

**HABITAT SELECTION BY PYGMY RABBITS
IN SOUTHEAST IDAHO**

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Abstract: Habitat selection by pygmy rabbits (*Brachylagus idahoensis*) was investigated on three levels: landscape scale, habitat scale, and home range scale. A Geographic Information System (GIS) model was developed for the Idaho National Engineering and Environmental Laboratory (INEEL) and used to predict areas of pygmy rabbit non-use and areas of potentially appropriate habitat. Within predicted areas of potential habitat, vegetative and physiographic characteristics were analyzed to develop a Habitat Suitability Model. Areas of suitable pygmy rabbit habitat were characterized by greater cover and density of total shrubs and big sagebrush (*Artemisia tridentata*). Soil texture also differed between use and non-use areas. Use patterns were then investigated within active pygmy rabbit home ranges using radiotelemetry. Home range areas receiving disproportionate levels of use were identified and sampled for vegetative and physiographic differences. Pygmy rabbits most frequently utilized areas with structurally diverse stands of shrubs and predominantly sandy soils. Burrow areas provided the greatest shrub cover and had a higher forb component; high use areas also had a complex vegetal profile. Low use areas were characterized by less overall vertical complexity in the shrub community. Our results suggest that pygmy rabbits are extreme habitat specialists on all levels.

INTRODUCTION

Pygmy rabbits (*Brachylagus idahoensis*) are a small rabbit species endemic to the Great Basin desert and surrounding intermountain areas. Within its range, its occurrence is not continuous; pygmy rabbits require dense stands of big sagebrush (*Artemisia tridentata*) for both food and cover. Sagebrush comprises 99 percent of their winter diet, and 51 percent of their summer diet, which is also supplemented by grasses (39%) and forbs (10%) (White et al. 1982). Also unique among western North American rabbits is the pygmy rabbit's burrowing habit. Burrow systems are typically constructed under clumps of big sagebrush, once again reinforcing the vital role of sagebrush to pygmy rabbit survival.

The pygmy rabbit is considered a sensitive species/species of concern in Idaho because of several factors. Given their reliance on sagebrush, pygmy rabbits have been characterized as habitat specialists or obligates. Consequently, reductions of suitable sagebrush habitat by agriculture, grazing, and development have had a significant impact on this species. Another factor that affects this species abundance is its seemingly limited ability to disperse long distances and to cross open habitat (Katzner and Parker 1997, Weiss and Verts 1984, Green and Flinders 1980). Because of these factors, the status of the pygmy rabbit varies locally throughout its range from being endangered to common, with its overall distribution generally reduced from historic levels (Washington Department of Fish and Wildlife 1995, Chapman et al. 1990). As a major factor in the decline of pygmy rabbits seems to be habitat loss, it is important to their conservation and management to determine what are the specific habitat preferences in this species. Studies have indicated that they prefer areas of tall, dense stands of sagebrush with deep, sandy soils (Katzner and Parker 1997, Gahr 1993, Kehne 1991, Weiss and Verts 1984, Green and Flinders 1980, Severaid 1950, Orr 1940, Grinnell et al. 1930). However, beyond this general preference, the degree of habitat selection by pygmy rabbits is not known. To determine how specialized they are, we conducted a comprehensive study that looked at habitat selection by pygmy rabbits on three different levels: large (landscape scale), medium (habitat scale), and small (home range scale).

The study was conducted at the Idaho National Engineering and Environmental Laboratory (INEEL), a 2,315 km² site located on the upper Snake River Plain in southeastern Idaho (Figure 1). Annual temperature averages 5.6°C at the INEEL, and mean annual precipitation is about 22 cm. The surface of the INEEL is gently rolling with some basalt flows and a few volcanic buttes. The subsurface consists of basalt from past lava flows. The site is characterized as sagebrush steppe, and the vegetation is dominated by big sagebrush-bunchgrass associations. A high diversity of forbs also occurs at the INEEL. A complete description of vegetation appears in Anderson et al. (1996).

METHODS

Pygmy rabbit habitat was analyzed on a **landscape scale** using Geographic Information System (GIS) modeling (Gabler 1997). This spatial analysis was based on known locations of pygmy

rabbit burrow sites on four thematic map layers: vegetation, surface geology, slope, and aspect. A predictive map incorporating overlays of these four layers was produced to determine areas of potential pygmy rabbit habitat. Reliability of this predictive model was field tested by verifying the presence or absence of pygmy rabbits at randomly selected predicted use and non-use sites.

Analysis at the **habitat scale** included sampling vegetative and physiographic characteristics at five different categories of pygmy rabbit use areas (Gabler 1997). These areas included *occupied burrow sites*, active burrows discovered during road surveys; *unoccupied burrow sites*, inactive burrows discovered within areas of predicted habitat as defined by GIS analysis; *active areas*, larger areas surrounding and encompassing the occupied burrow sites; *inactive areas*, larger areas surrounding and encompassing the unoccupied burrow sites; and *non-use areas*, areas of predicted non-use habitat as defined by GIS analysis. Thirty habitat characteristics were measured to test differences among the five site types. A principal components analysis (PCA) was used to develop a Habitat Suitability Model for pygmy rabbit habitat.

Finally, habitat was analyzed at the **home range scale** (Heady 1998). Radiotelemetry was used to determine home range use patterns of pygmy rabbits with relation to habitat. Areas of disproportionate use within the home range were identified and the associated level of use within these areas was estimated. Vegetative and physiographic characteristics were used to determine differences between high use areas, low use areas, and burrow areas. To better characterize shrub vegetation, the short and tall shrub communities were separated based on an arbitrary height of 50 cm.

RESULTS

Analysis at the **landscape scale** suggested that pygmy rabbit burrows are most likely to be found within approximately 23.4 percent of the total area of the INEEL (Figure 2). Spatial analysis of the vegetation map indicated that burrow sites were located within three vegetation classes: sagebrush-steppe on lava, sagebrush-steppe off lava, and sagebrush-winterfat (*Eurotia lanata*). Burrows were located in seven different geologic classes which included surficial deposits and alluvial deposits (Qmp, Qfy, Qp, Qes), and basaltic lava flows and pyroclastic deposits (Qbb, Qbc, Qbd). Mean aspect of burrow locations was 38.7°; mean slope was 8.6 percent. Landscape analysis of the four habitat layers yielded a 100 percent probability of predicting non-use sites, and a 57% probability of predicting pygmy rabbit use areas.

Habitat-scale analysis indicated that vegetation and physiography differed among the five site types, with most variation occurring between occupied burrow sites and non-use areas. Soils at occupied burrow sites contained the greatest sand component (81%); at non-use areas, the sand component was 51.6 percent. Clay contributed only 5.1 percent to soil composition at occupied burrow sites, and comprised 14.4 percent of soils at non-use areas. Relative cover and density of total live shrubs and big sagebrush were greater in occupied burrow sites than in non-use areas (Figure 3). Shrub height and relative forb cover were also lower in non-use areas (Figure 3).

Results of the vegetation and soil PCA were used to construct the following habitat suitability model:

$$\text{Vegetation } Z_1 = (0.833)(ST) + (0.784)(TLS) + (0.737)(SB) + (-0.655)(CT) + (0.625)(F) + (-0.593)(L) + (0.562)(TDT) + (-0.438)(HT) + (0.190)(TDS) + (0.132)(HS)$$

$$\text{Soil } Z_1 = (-0.994)(\%SAND) + (0.948)(\%SILT) + (0.893)(\%CLAY)$$

When the mean Z_1 and Z_2 vegetation scores were plotted (Figure 4a) non-use and active burrow sites separated out from the others areas. Predicted inactive burrow sites and general predicted sites clustered the closest. For Z_1 vegetation and Z_1 soil scores (Figure 4b) active burrows, active sites, and non-use sites clearly separated out with predictive inactive burrows and predicted sites again being most similar.

Habitat heterogeneity among use areas was also observed at the **home range scale**. Height of the short shrub community was greater at burrow areas than in high and low use areas (Table 1). A trend of greater canopy cover from short shrubs was also observed at burrow areas (Table 1). Relative cover of total live shrubs, total forbs, and big sagebrush were also greatest at burrow areas (Table 2). Density of the tall shrub community was lowest in low use areas (Table 1). Textural classes of soils at burrow, high use, and low use areas were predominantly sandy clay loam and sandy loam. Sand comprised greater than 60 percent of the soil at all use areas, and silt comprised less than 15 percent. Clay contributed significantly more to soil composition at low use areas, where the textural classes also included sandy clay, clay loam, and loam.

DISCUSSION

The GIS analysis indicated that, on a **landscape scale**, suitable pygmy rabbit habitat on the INEEL consists of sagebrush-steppe or sagebrush-winterfat communities. The areas are situated

ST = the relative density of *A. tridentata* over 50 cm tall
TLS = the relative coverage of live shrubs
SB = the relative coverage of *A. tridentata*
CT = the mean cover per shrub for shrubs over 50 cm tall
F = the relative coverage of forbs
L = the relative coverage of litter
TDT = the total density of shrubs over 50 cm tall
HT = the height of shrubs over 50 cm tall
TDS = the total density of shrubs 50 cm or shorter
HS = the height of shrubs 50 cm or shorter

Table 1. Results of one-way ANOVA tests (F) for height, density, and canopy of the short and tall shrub community measured by point quarter sampling. Kruskal-Wallis one-way ANOVAs on ranks (H) were calculated on data that were not normally distributed. Means = \pm standard error are shown. Values with the same lowercase letters were not significantly different according to Student-Newman-Keuls or Dunn's multiple comparison tests.

	Burrow areas (n=12)	High use areas (n=10)	Low use areas (n=10)	F/H^H	Level of signif. (P)
SHORT SHRUBS (< 50 cm)					
Height (cm)	28.0 \pm 1.05 ^a	23.0 \pm 1.04 ^b	23.1 \pm 0.82 ^b	8.77	0.0011*
Density (#/m ²)	1.49 \pm 0.38	1.72 \pm 0.36	2.40 \pm 1.66	1.24	0.31
Canopy (m ²)	0.09 \pm 0.01	0.07 \pm 0.01	0.06 \pm 0.01	5.27 ^H	0.07
TALL SHRUBS (> 50 cm)					
Height (cm)	70.0 \pm 1.95	65.1 \pm 3.01	63.8 \pm 1.56	2.28	0.12
Density (#/m ²)	0.35 \pm 0.04 ^a	0.24 \pm 0.06 ^b	0.19 \pm 0.02	8.90 ^H	0.012*
Canopy (m ²)	0.45 \pm 0.03	0.46 \pm 0.05	0.38 \pm 0.05	1.04	0.37

*Significant at $P < 0.05$ level

^HResults from Kruskal-Wallis one way ANOVA on ranks

Table 2. Results of one-way ANOVA tests (F) for relative cover of plant species recorded in point frame samples in burrow, high use, and low use areas. Kruskal-Wallis one-way ANOVAs on ranks (H) were calculated on data that were not normally distributed. Means \pm standard error are shown. Values with the same lowercase letters were not significantly different according to Student-Newman-Keuls or Dunn's multiple comparison tests.

	Burrow areas (n = 9)	High use areas (n = 9)	Low use areas (n = 8)	F/H	Level of signif. (P)
Big Sagebrush (<i>A. tridentata</i>)	21.8 \pm 1.88 ^a	10.2 \pm 2.33 ^b	11.0 \pm 1.92 ^b	9.99 ^F	0.0008*
Gray rabbit-brush (<i>C. viscidiflorus</i>)	1.78 \pm 1.01	0.30 \pm 0.17	0.30 \pm 0.18	1.46 ^H	0.48
Green rabbit-brush (<i>C. nauseosus</i>)	2.37 \pm 0.62	3.06 \pm 0.87	3.99 \pm 1.32	0.72 ^F	0.50
Horsebrush (<i>Tetradymia</i> spp.)	1.13 \pm 0.55	0.86 \pm 0.35	0.27 \pm 0.19	1.77 ^H	0.41
Prickly phlox (<i>L. pungens</i>)	1.83 \pm 0.62	2.73 \pm 0.85	3.60 \pm 0.95	1.17 ^F	0.32
Bluegrass (<i>Poa</i> spp.)	3.04 \pm 1.07	4.70 \pm 1.19	5.14 \pm 1.34	0.85 ^F	0.44
Bluebunch wheatgrass (<i>A. spicatum</i>)	0.92 \pm 0.44	3.30 \pm 2.13	1.66 \pm 0.80	0.79 ^H	0.67
Cheatgrass (<i>B. tectorum</i>)	0.49 \pm 0.21	1.30 \pm 0.81	0.33 \pm 0.29	1.76 ^H	0.42
Indian ricegrass (<i>O. hymenoides</i>)	0.58 \pm 0.23 ^a	0.15 \pm 0.09 ^{ab}	0.03 \pm 0.03 ^b	6.59 ^H	0.03*
Needle & thread grass (<i>S. comata</i>)	0.14 \pm 0.12	0.10 \pm 0.05	0.20 \pm 0.15	0.56 ^H	0.76
Squirreltail (<i>S. hystrix</i>)	0.42 \pm 0.20	0.13 \pm 0.07	0.7 \pm 0.39	2.25 ^H	0.32
Bare ground	29.2 \pm 2.98	21.4 \pm 2.38	25.8 \pm 2.41	5.60 ^H	0.06
Dead shrubs	5.05 \pm 1.15	4.9 \pm 0.90	4.5 \pm 1.06	0.07 ^F	0.93
Litter	19.5 \pm 2.15 ^a	33.7 \pm 2.58 ^b	30.1 \pm 3.83 ^b	6.85 ^F	0.005*
Microbiotic crust	0.61 \pm 0.21	1.9 \pm 0.46	2.8 \pm 1.03	3.03 ^F	0.07
Rocks	3.57 \pm 1.58	5.63 \pm 1.80	3.02 \pm 1.15	0.78 ^F	0.47
Total Forbs	7.06 \pm 1.09 ^a	3.81 \pm 0.63 ^b	4.51 \pm 0.59 ^b	4.53 ^F	0.02*
Total live shrubs	29.0 \pm 2.45 ^a	18.4 \pm 2.31 ^b	21.4 \pm 2.39 ^b	5.39 ^F	0.01*
Total grasses	6.22 \pm 1.26	10.1 \pm 1.66	8.07 \pm 1.27	1.89 ^F	0.17

* Significant at $P < 0.05$ level

on lava flows older than 15,000 years in age and on alluvial deposits of upper Pleistocene, playa deposits, and eolian sand (>50%) deposits. Within these areas, pygmy rabbits construct burrows in locations with zero to 49.7 percent slope and a mean orientation of 38.7°. With the exception of aspect, the observed habitat characteristics are similar to findings from other studies (Gahr 1993, Green 1978, Green and Flinders 1980, Grinnell et al., 1930, Katzner and Parker 1997, Kehne 1991, Orr 1940, Severaid 1950, Weiss and Verts 1984). The observed northeast burrow orientation agreed with Wilde's results (1978), however differed from a study conducted in Washington (Kehne 1993). This difference may be a reflection of the availability of suitable soils. Pygmy rabbits require sufficiently deep soil for burrow construction; at the INEEL, these soils are primarily available on leeward, or northeast slopes. In the Washington study area, pygmy rabbits may not have this same restriction, resulting in burrows without a particular aspect. Therefore, with the possible exception of burrow orientation, our results suggest that the combined application of these GIS criteria could be applicable to most areas within the pygmy rabbit's range.

The accuracy of predicting pygmy rabbit use areas (57% probability) may have been affected by several factors. A more detailed, updated vegetation map is needed to incorporate finer-scaled differences in shrub cover as well as temporal variability, e.g. vegetation loss due to fires. The use of additional map layers may also refine the analysis and improve overall predictability across the pygmy rabbit's range. This model, however can be a very useful first step for identification of appropriate pygmy rabbit habitat.

Habitat-scale analysis suggested that pygmy rabbits select burrow sites with relatively unique combinations of habitat characteristics. Comparisons of individual variables, as well as analysis of variable complexes, indicated significant differences between the non-use areas and the other use categories (Figure 4). In particular, greater cover, density, and height of the shrub community and greater forb cover characterized the occupied burrow sites, unoccupied burrow sites, and inactive sites in the PCA ordination. In contrast, non-use areas had lesser values for these variables. The selection of significant shrub cover and density in suitable pygmy rabbit habitat may be related to the greater associated food resources and protective cover. Also unique to non-use areas were greater values for silt and clay in the PCA of soil texture.

Given that measurable habitat differences were observed among the five use categories, the proposed habitat suitability model could be used to 1) determine suitable pygmy rabbit areas and non-use areas and 2) possibly rank sites within suitable areas.

Analysis at the **home range scale** found evidence of even finer-grained habitat selection. Pygmy rabbits appeared to select particular microhabitat characteristics for burrow locations. Compared to high and low use areas of the home range, burrow areas contained taller vegetation with greater cover. This may be related to the need for unobstructed, protected movement around the burrow entrance. In contrast, the low use areas provided little cover from short shrubs, and had a shorter and less dense tall shrub community that, consequentially, also provided less canopy coverage. In Wyoming, areas of low use also had less coverage and limited vertical density (Katzner and Parker 1997). Vegetation in high use areas was similar to burrow areas, but with

less open ground-level layers. Soils also differed among use areas, with the greatest clay component present in low use areas. Burrow area soils had the greatest amount of sand; this may be related to easier burrow excavation.

This home range analysis provides a better understanding of the pygmy rabbit's selection of burrow sites, and use of the surrounding areas. These data can now be used to identify the complex of variables necessary to pygmy rabbit home range for more effective habitat management.

MANAGEMENT IMPLICATIONS

Results of this study demonstrate that the pygmy rabbit is indeed a habitat specialist on all levels, from the landscape scale to the placement of burrows and use of the home range. This, in effect, greatly reduces what might have been considered suitable habitat within the Great Basin desert. Even areas with big sagebrush may not be suitable if the right combination of factors, shrub height and density, forb cover, etc., are not present. Thus, even in a seemingly contiguous stand of big sagebrush, the landscape may actually seem highly fragmented for pygmy rabbits. Given their seemingly poor dispersal ability and low reproductive capabilities, this may explain their slow recolonization of vacated habitat even under normal conditions. Coupling these factors with loss of sagebrush habitat due to fires, agriculture, and livestock grazing, has likely resulted in the general decline seen in this species.

Because of the high habitat specificity of this species, conservation efforts of this species should first focus on identification of appropriate habitat on a large scale. Such an analysis is needed to first of all determine how much appropriate habitat is still available to support existing populations of pygmy rabbits. Once the amount and location of appropriate habitat has been identified, managers can better determine where conservation efforts are most needed to maintain existing populations and where possible management strategies might be employed to restore populations in decline. The smaller scale habitat selection criteria of pygmy rabbits established by this and other studies should provide managers with the information needed to develop and employ such strategies.

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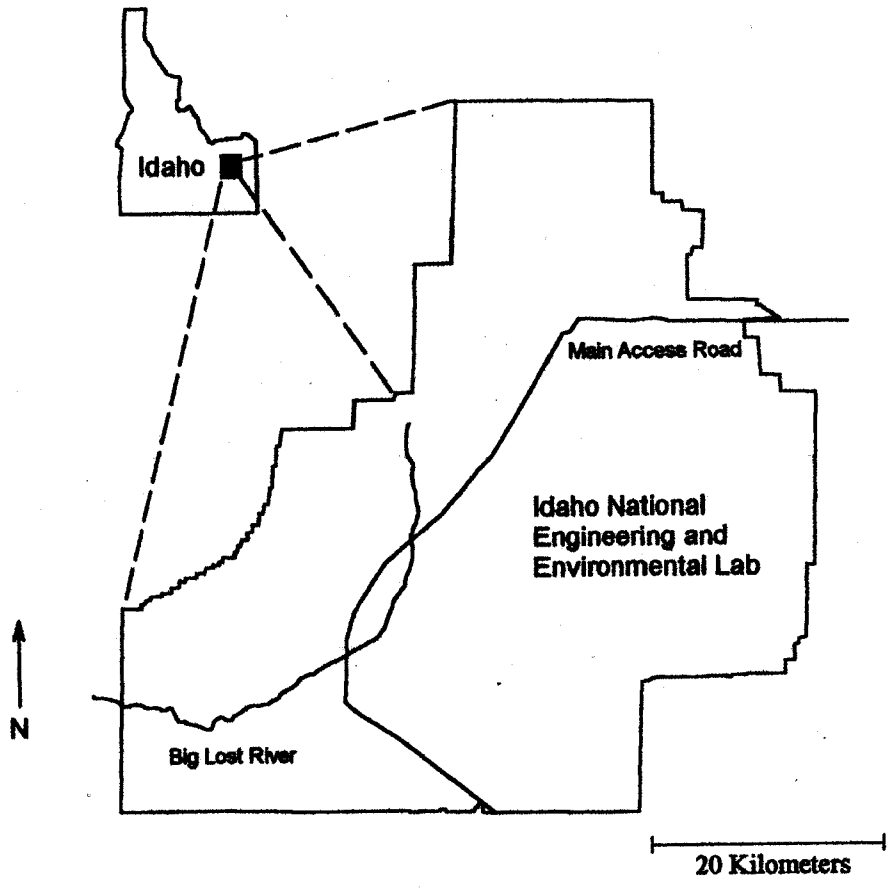
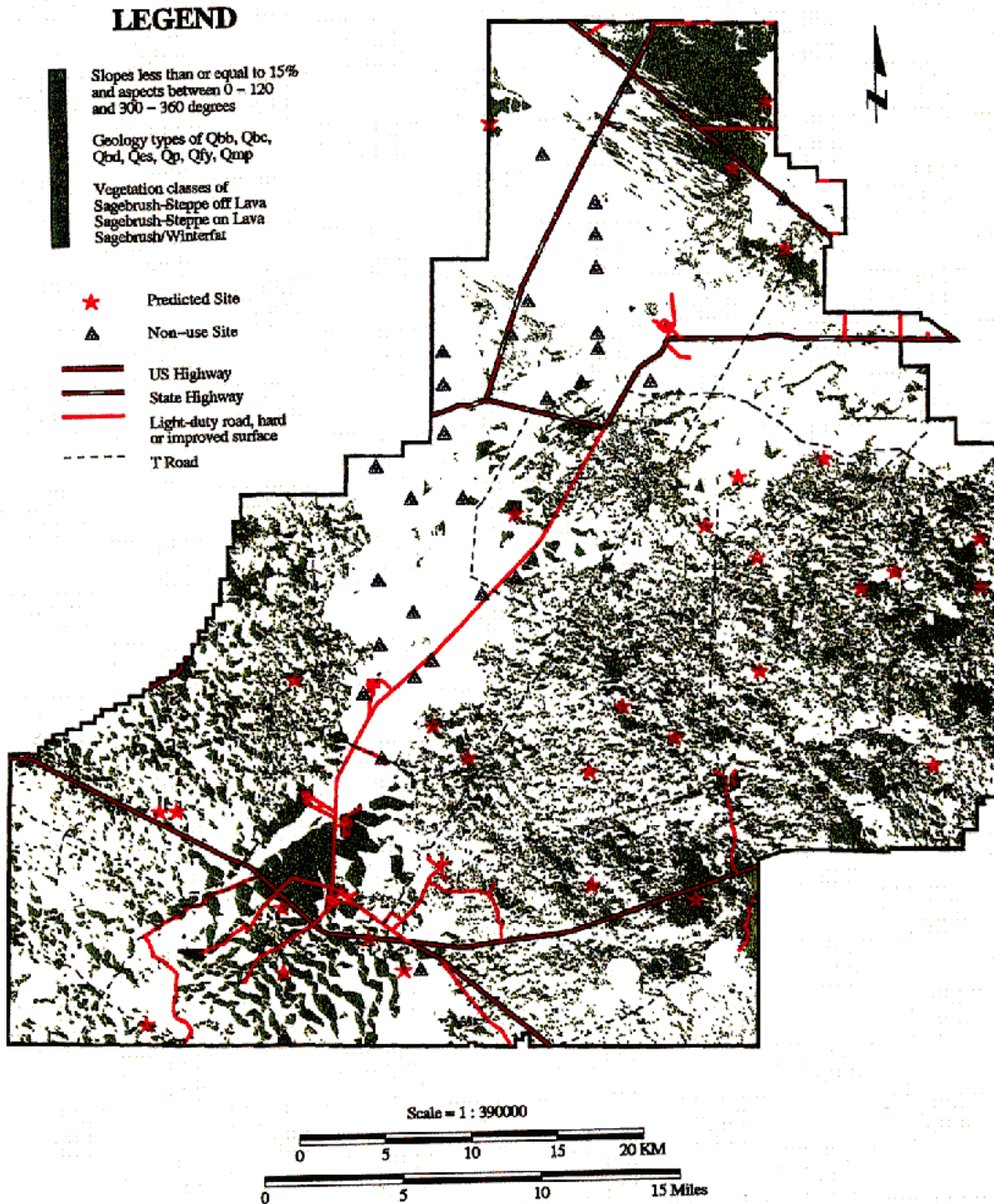


Figure 1. Map of study area.

Figure 2. Predicted appropriate vegetation, geologic, slope, and aspect classes. The seven geologic classes are: surficial alluvial deposits of Pinedale age (upper Pleistocene) along mainstreams (Qmp), younger fan alluvium (upper Pleistocene) (Qfy), playa deposits (Holocene to upper Pleistocene) (Qp), and Eolian sand (Holocene to upper Pleistocene) (Qes) and basaltic lava flows and pyroclastic deposits ranging in age from 15,000 to 730,000 years old (Qbb, Qbc, Qbd). Areas where both layers overlap represent predicted pygmy rabbit habitat. All other areas represent predicted non-use areas. The predicted sites and predicted non-use sites searched in this study are displayed.



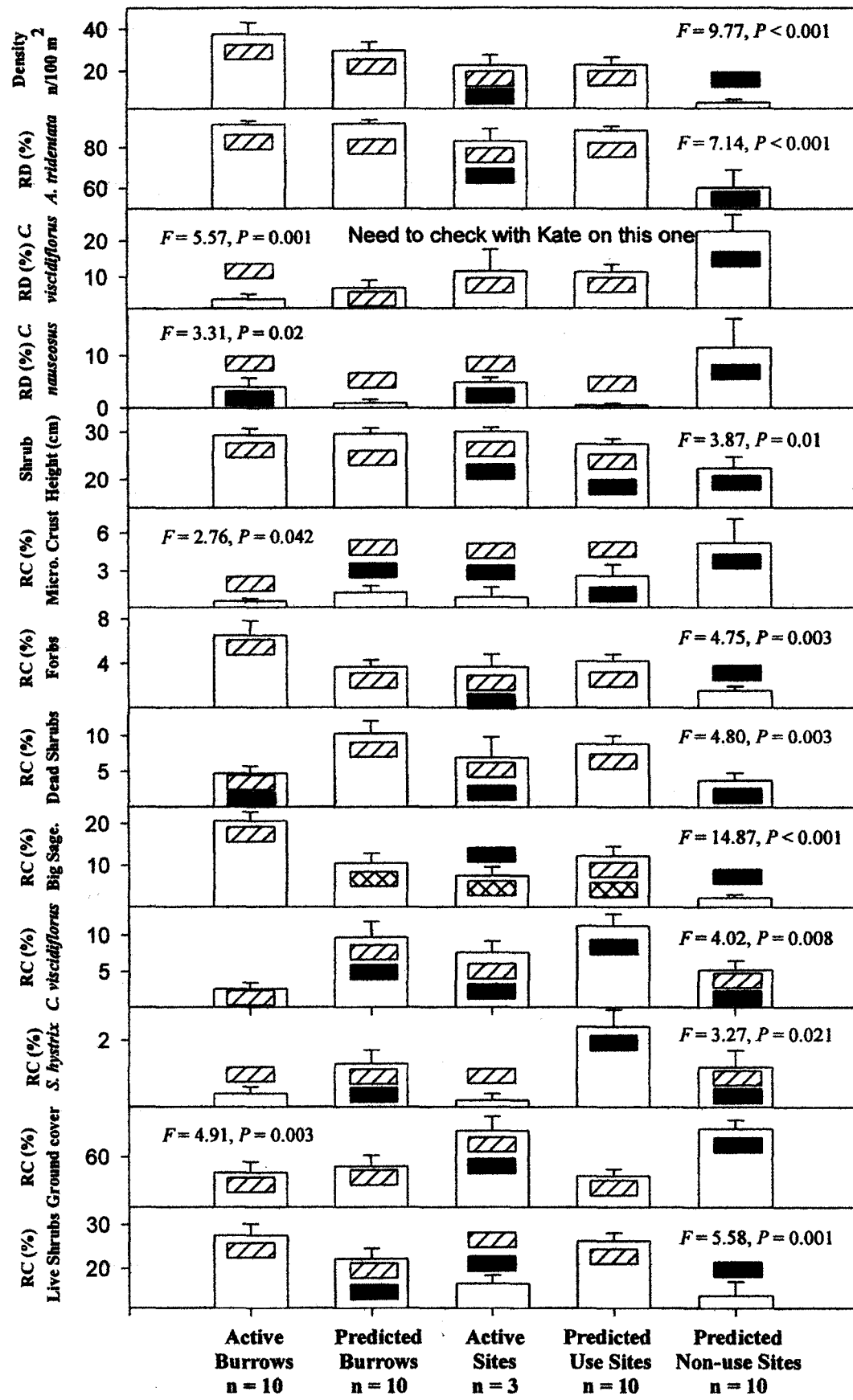


Figure 3. Results of comparisons of various vegetal characteristics on the Habitat-scale among the five types of sites.

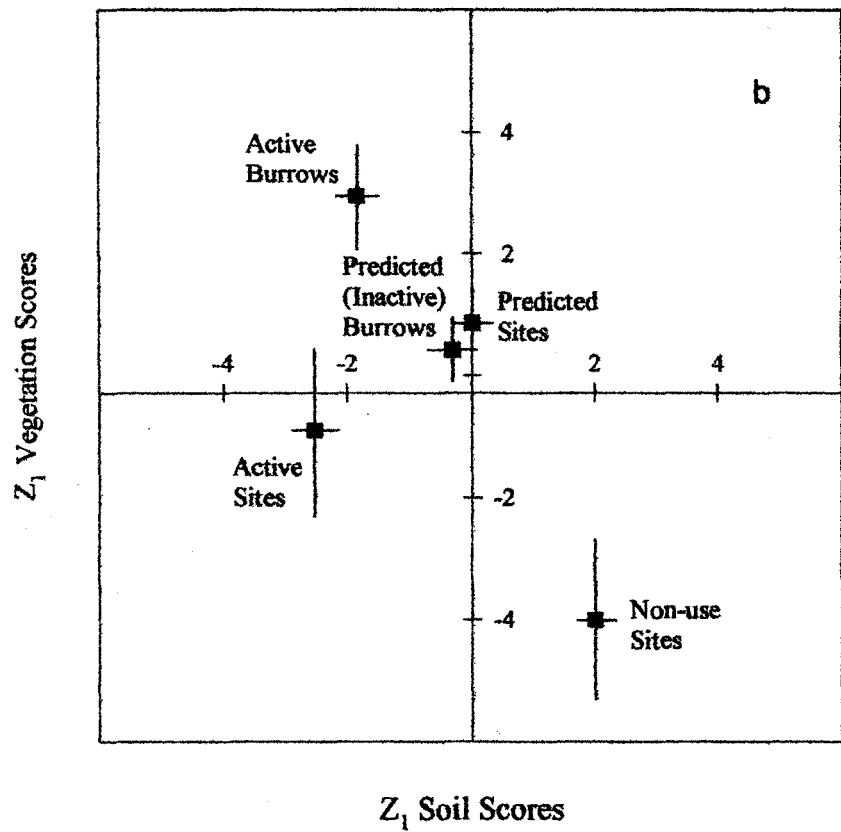
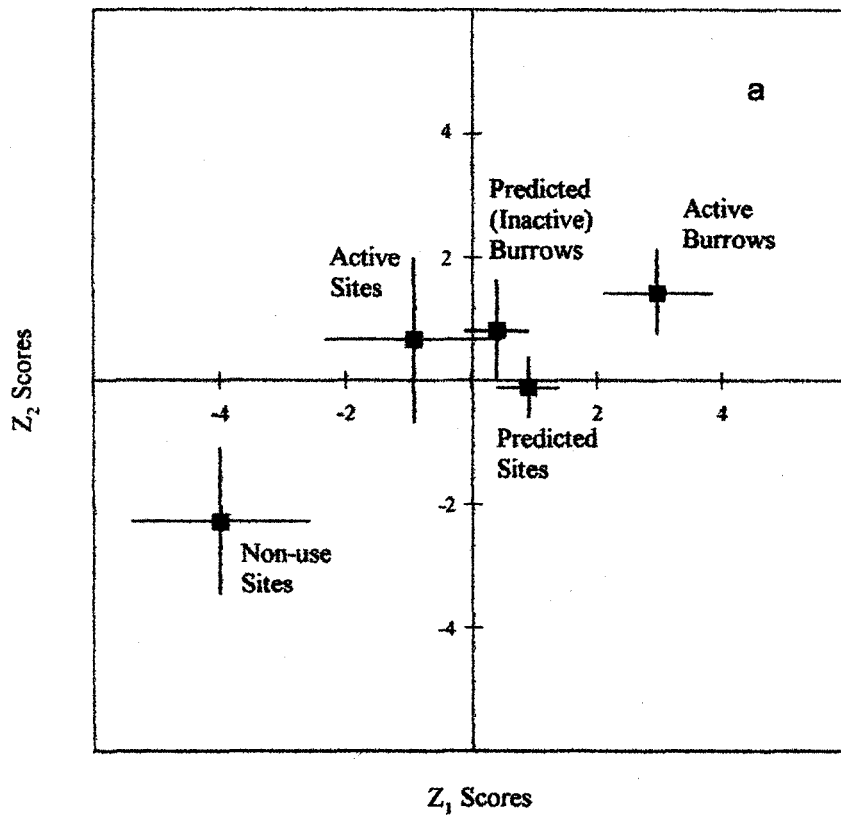


Figure 4. Plot of the Z_1 and Z_2 Scores from the PCA analysis of vegetation variables (a) and of the Z_1 for vegetation and Z_1 for soil variables (b) for the five different use areas.