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A HABITAT SUITABILITY MODEL FOR PYGMY RABBITS (*BRACHYLAGUS IDAHOENSIS*) IN SOUTHEASTERN IDAHO

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ABSTRACT.—A habitat suitability model was developed for pygmy rabbit (*Brachylagus idahoensis*) habitat on the Idaho National Engineering and Environmental Laboratory (INEEL) in southeastern Idaho. Suitable pygmy rabbit areas were characterized by greater cover and density of total shrubs and big sagebrush (*Artemisia tridentata*), as well as greater forb cover. Soil texture also played an important role in distinguishing suitable pygmy rabbit areas from nonuse sites. Principal components analysis (PCA) of several vegetation variables and soil texture was used to develop a habitat suitability model for pygmy rabbit habitat. This model, which can be used to successfully distinguish between pygmy rabbit use and nonuse areas on the INEEL, has the potential for use throughout the pygmy rabbit's range.

Key words: pygmy rabbit, Brachylagus idahoensis, *habitat suitability, southeastern Idaho, INEEL, vegetation, soil texture.*

Pygmy rabbits (*Brachylagus idahoensis*) are restricted to sagebrush-steppe areas of the Great Basin and adjacent intermountain regions. Within this area their distribution is further limited by the availability of "suitable" habitat for the construction of burrow systems. Several studies have attempted to describe characteristics of this suitable habitat for pygmy rabbits. These studies generally concluded that pygmy rabbits tend to prefer taller and denser stands of big sagebrush (*Artemisia tridentata*) within sagebrush-dominated areas (Grinnell et al. 1930, Orr 1940, Severaid 1950, Green 1978, Green and Flinders 1980, White et al. 1982, Gahr 1993, Katzner 1994, Katzner and Parker 1997). Weiss and Verts (1984) found shrub cover was the best of 10 variables for distinguishing sagebrush sites occupied by pygmy rabbits. Mean shrub cover in areas occupied by pygmy rabbits ranged from 29% in Oregon (Weiss and Verts 1984) to 43–46% in Idaho and Wyoming (Green 1978, Green and Flinders 1980, Katzner and Parker 1997). These values were in contrast to 16% (Green 1978, Green and Flinders 1980,Weiss and Verts 1984) to 26% cover (Katzner and Parker 1997) for nonuse areas. Possible reasons for the preference for greater sagebrush cover are that it constitutes a large portion of their diet (Green and Flinders 1980) and may offer better protection from predators. Compared to larger leporids, pygmy rabbits are relatively slow and may better elude predators when under a shrub canopy (Orr 1940, Wilde 1978).

Other factors that may define pygmy rabbit habitat are soil depth and texture (Weiss and Verts 1984). Kehne (1991) found 96% of pygmy rabbit burrow sites in Washington in soils at least 51 cm deep, and 72% of burrow sites had either coarse silty, ashy, or coarse loamy soils, all with <18% clay.

Beyond the general preference of pygmy rabbits for taller and denser sagebrush cover and deep, sandy soils, little more is known of their specific habitat requirements. Additionally, there are often areas with appropriate looking woody vegetation and physiognomy that are not necessarily suitable pygmy rabbit habitat (Green and Flinders 1980). Green and Flinders (1980) hypothesized that subtle variations other than sagebrush density in the vegetative component make an area appropriate for pygmy rabbits. This hypothesis has not yet been tested and the question remains: How specific is habitat selection by pygmy rabbits?

Given the pygmy rabbit's restriction to sagebrush-steppe, loss of this habitat type could impact the species' survival. This is increasingly so if only a subset of the habitat is suitable. If there is indeed a unique and identifiable subset of habitat factors pygmy rabbits are selecting, this information could be used

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to develop a predictive habitat suitability model. This model could then be used to assess the suitability of specific areas for pygmy rabbits and help develop sound conservation management plans for the species.

We investigated habitat requirements of pygmy rabbits in a 2305-km^2 area of sagebrush-steppe in southeastern Idaho. Given what is known of pygmy rabbit habitat, we generated and tested 3 predictions. First, habitat characteristics between areas of use and nonuse have the largest differences across several vegetal axes. Second, if rabbits are selecting on a finer scale, then there are significant differences in characteristics between actual burrow sites and surrounding areas. Third, if some burrow sites are better than others, there are differences in habitat characteristics between occupied and unoccupied or abandoned burrow sites. The support or refutation of these predictions will help determine the scale of habitat selection by pygmy rabbits and contribute to the development of a predictive habitat model for assessing the suitability of a given area for pygmy rabbits.

STUDY AREA

The study was conducted on the Idaho National Engineering and Environmental Laboratory (INEEL). The INEEL is located on the Snake River plain in southeastern Idaho (Fig. 1). Mean annual precipitation at the INEEL is 22 cm, most of which falls from winter to early summer. Snowcover usually persists for at least 2–3 months. Temperature ranges from –9°C to 35°C. Prevailing winds over much of the INEEL come from the southwest (Yanskey et al. 1966).

The surface of the INEEL is relatively flat with some basalt flows and a few volcanic buttes. The subsurface is made up of basalt from past lava flows. Most of the soil is derived from older silicic volcanic and Paleozoic rocks from the surrounding mountains (McBride et al. 1978). In the southern portion of the INEEL, soils tend to be gravelly, while in the northern portion the soil is made up of lake and aeolian deposits composed mainly of unconsolidated clay, silt, and sand (Kramber et al. 1992). Soil depth on the INEEL typically varies from a few centimeters on the more recent or exposed flows to several meters in low-lying areas. Accumulation is also greater on leeward sides of lava ridges and on alluvial fans. The native vegetation at the INEEL consists of a shrub overstory with an understory of perennial grasses and forbs (Anderson et al. 1996).

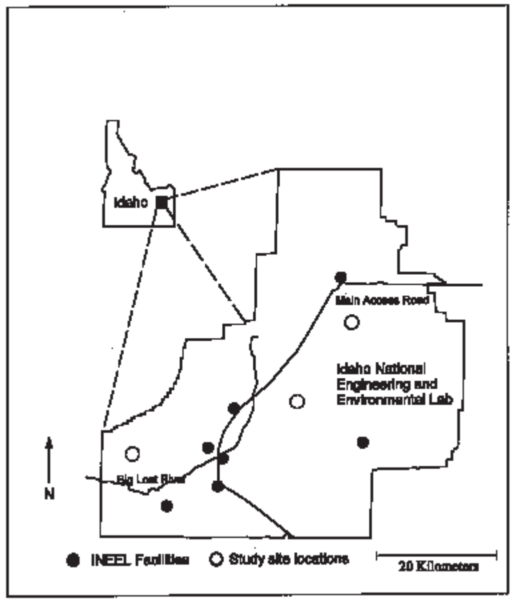


Fig. 1. Idaho National Engineering and Environmental Laboratory (INEEL).

METHODS

Sampling Habitat Characteristics

We measured habitat characteristics on plots within 5 different pygmy rabbit use categories (Fig. 2) defined as follows:

1. *Occupied burrow site*: a 40 × 40-m plot centered on an occupied pygmy rabbit burrow discovered during road surveys of the study area (Gabler 1997).
2. *Unoccupied burrow site*: a 40 × 40-m plot centered on an inactive burrow discovered within areas of predicted habitat as defined by GIS analysis (Gabler 1997).
3. *Active area*: a 360 × 360-m plot centered on occupied burrow sites.
4. *Inactive area*: a 360 × 360-m plot centered on an unoccupied burrow site.
5. *Nonuse area*: a 360 × 360-m unoccupied plot in areas of predicted nonuse habitat as defined by GIS analysis (Gabler 1997).

Habitat characteristics were measured within 10 occupied burrow sites, unoccupied burrow sites, inactive areas, and nonuse areas. Because occupied burrow sites were clustered such that 360 × 360-m plots around each site overlapped, only 3 active areas were defined in which habitat characteristics were measured.

We measured habitat characteristics at each sample point within the study plots. In the occupied and unoccupied burrow site plots, habitat variables were measured at 17 sampling points. These variables were sampled at the point centered directly at the burrow system entrances (Fig. 2) and at the surrounding 16 points formed by the 30 × 30-m grid (Fig. 2A). In the active, inactive, and nonuse area plots, the 360 × 360-m sampling grid was divided into 10-m intervals along the east–west axis. Four random points were chosen to serve as the origin of north–south oriented transects (Fig. 2), and 6 random points were sampled along each transect for a total of 24 sample points per grid (Fig. 2B.). Mean measurements of each habitat variable (N = 17, occupied and unoccupied burrow sites; N = 24, active, inactive, and nonuse areas) were used to compare the 5 use categories.

We used 2 techniques to measure the habitat characteristics, point-quarter sampling (Brower et al. 1990) and point interception (Floyd and Anderson 1982). For the point-quarter method, distance to the nearest tall shrub (>50 cm) and distance to the nearest short shrub (<50 cm) were measured in each quarter. A height of 50 cm was arbitrarily chosen to separate the tall shrub community from the short shrub community. Distance measurements were then used to calculate total shrub density (TD)/100 m^2 and relative density (RD) for major shrub species in the tall and short categories according to Brower et al. (1990). The major shrub species measured were big sagebrush, green rabbitbrush (*Chrysothamnus viscidiflorus*), and gray rabbitbrush (*C. nauseosus*). In addition, we estimated shrub cover for the 2 height classes by measuring the longest diameter of live canopy and the perpendicular diameter. These 2 measurements were then used as the X and Y diameters of an ellipse to estimate cover area.

The point-frame method (Floyd and Anderson 1982) was used to estimate relative cover (RC) for various vegetation and habitat classes, including microbiotic crust, individual shrub species, total dead shrubs, individual grass species, total forbs, bare ground, litter, and rock. These classes were then lumped into larger coverage categories: total live shrubs, total grasses, and total groundcover excluding vascular vegetation and rocks. Relative coverage was calculated as:

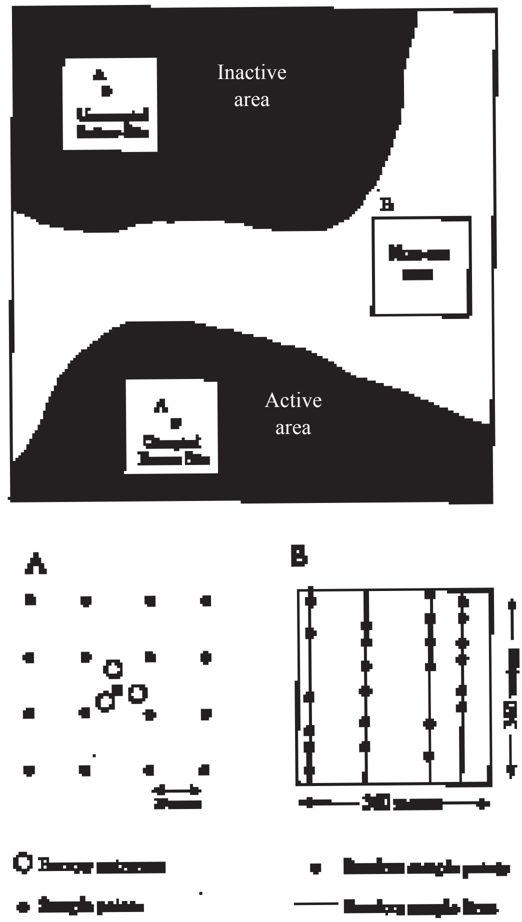


Fig. 2. Three scales used to measure habitat characteristics for pygmy rabbits (*Brachylagus idahoensis*) on the INEEL: (1) directly at pygmy rabbit burrow systems (A); (2) in a 30 × 30-m grid around each burrow system (A); and (3) in a 360 × 360-m grid encompassing the burrow systems, both active and inactive, and in nonuse areas (B).

$$RC_i = n_i/s*36,$$

where n_i is the number of "hits" (Floyd and Anderson 1982) of cover type I, s is the number of sample points (17 or 24), and 36 is the number of sample points within the frame.

Diversity for each site was also calculated using the Shannon-Weiner index (Zar 1984).

In addition to vegetation measurements, we collected surface soil samples from 3 points directly next to burrow entrances and from 5 randomly selected points within each 360 × 360-m plot. Particle size analysis was conducted for each sample. The hydrometer method described by Palmer and Troeh (1995), with modifications as described in Gabler (1997), was used.

Data Analysis

Means of habitat characteristics were compared among occupied burrow sites, unoccupied burrow sites, active areas, inactive areas, and nonuse areas. We used univariate comparisons to first identify which individual habitat characteristics might differ among the various sites, followed by multivariate analysis (principal components analysis [PCA]; Morrison et al. 1992) to determine if the collective composition of the various sites differed. We then compared the outcome of each to help identify which habitat variables likely were most important relative to selection of habitat by pygmy rabbits.

A 1-way analysis of variance (ANOVA) was used for the univariate analysis to test the null hypothesis that no difference existed among the 5 plot types for any of the habitat variables. Alpha levels were adjusted for multiple comparisons using the Bonferroni method. If the null hypothesis was rejected in an ANOVA, a Tukey multiple-comparisons test was performed to determine differences among treatments. All variables measured as percentages were arcsine transformed.

For the PCA analysis, we generated standardized Z_1 and Z_2 principal component loadings for each variable. After the 1st pass, variables with low loadings (<0.1) were eliminated. The remaining variables were reanalyzed and their loadings were used to generate Z_1 and Z_2 scores for each plot type. Z_1 and Z_2 scores for the 5 plot types were compared with the ANOVA design described above. Separate PCA analyses and statistical tests were conducted for each vegetation characteristic and soil texture. The 2 resulting predictive equations were used as the predictive model for pygmy rabbit habitat. All statistical analyses were conducted using Systat for Windows (Wilkinson et al. 1992).

RESULTS

Of the 30 ANOVA tests performed for the different habitat characteristics measured, 13 indicated significant differences among the 5 plot types (Fig. 3). Range tests detected differences most often between nonuse areas and 3 of the 4 other plot types (occupied burrow sites, unoccupied burrow sites, and inactive areas). The separation between nonuse areas and occupied burrow sites was seen most often. In 11 cases in which significant differences were detected, nonuse areas had maximum mean values in 3 cases while occupied burrow sites had maximum values in 6 cases. Of the same 11 cases, there were 8 and 2 minimum mean values for nonuse areas and occupied burrow sites, respectively. Among the 4 plot types of actual use (occupied burrow sites, unoccupied burrow sites, active areas, and inactive areas), range testing detected significant differences only for relative cover of big sagebrush, green rabbitbrush, and squirreltail grass (*Sitanion hystrix*; Fig. 3). Of the 4 actual use categories, nonuse areas differed statistically the least often with active areas.

Soil Texture Analysis

At occupied burrow sites and active areas, mean percent sand was 81.0% and 87.5% while mean percent clay was 5.1% and 5.0%, respectively. The mean sand component at inactive areas and unoccupied burrow sites was 66.9% and 69.6%, respectively, with a mean clay component of 8.7% and 7.3%, respectively. The portion of sand and clay at nonuse areas was 51.6% and 14.4%, respectively. No univariate comparisons among treatments were made on the soil variables (% sand, % silt, and % clay) because they were all correlated.

Principal Component Analysis

Seventeen vegetation variables were used in a PCA. The number of variables chosen was based on their presence at all or most of the 43 plots. Variables used in the PCA included shrub height, canopy cover per shrub, and total density for both tall and short shrub communities; relative density of big sagebrush >50 cm tall; relative densities of big sagebrush and green rabbitbrush ≤50 cm tall; relative cover of bare ground, litter, forbs, dead shrubs, big sagebrush, total live shrubs, and total grass; and diversity index of shrub and grass species, relative

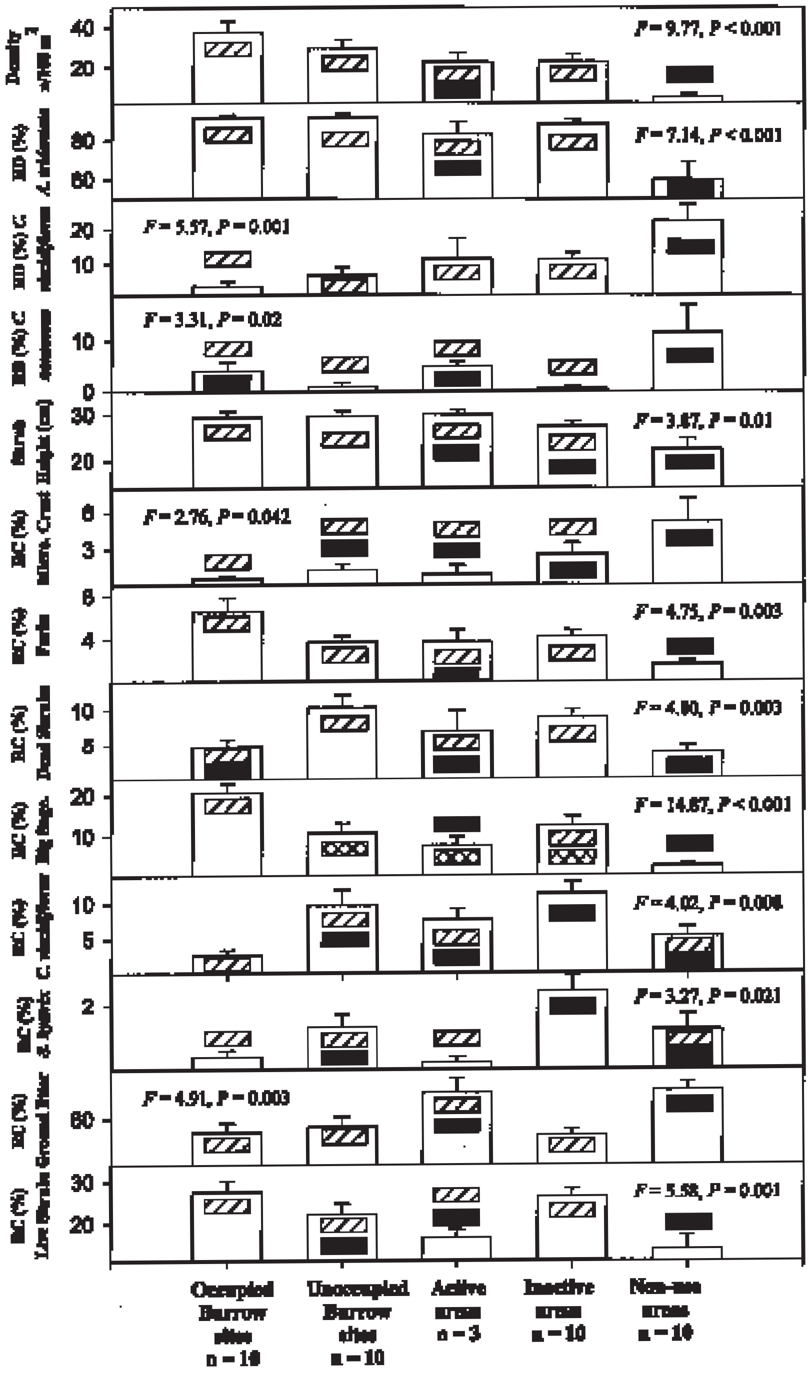


Fig. 3. Results of 1-way analysis of variance tests for those variables with significant *F*-values at the 5 sample site types. The means of groups within a variable that did not differ significantly in a Tukey multiple-comparison test are indicated by bars with the same fill pattern.

coverage of total forbs and total dead shrubs, and relative coverage of big sagebrush.

After calculating the first PCA, we deleted 7 of 17 variables from the analysis because they generated small component loadings relative to the other variables. A PCA of the remaining 10 variables defined the first 2 components, which accounted for 63% of variation among plots (Table 1). Six of these variables also differed significantly among plot types in univariate analysis.

From the first component, mean Z_1 scores for each plot type were significantly different (Table 2). This indicates a difference among plot types for the collective description of variables. Nonuse areas had a significantly negative Z_1 mean compared to occupied burrow sites, inactive sites, and unoccupied burrow sites (Table 2). The negative Z_1 mean for nonuse areas corresponded to high negative loadings in mean canopy cover per shrub for the tall shrub community, relative coverage of litter, and height of the tall shrub community (Table 1). These variables contributed inversely to the Z_1 score; therefore, higher values for these variables resulted in a lower Z_1 score.

Occupied burrow sites, inactive areas, and unoccupied burrow sites all had significantly positive Z_1 means. These corresponded to high positive loadings of relative big sagebrush density within the tall shrub community, relative coverage of total live shrubs, relative coverage of big sagebrush, relative coverage of forbs, total density of tall shrubs, and, to a lesser extent, total density and height of the short shrub community (Table 1). These variables contributed positively to the Z_1 score; therefore, higher values for these variables resulted in a larger Z_1 score. Because active areas had a mean Z_1 score that did not differ significantly from the other 4 plot types, active areas were assumed to be intermediate for Z_1.

Z_2 scores were calculated from the 2nd component and a 1-way ANOVA was performed on mean Z_2 scores. Significantly different Z_2 scores were detected only between nonuse

TABLE 1. Two 1st principal components derived from principal components analysis of 10 vegetation variables and the 2 components for soils in active pygmy rabbit (*Brachylagus idahoensis*) sites, occupied burrow sites, predicted pygmy rabbit sites, predicted (inactive) burrows, and nonuse sites on the Idaho National Engineering and Environmental Laboratory.

	Latent roots (eigenvalues) Vegetation 1	2		Soils 1	2
	3.58	2.76		2.68	0.31
VARIABLES[a]	1	2		1	2
Sagebrush tall	0.833	0.141	Sand	–0.994	0.100
Total live shrub	0.784	–0.117	Silt	0.948	–0.318
Sagebrush	0.737	0.482	Clay	0.893	0.450
Cover tall	–0.655	0.331			
Forbs	0.625	0.171			
Litter	–0.593	0.472			
Total density tall	0.562	0.584			
Height short	0.132	0.855			
Total density short	0.190	–0.813			
Height tall	–0.438	0.633			
	Percent of total variance explained				
	1	2		1	2
	35.8	27.6		89.5	10.45

[a]Sagebrush tall = relative density of *A. tridentata* >50 cm tall
Total live shrub = relative coverage of live shrubs
Sagebrush = relative coverage of *A. tridentata*
Cover tall = mean cover per shrub for shrubs >50 cm tall
Forbs = relative coverage of forbs
Litter = relative coverage of litter
Total density tall = total density of shrubs >50 cm tall
Total density short = total density of shrubs ≤50 cm
Height short = height of shrubs ≤50 cm
Height tall = height of shrubs >50 cm tall

TABLE 2. Results of 1-way analysis of variance tests on Z_1 and Z_2 vegetation scores and Z_1 soil scores among active pygmy rabbit (*Brachylagus idahoensis*) sites, occupied burrow sites, nonuse areas, predicted pygmy rabbit sites, and unoccupied burrows on the Idaho National Engineering and Environmental Laboratory. Means ± standard errors are listed and sample sizes are included in parentheses. Means of groups that did not differ significantly in a Tukey multiple-comparisons test are indicated by the same letter in superscript.

	Vegetation					
	Z_1 mean	F	P	Z_2 mean	F	P
Active areas (3)	-0.92 ± 1.4^{ab}	8.750	<0.001	0.64 ± 1.4^{ab}	3.170	0.024
Occupied burrow sites (10)	2.96 ± 0.8^{a}			1.41 ± 0.7^{a}		
Nonuse areas (10)	-3.99 ± 1.4^{b}			-2.29 ± 1.2^{b}		
Inactive areas (10)	0.89 ± 0.5^{a}			0.11 ± 0.5^{ab}		
Unoccupied burrow sites (10)	0.42 ± 0.5^{a}			0.81 ± 0.8^{ab}		

	Soil		
	Z_1 mean	F	P
Active areas (15)	-2.54 ± 0.5^{a}	20.92	<0.001
Occupied burrow sites (30)	-1.84 ± 0.3^{ab}		
Nonuse areas (50)	2.05 ± 0.3		
Predicted sites (50)	0.04 ± 0.3^{c}		
Unoccupied burrow sites (30)	-0.32 ± 0.4^{bc}		

areas and occupied burrow sites (Table 2). Nonuse areas had a significantly negative Z_2 score, which mainly corresponded to negative loadings in total density of short shrubs (Table 2). The significantly positive mean for occupied burrow sites corresponded with high positive loadings in height of both tall and short shrubs, total density of tall shrubs, and coverage of big sagebrush and litter (Table 2). Z_1 and Z_2 scores were plotted against each other (Fig. 4A).

For the PCA of the 3 soil texture variables, the 1st principal component accounted for 89.5% of overall variation between sites (Table 1). The 2nd component explained only 10.5% of the variability and therefore was not analyzed. Loadings for the 1st component were used to calculate Z_1 scores for occupied burrow sites, unoccupied burrow sites, active areas, inactive areas, and nonuse areas. Nonuse areas had a significantly positive Z_1 mean compared to the other 4 plot types (Table 2). This positive mean corresponded to high positive loadings for silt and clay (Table 1). Active areas and occupied burrow sites, however, had negative means, corresponding to high sand values. These 2 site types did not differ significantly from each other and thus were assumed to have a similarly high sand content. The inactive areas and unoccupied burrow sites were more intermediate, with a greater sand component at the unoccupied burrow sites. Unlike inactive areas, unoccupied burrow sites did not differ significantly from occupied burrow sites and active areas (Table 2).

A plot of the vegetation and soil Z_1 scores (Fig. 4B) produced distinct separations among the 5 different plot types, with occupied burrow sites and nonuse areas the most separated from the other 3.

Habitat Suitability Model

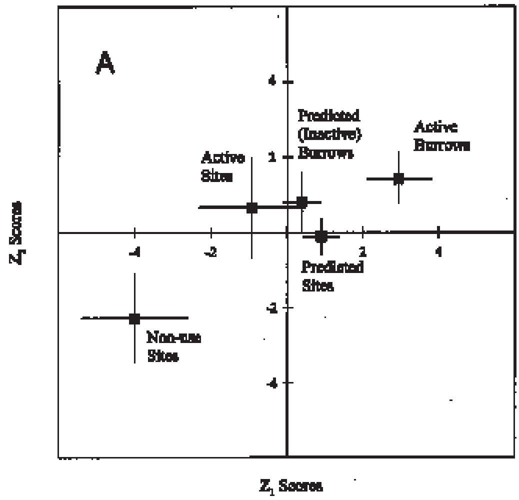
Based on results of the vegetation and soil PCA, we formulated the following equations from the Z_1 scores for use as a habitat suitability model:

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

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

where:

ST = relative density of *A. tridentata* >50 cm tall
TLS = relative coverage of live shrubs
SB = relative coverage of *A. tridentata*
CT = mean cover per shrub for shrubs >50 cm tall
L = relative coverage of litter
F = relative coverage of forbs
TDT = total density of shrubs >50 cm tall
TDS = total density of shrubs ≤50 cm



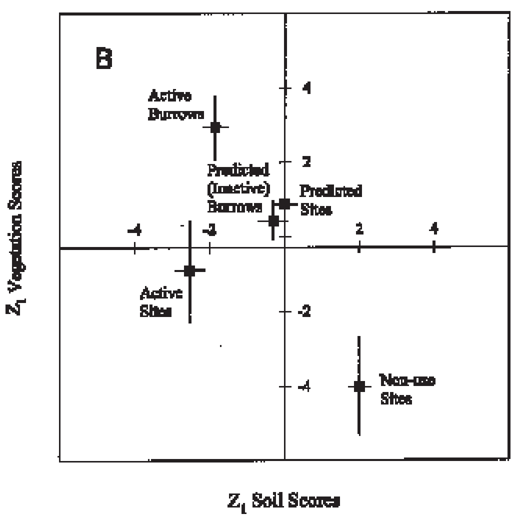


Fig. 4. Plots of mean Z_1 and Z_2 vegetation scores ($\pm s_{\bar{x}}$) (4A) and mean Z_1 vegetation and Z_2 soil scores ($\pm s_{\bar{x}}$) (4B) for the 5 pygmy rabbit use site types on the INEEL.

HS = height of shrubs ≤50 cm
HT = height of shrubs >50 cm tall

DISCUSSION

Results of our study suggest that pygmy rabbits select burrow sites based on a fairly unique, and thus identifiable, combination of vegetation variables and soil characteristics (prediction 1). This was indicated by both the comparisons of individual habitat variables and PCA score differences between the 4 use categories and the nonuse areas. One of the major contributing factors to the observed differences among use categories was the relative cover of big sagebrush; relative cover at use areas ranged from 3 to 10 times greater than at nonuse areas. This result corresponds with findings of others (Grinnel et al. 1930, Orr 1940, Severaid 1950, Green and Flinders 1980, Weiss and Verts 1984, Gahr 1993, Katzner and Parker 1997). Because 51–99% of pygmy rabbit diet consists of big sagebrush (Green and Flinders 1980), greater sagebrush cover would represent greater food resources for the pygmy rabbit. Greater shrub cover may also represent better protection from predators. Pygmy rabbits move more slowly and are more vulnerable in open habitats than are other leporids (Orr 1940) and therefore are thought to better elude predators while under a shrub canopy (Orr 1940, Wilde 1978). In addition to big sagebrush, our results indicate other vegetal variables, such as ground litter, relative coverage of forbs, and characteristics of the short (<50 cm) shrub community, also likely play a role in the suitability of an area for pygmy rabbits. The inability of multiple range tests to distinguish between active areas and nonuse areas likely is due to the small sample size (3) for active areas.

A 2nd result of our study was that, within use areas, there were identifiable differences in vegetation characteristics between occupied burrow sites and the surrounding (360 × 360-m) active areas (prediction 2). It is not clear, however, whether those differences were caused by detailed selection by pygmy rabbits or modifications of the burrow area. For example, increased activity at burrows by pygmy rabbits may prevent new shrubs from establishing, allowing the existing shrubs to grow larger (Wilde 1978, Gahr 1993). Differential consumption of grasses and forbs by the pygmy rabbit may decrease grass biomass and allow forbs a competitive advantage (Green and Flinders 1980). It also may explain the higher forb density found in this study at occupied burrow sites. However, neither we nor Weiss and Verts (1984) detected any difference in grass cover among sites; thus, whether pygmy rabbits have an effect on forb and grass densities is not completely known. Pygmy rabbits may in fact modify the environment surrounding their burrows; however, indications are that they also select for subtle vegetation differences for the placement of their burrows within what could be considered acceptable habitat.

Last, we also found differences between occupied burrow sites and unoccupied burrow sites (prediction 3). This suggests that pygmy rabbits are not only selecting specific habitat characteristics within the "acceptable" range, but they also may be making distinctions among various usable burrow sites. Although both occupied and unoccupied burrow sites are considered suitable pygmy rabbit habitat, when pygmy rabbit populations are low, as they appeared to be during this study (Gabler 1997), populations may shrink back into more optimal burrow habitat. Occupied burrow sites may represent this optimal habitat by providing more sagebrush cover. Unoccupied burrow sites may represent secondary habitat that is utilized only when pygmy rabbit densities are higher. Again, pygmy rabbits may be modifying the environment around their burrows. Then, once the burrows are abandoned, the area reverts back to conditions similar to the surrounding areas. There is some support for this explanation, as little difference was observed between unoccupied burrow sites and inactive areas. These 2 contradicting hypotheses could be tested by a temporal study of burrow systems as they change from occupied to unoccupied. Such data could also give more insight into whether pygmy rabbit population density affects habitat selection. Factors other than habitat differences could also explain why pygmy rabbits abandon burrows, e.g., depletion of food resources, predator avoidance, etc. Again, a temporal study of burrow systems would help clarify the possible role of these factors.

If pygmy rabbits select for burrow locations on such a fine scale within suitable habitat, as inferred by this study, the implications could be considerable. For example, although 23.4% of the INEEL contains areas most likely to contain pygmy rabbit burrows within predicted habitat (Gabler 1997), a much smaller portion of those areas may actually be suitable for burrow locations. Therefore, even slight habitat changes within these smaller areas could render some areas unsuitable for burrow construction.

Habitat Suitability Model

Given the measured vegetation and soil differences among the different use categories, the proposed habitat suitability models could be used to (1) determine suitable pygmy rabbit areas and nonuse areas and (2) possibly rank sites within suitable areas.

If the recommended variables for vegetation and soil are collected at a location and the values are standardized, resulting Z_1 scores can be compared to those from different use categories in this study (Fig. 4). For example, if a Z_1 vegetation score for an area is around –4 and the Z_1 soil score is about +2, then it is likely a nonuse area (Fig. 4B). If a Z_1 vegetation score for an area is around +3 and the Z_1 soil score is less than zero, then it has the potential of a highly preferred burrow site (Fig. 4B). An area that has more intermediate Z_1 vegetation scores and Z_1 soil scores that are close to zero (Fig. 4B) may be usable but would not be a preferred site.

CONCLUSIONS

Evidence from other studies (Weiss and Verts 1984, Washington Department of Fish and Wildlife 1995) suggests that pygmy rabbits have declined within their range over this last century. Their numbers are also susceptible to rapid declines (Janson 1946, Bradfield 1975, Weiss and Verts 1984), and population recovery may be very slow (Wilde 1978). The loss of suitable sagebrush habitat to agriculture and the conversion of these lands to accommodate grazing appear to be extensive. These factors, coupled with an increase in fire frequency within this century, pose serious threats to pygmy rabbit habitat (Chapman et al. 1990, Gabler 1997).

This study has found that variables important to pygmy rabbit critical habitat are identifiable. Pygmy rabbits appear to select suitable habitat based on a complex of vegetation and soil characteristics. By incorporating these variables, the habitat suitability model provides an excellent tool for identifying nonuse areas and is a fairly good indicator of potential use areas. As such, the habitat suitability model may help land managers identify potential pygmy rabbit habitat and thereby prevent further loss and degradation of pygmy rabbit habitat when making land-use decisions. This model has great potential for use throughout the pygmy rabbit's range to aid in the conservation of pygmy rabbit habitat and, ultimately, to aid in the conservation of this species.

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