake, Snake, Spring, White River. In each valley, transects of Sherman live traps will be set up for 3 consecutive nights (O'Farrell et al 1977). The transects will be located in primary vegetation types determined by a REGAP data set. The traps will be baited in the evening and checked in the morning. The animals found will be identified by experts from the Southern Nevada Water Authority. Animals will be marked to keep track of recaptures. Once an exhaustive small mammal survey of each of the valleys mentioned is complete, the data collected will be compiled into a database. During the surveys, the elevation and latitude data will be taken by a Global Positioning System (GPS), the soil data will come from onsite observations, and the vegetation types will be identified using the Region-Wide Gap Analysis Program (REGAP). The data specifically associated with the four variables (elevation, latitude, soil type, and vegetation) along with mammals collected, will then be analyzed using a multiple variable analysis technique. For this particular study, polytomous logistic regression (PLR), a type of multiple variable analyses will be used. The results will show which variable, vegetation, latitude, elevation, or soil is most important when determining relative abundance and species richness for Eastern Nevada.

Study Area

The study area encompasses 9600 square miles of Eastern Nevada and falls roughly between the towns of Alamo, Nevada to the South and Ely, Nevada to the North. The area is bordered to the East by the State of Utah and to the West by Highway 318. In the Southern portion of the study area, in Delamar and Dry Lake Valleys, the floristic community transitions from the Sonoran Province (Mojavean Subprovince) to the Great Basin Province (Flora of North America, V. 1, Chpt. 6). The remainder of the study area falls strictly within the Great Basin floristic province. The area also encompasses both Lower and Upper Sonoran life zones.

Methods

Data Collection

The small mammal surveys were conducted between 17 May and 14 October 2005 in the following Eastern Nevada basins: Cave, Delamar, Dry Lake, Lake, Spring, Snake, and White River Vallies (Map: Appendix A). The specific survey site locations were chosen based on the Region-Wide Gap Analysis Program (REGAP) vegetation data and field observations of specific vegetation communities (Ramsey 2000). Within each valley several unique vegetative communities were sampled. Using the REGAP's Intersecting Vegetation Coverage Description, each community was classified as one of the following:

- Great Basin Pinyon-Juniper Woodland
- Great Basin Xeric Mixed Sagebrush Shrubland
- Inter-Mountain Basins Big Sagebrush Shrubland
- Inter-Mountain Basins Big Sagebrush Steppe
- Inter-Mountain Basins Greasewood Flat
- Inter-Mountain Basins Mixed Salt Desert Scrub
- Inter-Mountain Basin Semi-Desert Shrub Steppe

Soil types at the survey sites were determined by onsite observations. Each soil type was classified as one of the following:

- Loam
- Loam with sand
- Loam with sand and gravel
- Loam with silt
- Loam with silt and gravel
- Sand
- Sand with gravel
- Sand dunes
- Sand dunes with gravel
- Silt
- Silt with sand

At each survey site, small mammal species richness and relative abundance was determined using mark and recapture (Nietfield 1996). Small mammals were captured using 12 inch Sherman folding live traps (Maly and Crawford 1985). The traps were laid out in two parallel transects, A and B lines, 53 meters apart (O'Farrell and Clark 1986). At the beginning of the A line, UTM coordinates were recorded. This served as a reference point and as the latitude variable of the study. Elevation was recorded at this same location.

Each transect consisted of 20 single trap stations spaced 15 meters apart (Transect Layout and Trap: Appendix B). Traps were baited with a seed, oat, and peanut butter mixture (Schemnitz 1996) and set in the late afternoon. Traps were checked after sunrise the following morning. At both set and check time; temperature, cloud cover, and wind speed were recorded since weather can affect the capture of small mammals (Gentry et al1966). Moon phase was also noted (Data Sheet: Appendix D).

All captured animals were weighed and identified to species, sex, sexual condition, and age. Occasionally, foot and tail measurements were taken to identify between similar species. New captures were marked by clipping a small patch of hair on the back of the animal. Previously marked animals were recorded as recaptures. Any additional observations on the animal were also recorded. Most sites were surveyed for 120 trap nights (40 traps x 3 consecutive nights).

Data Analysis

The small mammal data collected was placed in SPSS (Keesing 1998). SPSS is a computer program designed to perform advanced statistical analysis. Its capabilities include: Analysis of Variance, Basic Statistics, Correlation and Regression, Graphics, Multivariate Analysis, Nonparametrics, Tables, Time Series Analysis, Simulation and Distributions, and Statistical Process Control. For this project, numeric codes were applied to vegetation types, soil types, each site's relative abundance value, and each site's species richness value (Codes: Appendix C). This is because SPSS only runs logistic regression with numerical values. The Kolmogorov-Smirnovz normality test was conducted to determine the distribution of the data set (Cross and Petersen 2001). The results indicated that the data was not parametrically assigned.

Non-parametric PLR was then used to assess which variables were significant in determining *P.maniculatus* relative abundance and overall species richness. PLR requires independence of variables. Spearman rank correlations were administered in a pairwise fashion to the different variables. Variables that had a Spearman rank correlation >0.50 with significance $\leq$0.05 were considered to be significantly correlated (Hosmer and Lemeshow 2000). Only one of these correlated variables was then used in PLR under the assumption that the two variables measured the same environmental characteristic (Harris et al. in review). Vegetation type was correlated with UTM-N (latitude) and elevation (Table 1); therefore, vegetation was not included in the analysis.

Table 1 Correlation

		UTM_N	Veg_code	Soil_code	Elevation_ft
UTM_N	Correlation Coefficient	1			
	Sig. (2-tailed)	.			
	N	822			
Veg_code	Correlation Coefficient	-0.510	1		
	Sig. (2-tailed)	0.000	.		
	N	822	822		
Soil_code	Correlation Coefficient	-0.108	0.103	1	
	Sig. (2-tailed)	0.002	0.003	.	
	N	822	822	822	
Elevation_ft	Correlation Coefficient	0.487	-0.510	0.061	1
	Sig. (2-tailed)	0.000	0.000	0.080	.
	N	822	822	822	822

A stepwise PLR was preformed with an entry criterion of 0.3 and an exit criterion of 0.15 (Hosmer and Lemeshow 1989; and Mickey and Greenland 1989). Model variables were considered to be significant at a $P<0.1$ level of significance (Hosmer and Lemeshow 1989). To determine the robustness of the model a jackknife validation/reclassification percentage was obtained. This analysis was completed twice, once for the environmental variables related to relative abundance and once compared to species richness.

Results

A total of 15 different species of rodents were captured throughout the 40 transect lines within the 8 eastern Nevada valleys. These species as well as their common names and federal or state status are found in Table 2.

Table 2 Species List

Scientific Name	Common Name	Status
Ammospermophilus leucurus	White-Tailed Antelope Squirrel	common
Dipodomys merriami	Merriam Kangaroo Rat	common
Dipodomys microps	Chisel-toothed Kangaroo Rat	common
Dipodomys ordii	Ord Kangaroo Rat	common
Lemmiscus curtatus	Sagebrush Vole	common
Microdipodops megacephalus	Dark Kangaroo Mouse	rare
Neotoma lepida	Desert Wood Rat	common
Onychomys leucogaster	Northern Grasshopper Mouse	common
Onychomys torridus	Southern Grasshopper Mouse	common
Perognathus longimembris	Little Pocket Mouse	unknown
Perognathus parvus	Great Basin Pocket Mouse	unknown
Peromyscus maniculatus	Deer Mouse	common
Peromyscus truei	Pinon Mouse	unknown
Reithrodontomys megalotis	Western Harvest Mouse	common
Tamias minimus	Least Chipmunk	unknown

The overall species richness for all of Eastern Nevada as well as for each valley is represented in Table 3. *Peromyscus maniculatus* relative abundance for both the entire project area and individual valleys is also represented in Table 3.

Table 3 Species and Valleys

	Cave	**Delamar**	**Dry Lake**	**Dry Lake/Mule Shoe**	**Lake**	**Snake**	**Spring**	**White River**	**Total animals captured**
Ammospermophilus leucurus	4	3	2	0	0	7	18	5	39
Dipodomys merriami	0	72	43	0	0	0	0	0	115
Dipodomys microps	21	3	13	0	3	10	31	7	88
Dipodomys ordii	17	0	0	0	4	9	23	10	63
Lemmiscus curtatus	0	0	0	0	1	0	1	0	2
Microdipodops megacephalus	20	0	0	0	1	1	15	0	37
Neotoma lepida	0	6	0	0	0	0	15	0	21
Onychomys leucogaster	6	0	1	1	0	2	10	2	22
Onychomys torridus	2	0	6	1	0	0	2	0	11
Perognathus longimembris	0	23	8	0	0	5	1	0	37
Perognathus parvus	27	0	0	10	35	25	31	33	161
Peromyscus maniculatus	1	8	2	3	54	10	71	6	155
Peromyscus truei	0	0	0	0	0	0	4	0	4
Reithrodontomys megalotis	0	0	1	0	1	0	2	6	10
Tamias minimus	0	0	0	0	31	0	22	0	53
Species Richness	8	6	8	4	7	8	14	7	XX
Total animals captured per valley	98	115	76	15	130	69	246	69	818
	Cave	**Delamar**	**Dry Lake**	**Dry Lake/Mule Shoe**	**Lake**	**Snake**	**Spring**	**White River**	**Total animals captured**

Species Richness

Polytomous logistic regression showed that soil was the only significant variable in determining species richness with a P-value < .001(Table 4). The model had a validation/reclassification percentage of 48%. This means the predictive model correctly classified 48% of the data. The Cox and Snell Pseudo R^2 was 0.694, which means the model is somewhat robust.

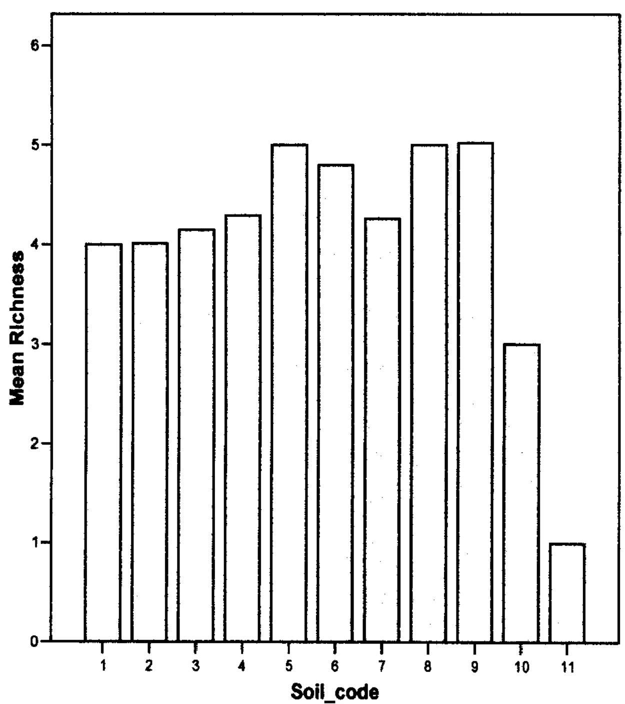
Table 4 Species Richness Regression Analysis

Variables	**P-Value**	**Trend**
Soil	<0.001	Least richness found in silt with sand (soil code 11)

Jackknife validation/reclassification = 48%
Cox and Snell Pseudo R^2 = 0.694

The trend in species richness related to soil can be seen in Graph 1. The mean richness on the Y-axis represents the average number of different species found in one particular soil type. For instance, an average of 5 different species was the most found in any soil type.

Graph 1 Richness V. Soil



Soil Codes

Loam 1
Loam with sand 2
Loam with sand and gravel 3
Loam with silt 4
Loam with silt and gravel 5
Sand 6
Sand dunes 7
Sand dunes with gravel 8
Sand with gravel 9
Silt 10
Silt with sand 11

Relative Abundance

Polytomous logistic regression showed that soil was the only significant factor in determining relative abundance with a P-value of <.001 (Table 5). The model had a validation/reclassification percentage of 56%. The Cox and Snell Pseudo R^2 was 0.701.

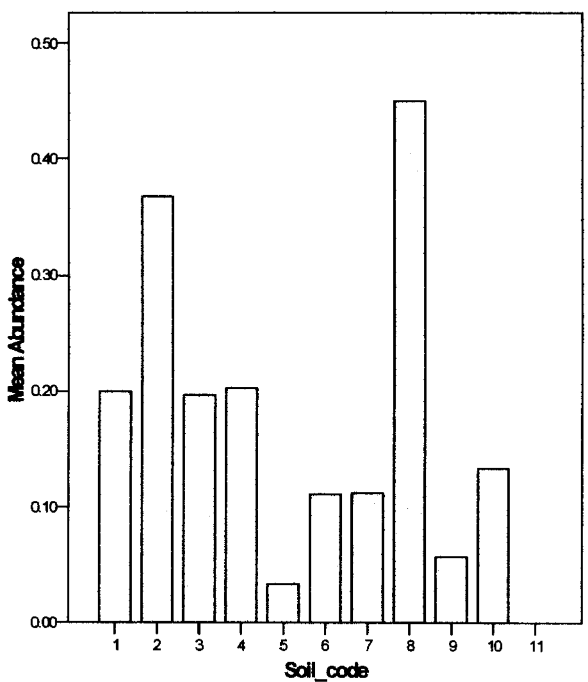
Table 5 Relative Abundance Regression Analysis

Variables	P-Value	Trend
Soil	<0.001	Loam with sand (soil code 2) and Sand dunes with gravel (soil code 8) had highest relative abundance

Jackknife validation/reclassification = 56%
Cox and Snell Pseudo R^2 = 0.701.

The trend in relative abundance related to soil can be seen in Graph 2. The mean relative abundance on the Y-axis represents the percentage of *P.maniculatus* caught in a particular soil type, with 1 representing 0-10% of total animals caught being *P. maniculatus*, 2 = 11%-20%, 3 = 21%-30%, and so on in a similar fashion.

Graph 2 Relative Abundance V. Soil



Soil Codes

Loam 1
Loam with sand 2
Loam with sand and gravel 3
Loam with silt 4
Loam with silt and gravel 5
Sand 6
Sand dunes 7
Sand dunes with gravel 8
Sand with gravel 9
Silt 10
Silt with sand 11

Discussion

The results showed that soil was the most significant environmental variable in determining both species richness and relative abundance in the valleys surveyed. Least species richness was found in silt with sand, meaning there are not a lot of different species occurring in this soil type. Specifically, only 4 animals were caught in this soil type and they were all *Dipodomys merriami*. A possible explanation for this is that only 1 trap line was set in this particular soil type. This may have limited the number of animals to be caught compared with other soil types that had multiple trap lines set within them. Since *D. merriami* is a generalist, meaning it usually occupies a vast number of habitats, these results are biologically meaningful because if any species were to be caught in an area with limited traps the probability is higher that it would be a generalist.

The soil types: loam with silt and gravel, sand, sand dunes with gravel, and sand with gravel all had high species richness with 4.5 -5 different species in each soil type. This means these soil types are preferred by many different species. It could also mean that many more trap lines were placed in these areas, thus creating a higher chance to catch a higher variety of rodents. This unevenness in trapping could have skewed the equality between the soil types in relation to species richness.

The highest relative abundance, between 40 and 50% of the total species accounted for being *P.maniculatus*, was found in loam with sand and sand dunes with gravel. These soil types may be considered disturbed which supports the Beever and Brussard 2004 study. Beever and Brussard found that sites with feral horse grazing, which created a disturbed habitat had a much greater number of *P.maniculatus* then sites without horse grazing.

The least relative abundance was found in loam with silt and gravel, and silt with sand, with 0% of the total species caught being *P.maniculatus*. Similarly, the lowest species richness was found in silt with sand. This may reflect that silt with sand is a poor soil type for rodents. It may also support the idea that the number of traps placed in this particular soil type was limited as mentioned above.

Even though McCain's 1994 study determined that latitude and elevation were the two most universal ecological gradients, latitude and elevation did not come out to be significant for species richness in this study. These findings go against my original hypothesis that elevation and latitude would be most significant. This may be due to the fact that the trapping area was within a relatively small geographic area. In other words, the elevation and latitudinal gradients were small. This did not provide enough variation to make them significant in determining species richness or relative abundance.

Vegetation did not come out to be significant either. The Brown 1973 paper found that in sand dune habitats the diversity of shrubs had no direct effect on the diversity of rodents. This is also reflected in my study, as the sand dune habitats had the highest species richness with vegetation not coming out to be a significant factor. However, Price et al (1978) found that heteromyid distributions were correlated to vegetation, which could be due to factors not addressed in this study.

Further analyses were attempted in this study, but lack of data variability prevented accurate depictions of significance for variables. An attempt to look at the significance of all four environmental variables in relation to species richness and relative abundance for each individual valley was unable to be completed due to lack of intra-valley variation. The elevation and latitudinal gradients had little to no variation which would not allow the regression model to compare differences. Soil types and vegetation had similar issues with regards to small gradients.

Future studies might increase the sample size within valleys, soil types, and vegetation types. This would create a greater opportunity to catch more species in different habitat types, providing for a more intensive survey of the valleys. In this case, a regression analysis comparing the different valleys to one another would be appropriate. Since soil was determined to be significant, a follow up study could arrange trap lines equally among the different soil types. This would create a more controlled study regarding this particular component of my study.

Conclusion

Knowing that soil effects the species richness and relative abundance of small mammals in this arid landscape study will make it possible for land managers to make appropriate conservation decisions and land use plans. Inevitably with growth, the land will need to be developed. However, with this knowledge, the desertification of the desert will become an important component. The destruction of soil types will affect the desert ecosystems in negative ways since it has been shown in this study that it is a significant factor in determining small mammal species richness and relative abundance

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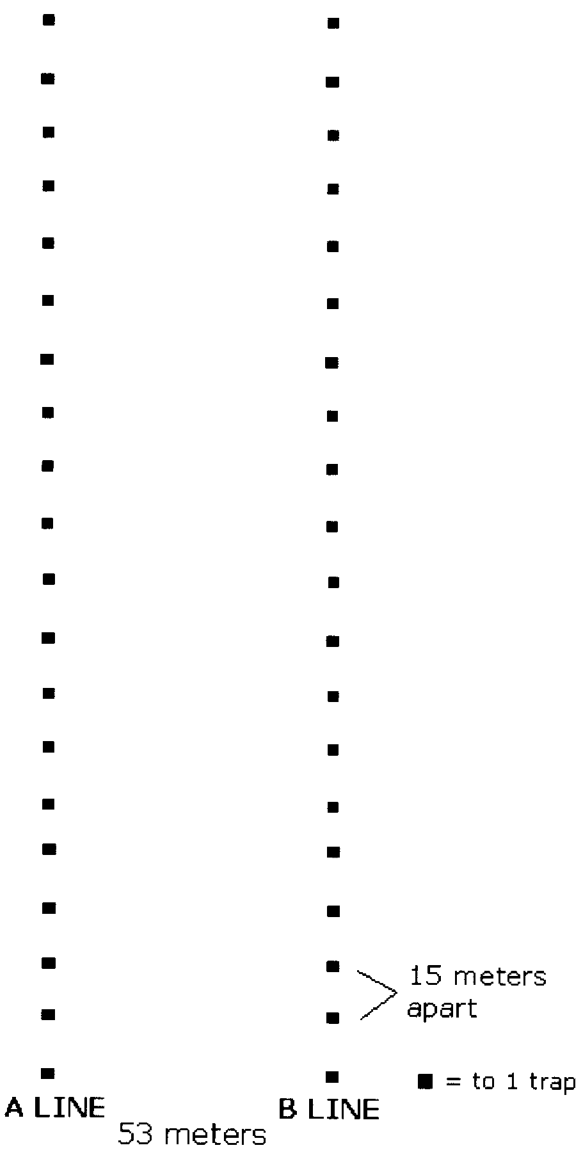
Appendix A Map

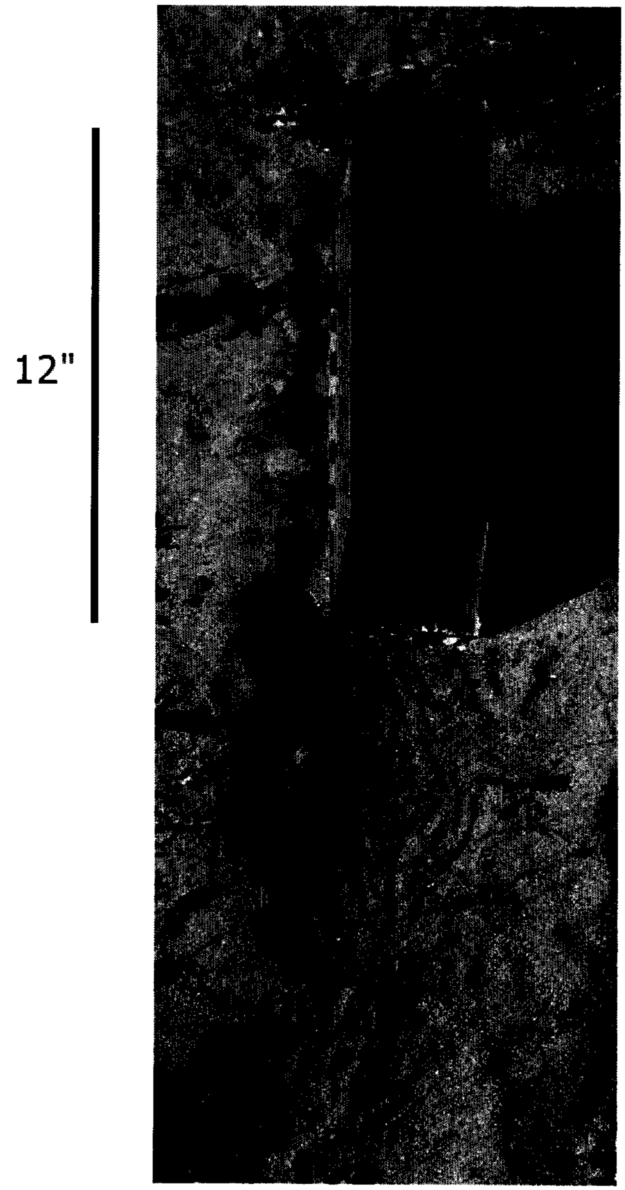
Appendix B

Transect Layout

Transects are 53 meters apart from one another. There are 20 traps per each transect. Traps are 12 inches long and 15 meters from the next trap.Entire transect is approximately 280 meters long.



Sherman Trap



Appendix C

Vegetation Code Table

Vegetation Type	**Code**
Great Basin Pinyon-Juniper Woodland	1
Great Basin Xeric Mixed Sagebrush Shrubland	2
Inter-Mountain Basins Big Sagebrush Shrubland	3
Inter-Mountain Basins Big Sagebrush Steppe	4
Inter-Mountain Basins Greasewood Flat	5
Inter-Mountain Basins Mixed Salt Desert Scrub	6
Inter-Mountain Basin Semi-Desert Shrub Steppe	7

Soil Code Table

Soil Type	**Code**	**Soil Type**	**Code**
Loam	1	Sand dunes	7
Loam with sand	2	Sand dunes with gravel	8
Loam with sand and gravel	3	Sand with gravel	9
Loam with silt	4	Silt	10
Loam with silt and gravel	5	Silt with sand	11
Sand	6		

Appendix D

Small-mammal Data Sheet

Date:________ Location:__________________________ Transect:________ Surveyors:_________________________

UTM'S: ________________N;________________E Datum:___________ Zone:______ Elevation___________

Plot corner:________ Orientation of trap line:____________ Area reference:_________________________________

Habitat Description:____

REGAP Veg type: ____

Trap set: Time:__________Temp:_______ Cloud cover:______ Wind:_______ Moon phase:_______

Trap check: Time:_______Temp:_______ Cloud cover:______ Wind:_______

Species	Sex	Sex Cond.	Age	Wt.(g)	Recap	Trap #	Comments

Wind: (0) <1; (1) 1-3; (2) 4-7; (3) 8-12; (4) 13-18; (5) 19-25; (6) 25-32

Cloud Cover: (0) clear; (1) partly cloudy; (2) cloudy; (3) drizzle; (4) rain; (5) snow; (6) fog

Moon: (0) none; (1) quarter; (2) half; (3) three quarters; (4) full

Age: Ad or Juv.

Recap: Y or N

Sex cond.: (1) testes abdominal; (2) testes scrotal; (3) testes scr. down; (4) vulva inactive; (5) vulva turgid; (6) cop. plug (7) pregnant; (8) lactating; (9) post lactating