



11-11-2005

## Habitat use patterns within the home range of pygmy rabbits (*Brachylagus idahoensis*) in southeastern Idaho

Laura T. Heady  
*Idaho State University, Pocatello*

John W. Laundré  
*Instituto de Ecología, A.C. Durango, México*

Follow this and additional works at: <https://scholarsarchive.byu.edu/wnan>

### Recommended Citation

Heady, Laura T. and Laundré, John W. (2005) "Habitat use patterns within the home range of pygmy rabbits (*Brachylagus idahoensis*) in southeastern Idaho," *Western North American Naturalist*. Vol. 65 : No. 4 , Article 7.

Available at: <https://scholarsarchive.byu.edu/wnan/vol65/iss4/7>

This Article is brought to you for free and open access by the Western North American Naturalist Publications at BYU ScholarsArchive. It has been accepted for inclusion in Western North American Naturalist by an authorized editor of BYU ScholarsArchive. For more information, please contact [scholarsarchive@byu.edu](mailto:scholarsarchive@byu.edu), [ellen\\_amatangelo@byu.edu](mailto:ellen_amatangelo@byu.edu).

## HABITAT USE PATTERNS WITHIN THE HOME RANGE OF PYGMY RABBITS (*BRACHYLAGUS IDAHOENSIS*) IN SOUTHEASTERN IDAHO

Laura T. Heady<sup>1</sup> and John W. Laundré<sup>2</sup>

**ABSTRACT.**—Pygmy rabbits (*Brachylagus idahoensis*) are a small sagebrush (*Artemisia tridentata*) obligate lagomorph found within the Great Basin of northwestern United States. Because of its reliance on sagebrush, this species is thought to be experiencing a major range reduction as a result of loss of sagebrush habitat. To aid in conservation of this species, we need to better understand its use of the sagebrush environment. We estimated summer home range use patterns by relocating 5 radio-collared pygmy rabbits (3 females and 2 males) over a 24-hour cycle. We then compared soil texture, shrub density, height, and canopy cover between areas close to burrow entrances and areas of high use and low use. Mean home range sizes of female and male rabbits were 37.2 and 67.9 ha, respectively. Rabbits had disproportionate amounts of time ( $68.4\% \pm 9.1, s_{\bar{x}}$ ) and travel ( $63.0\% \pm 5.7, s_{\bar{x}}$ ) in areas within a 60-m radius of their burrows. Soil texture did not differ among the 3 areas, but shrub density, specifically big sagebrush, and forb density were significantly higher close to the burrow than in the high- and low-use areas. We conclude that pygmy rabbits are possibly burrow obligates and that their abundance and distribution are likely limited by available burrow sites.

*Key words:* pygmy rabbit, *Brachylagus idahoensis*, home range use, habitat selection.

In the field of conservation biology, there is an increasing emphasis on shifting conservation efforts from the single species to the community and ecosystem level (McNaughton 1989). In this effort, however, data on single species are still relevant and necessary to ensure the protection of all representatives of a biological community. This is especially true for highly specialized species. This is the case for the pygmy rabbit (*Brachylagus idahoensis*). Pygmy rabbits are considered unique among leporids for several reasons. The main factor is their reliance on big sagebrush (*Artemisia tridentata*) as their primary food source. The shrub constitutes 99% of their winter and 51% of their summer diet, which is supplemented by grasses (39%) and forbs (10%; White et al. 1982). Consequently, their range has historically been limited to the sagebrush area of the Great Basin and some adjacent intermountain areas. Also unique among western North American rabbits is pygmy rabbits' reliance on burrows. They typically construct their burrow systems under clumps of big sagebrush, which is further evidence of the importance of sagebrush to pygmy rabbit survival.

Because of these life history characteristics, pygmy rabbits are sagebrush obligates and are

sensitive to anthropogenic changes (e.g., fires, cattle grazing, habitat fragmentation) currently occurring in the sagebrush steppe. Consequently, the status of the pygmy rabbit varies throughout its range from locally common to endangered, with its overall distribution generally reduced from historic levels (Chapman et al. 1990, Washington Department of Fish and Wildlife 1995). Because of the pygmy rabbit's dependence on sagebrush, conservation efforts for this species must center on understanding the vegetative factors important in their use of the sage-steppe habitat.

Vegetative structure and physiography at burrow sites are well documented, with significantly higher shrub cover and density and deeper soils than at non-burrow areas (Green and Flinders 1980, Weiss and Verts 1984, Pritchett et al. 1987, Gahr 1993, Katzner 1994, Gabler et al. 2001). However, the burrow is only one element of the pygmy rabbit's home range area. Although potentially as important, only limited data exist on the use and habitat characteristics of other parts of the home range. Katzner and Parker (1997) documented winter use of areas surrounding burrows but commented that the use pattern seen may be attributed more to the patchy nature of the

<sup>1</sup>Department of Biological Sciences, Idaho State University, Pocatello, ID 83209.

<sup>2</sup>Corresponding author: Instituto de Ecología, A.C., Centro Regional Durango, Km 5 Carr. a Mazatlán, C.P. 34100, Durango, Durango, México.  
e-mail: launjohn@hotmail.com.

study area and snowcover than to possible selection by pygmy rabbits. We found no available information on use or habitat composition of summer home ranges. Thus, based on current information, conservation efforts for this species would rely on characteristics around burrow sites as the only factors critical to pygmy rabbit habitat. Clearly, to better address the conservation needs of pygmy rabbits, we need more information, especially in the summer, on how pygmy rabbits use their home range area and on vegetation characteristics of other parts of the home range.

Our objective was to study behavioral use, vegetation, and physiographic features of summer home ranges of pygmy rabbits in southeastern Idaho. We did this by testing the following predictions: (1) pygmy rabbits do not use their home range with equal intensity (i.e., within the home range, areas of high and low use can be identified), and (2) these areas of varying use levels correspond to differences in habitat characteristics. The results of these tests should help increase our knowledge of factors critical to pygmy rabbit survival and be useful in efforts toward conserving this species.

#### STUDY SITE

The Idaho National Engineering and Environmental Laboratory (INEEL) is a U.S. Department of Energy research facility located approximately 80 km northwest of Pocatello, Idaho. The INEEL is approximately 2300 km<sup>2</sup>, relatively flat, and around 1500 m in elevation. Annual temperature averages 5.6°C, and average annual precipitation is about 22 cm.

Site vegetation is sagebrush steppe dominated by big sagebrush–bunchgrass associations. Common shrub species include big sagebrush, green rabbitbrush (*Chrysothamnus viscidiflorus*), and gray rabbitbrush (*C. nauseosus*); most abundant grasses are thick-spiked wheatgrass (*Elymus lanceolatus*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread grass (*Stipa comata*), Nevada bluegrass (*Poa secunda*), and bottlebrush squirreltail (*Elymus elymoides*). The INEEL also supports a high diversity of forbs. A complete description of vegetation appears in Anderson et al. (1996).

The study was conducted on 2 sites of the INEEL that differ in topography and geology. The 1st site (Old 26), located in the southwestern portion of the INEEL, is on an old lava

flow with variable topography at an elevation of approximately 1615 m above sea level. The 2nd site (Northern site) is located in the northern part of the INEEL on a relatively flat area with stable eolian sand dunes. Elevation of the Northern site is approximately 1460 m above sea level. Both study areas consist of vegetation classified as sagebrush steppe (Anderson et al. 1996).

#### METHODS

##### Trapping and Telemetry

We trapped pygmy rabbits in 1995 and 1996 with live-traps (#106, 65 × 23 × 23 cm; Tomahawk Live Trap Co., Tomahawk, WI) baited with apple slices and set in the vicinity of active burrows. Heavy plastic wrapping or small plywood boards were placed over one end of each trap to create additional shelter for trapped individuals.

We transferred captured rabbits into a black cloth bag to minimize stress during handling. We fitted radio collars (Model SOM-2380A; Wildlife Materials, Inc., Carbondale, IL) to the captured animals and then released them. Trapping and handling procedures were in accordance with the animal welfare protocol approved by the Animal Welfare Committee at Idaho State University.

To determine patterns of home range use (prediction 1), we tracked collared rabbits from 2 fixed telemetry stations, approximately 500–750 m apart. We identified the position of each telemetry station in universal transverse mercator (UTM) coordinates with a Trimble global positioning system (GPS; Trimble Navigation Limited, Sunnyvale, CA) and differentially corrected with Trimble PathfinderPro software. Each station had a Telonics TR-4 receiver and twin 4-element yagi directional antennas with null-peak junction boxes (Telonics, Inc., Mesa, AZ; Laundré and Keller 1981). Every 15 minutes we estimated collared animals' locations by taking simultaneous compass bearings from compass roses mounted on the antenna mast at each station. By taking simultaneous bearings at fairly close distances (within 250–350 m) and by frequently calibrating the telemetry stands, we attempted to minimize triangulation error. We determined triangulation error by taking fixes on a stationary transmitter at a known location. Thus, we

estimated that displacement of a pygmy rabbit's true position was  $\pm 10.1$  m. During the 1995 field season, all telemetry sessions consisted of continuous 24-hour blocks, except two 12-hour sessions. Due to a decrease in available personnel in 1996, sessions were 8-hour and 12-hour blocks. However, we appropriately sampled the 8-hour and 12-hour blocks to most equally represent the 24 hours of a full day.

#### Identification of Home Range Size and Use

We used the grid method to estimate home range use patterns (Rongstad and Tester 1969, Fossey 1974, Laundré and Keller 1981, White and Garrott 1990). We divided the spatial area used by a monitored individual into a matrix of 900-m<sup>2</sup> (30-m  $\times$  30-m) grid cells, defined by UTM coordinates. We estimated the locations, in UTMs, of an individual within the grid at each successive fix from raw telemetry data with the Tripoly telemetry program (Intermountain Wildlife Research, Pocatello, ID). The total number of grid cells entered by an individual represented the home range area. We assumed equal-velocity and straight-line movements between fixes to estimate cumulative time spent and cumulative distance traveled in each cell (Laundré and Keller 1981). Distance values for cells that an individual crossed between fixes were the lengths of the straight-line segments within the cells. Time spent in each cell was the proportion of each cell distance value to the total distance between fixes. We put distance and time estimates as percentages of the total time an animal was monitored and the total distance it traveled. We assigned each grid cell a rank based on these percentages to assess home range use patterns and to identify areas of high use (>10%) or low use (Ables 1969, Fossey 1974, Laundré and Keller 1981).

We analyzed the cumulative number of new grid cells entered by an individual for each subsequent 24-hour session to determine the adequacy of the sample size (Laundré and Keller 1981). When new grid-cell use declined sufficiently (<5%), we concluded that we had sufficient data to estimate home range size and use.

Because of their use of a burrow, pygmy rabbits can be considered central-place foragers (Rosenberg and McKelvey 1999). To determine

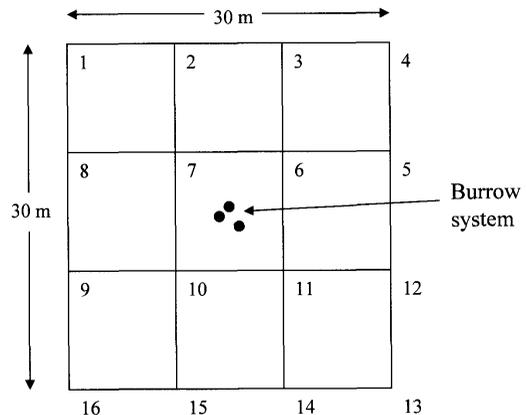


Fig. 1. Sixteen-point grid used for vegetation sampling at burrow, high-use, and low-use areas. At burrow areas, a 17th sample was taken at the burrow entrances located at the center of the grid. This 17th point, and points 6, 7, 10, and 11, were considered "inner" samples; the remaining were considered "outer" samples.

whether home range use by pygmy rabbits was consistent with central-place foraging behavior, we used a chi-square goodness-of-fit test. Thus, the observed distribution of percent time spent in home range cells relative to their distance from the burrow cell was tested against the distribution predicted by the distance-based model (model 1) proposed by Rosenberg and McKelvey (1999:1031). This model accounts for the higher use that areas near the burrow would normally receive because of their location relative to that central focal point.

#### Habitat Characterization

To test for differences in habitat characteristics among areas of different use (prediction 2), we measured several vegetation characteristics, slope, aspect, and soil texture. We sampled vegetation characteristics within 30-m  $\times$  30-m, 16-point grids (Fig. 1) placed in each of the 3 area types. The burrow system grids had an additional 17th sampling point, directly centered in the grid at the location of the actual burrow entrances. For analysis of habitat within burrow grids, this central point and the 4 adjacent points (6, 7, 10, and 11 in Fig. 1) were "inner" grid samples, and the remaining points were "outer" grid samples.

We used the point-quarter sampling method to characterize the shrub community (Brower et al. 1998). We divided the shrub community into "short" ( $\leq 50$  cm tall) and "tall" ( $> 50$  cm)

components. For each, we measured point-to-plant distance, height, and canopy of the nearest shrub in each quadrant at each sampling point in the grid and identified each to species. Estimates of shrub density were based on point-to-plant distances as outlined by Brower et al. (1998). Additionally, we used the point-interception method (Floyd and Anderson 1982) to estimate importance values for shrub species, grass species, forbs, bare ground, litter, rocks, and microbotic crust. We centered the 36-point frame over each point in the sampling grid. At the center of each grid, we measured slope and aspect. We collected soil samples at a depth of approximately 10 cm at 3 random locations in each grid and estimated soil texture with the soil fractionation method outlined in Brower et al. (1998). Soil classifications were based on the standard texture triangle (Brady 1990).

#### Statistical Methods for Habitat Characterization

Two-tailed, paired-sample *t* tests were used to determine whether the shrub community was significantly different between inner and outer grid samples at 12 burrow sites. Mean measurements of height, canopy, and density for both the short and tall shrub communities were tested. A 1-way analysis of variance (ANOVA) was used to test for differences in mean height, canopy, and density of shrubs; slope; and aspect among burrow ( $n = 12$ ), high-use ( $n = 10$ ), and low-use areas ( $n = 10$ ). Slope data, recorded as percentages, were arcsine transformed. Differences in relative density of grass and shrub species, total live shrubs, total grasses, total forbs, bare ground, litter, rock, and microbotic crust among burrow ( $n = 9$ ), high-use ( $n = 9$ ), and low-use areas ( $n = 8$ ) were also tested using 1-way ANOVA. Species that occurred only rarely were excluded from analysis. Student-Newman Keuls multiple-comparison tests were performed if the null hypothesis was rejected. Data that were not normally distributed were tested by a Kruskal-Wallis 1-way ANOVA on ranks and Dunn's multiple comparison test. Multiple analysis of variance (MANOVA) was used to test the effect of use area on overall soil composition, and 1-way ANOVA tests were conducted to identify the difference in sand and clay composition in the 3 use areas (burrow area,  $n = 10$ ; high-use area,  $n = 9$ ; low-use area,  $n = 9$ ).

Principal components analysis (PCA) was used to identify habitat variable complexes which best characterized burrow, high-use, and low-use areas (Gauch 1982, Jackson 1991). A correlation matrix of 14 variables was produced for 9 burrow areas, 8 high-use areas, and 7 low-use areas. Habitat variables included in the analysis were height, canopy, and density of tall and short shrubs; relative cover of big sagebrush, total live shrubs, total grasses, forbs, litter, and microbotic crust; and composition of sand and clay. Factor scores were then calculated and plotted for each use area.

All data were analyzed using SigmaStat for Windows (Jandel Corp., San Rafael, CA) and Systat for Windows (Systat, Inc., Evanston, IL) statistical software. Analysis was performed with a significance level of  $\leq 0.05$  as outlined in Zar (1984).

## RESULTS

### Trapping and Telemetry

We trapped 11 pygmy rabbits, 7 females and 4 males, during the 2 years of this study (Heady 1998). Of the 11 animals captured, we successfully radio-collared 9 rabbits and monitored 5 individuals (3 females and 2 males) sufficiently (3 or more 24-hour sessions) for home range analysis. We assigned 3-letter identification codes to all rabbits represented in the analysis.

### Home Range Analysis

The number of new grid cells entered declined after 3 or 4 sessions (Fig. 2), indicating this sample size was sufficient to estimate home range size and use. Females showed relatively little increase in grid-cell use with consecutive sessions, whereas a large increase followed by a stabilization was observed with both males. The average total number of grid cells entered was 41.3 and 75.5 for females and males respectively, or home range sizes of 37.2 and 67.9 ha (Table 1). Within the home ranges, 3 individuals used 2 burrow systems, and the 2 other rabbits used only a single system each.

Based on the assigned ranks of percent total time spent and distance traveled in the grid cells, home range use patterns were not uniform (Fig. 3). The observed distributions of total time spent (hours) within cells differed significantly from the distance-based null model of Rosenberg and McKelvey (1999) for

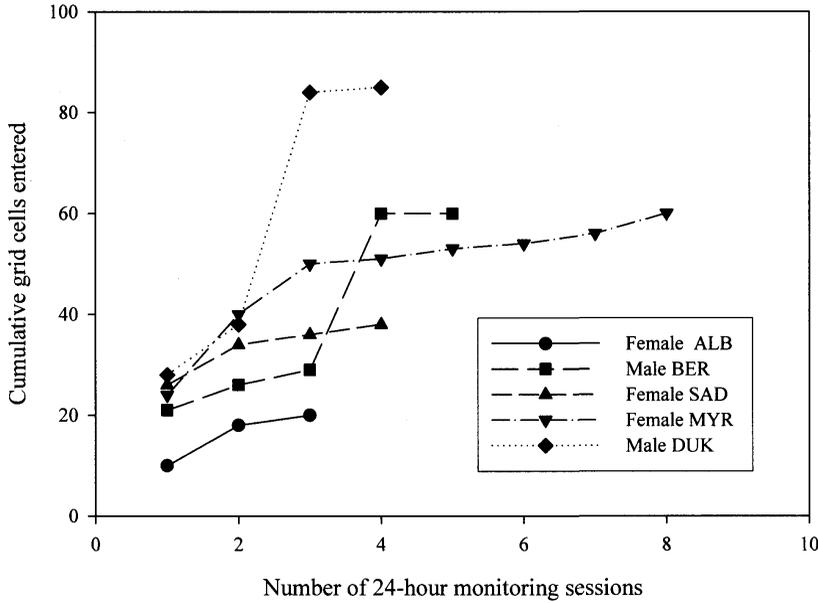


Fig. 2. Cumulative grid cells entered with each subsequent 24-hour telemetry session. Most sessions were complete 24-hour periods, except representative 24-hour sampling of female SAD and male DUK.

all individuals (ALB:  $\chi^2 = 28.8$ ,  $df = 3$ ,  $P < 0.001$ ; SAD:  $\chi^2 = 13.5$ ,  $df = 3$ ,  $P < 0.005$ ; BER:  $\chi^2 = 37.4$ ,  $df = 5$ ,  $P < 0.001$ ; MYR:  $\chi^2 = 135.5$ ,  $df = 12$ ,  $P < 0.001$ ; DUK:  $\chi^2 = 108.0$ ,  $df = 12$ ,  $P < 0.001$ ). In all cases the differences were from higher use than expected of the areas within 60 m of the burrow. Considering the burrow cell and the surrounding cells within 60 m, rabbits spent  $68.4 \pm 9.0\%$  ( $s_{\bar{x}}$ ) of their total time and traveled  $63.0 \pm 5.7\%$  of the total distance in these areas.

Comparison of Habitat Characteristics Within Burrow Areas

In addition to the 5 burrow sites, 4 additional burrows that showed evidence of activity by unidentified pygmy rabbits were also sampled for most variables ( $n = 12$ ). Two low-use areas ( $n = 10$ ) and 2 high-use areas ( $n = 10$ ) were randomly selected from each of the 5 rabbits' home ranges and were each sampled for most habitat variables, along with associated burrow areas used by the individual. In the burrow grids there were significant differences between inner and outer sampling points for several characteristics (Fig. 4). Within the tall shrub community, mean height and density were significantly higher at inner sampling

TABLE 1. Total grid cells used by radio-tracked pygmy rabbits in southeastern Idaho during 1995–96 and the estimated home range sizes. Means are  $\pm$  standard errors.

Radio-tracked rabbits	Total # grid cells entered	Total area (km <sup>2</sup> )
Female		
ALB	20	1.80
SAD	38	3.42
MYR	66	5.94
MEAN	$41.3 \pm 13.4$	$3.72 \pm 1.2$
Male		
BER	64	5.76
DUK	87	7.83
MEAN	$75.5 \pm 11.5$	$6.80 \pm 1.0$

points (Table 2). We observed the opposite trend for density of short shrubs, but the difference was not significant.

Comparison of Habitat Characteristics Among Use Areas

We found significant differences in the vegetative community among the 3 use areas. Height of short shrubs and density of tall shrubs were

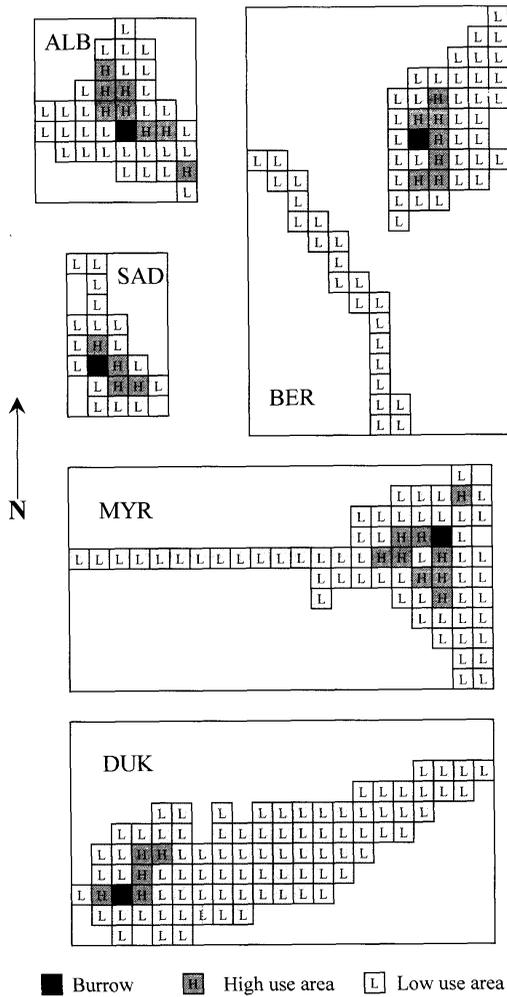


Fig. 3. Individual grid-use patterns, high vs. low use, based on percentage of total time followed and percentage of total distance traveled for 3 females (SAD, ALB, and MYR) and 2 males (BER and DUK). Cells containing burrows are colored black.

significantly higher at burrow sites than in low- and high-use areas (Table 3).

Point-frame data suggest that relative densities of total live shrub species, total forbs, and *A. tridentata* are significantly greater in burrow areas than in low- and high-use areas (Fig. 5). Burrow sites also had a significantly lower density of ground litter than the other 2 areas and tended to have less microbiotic crust and more bare ground.

Mean composition of sand, clay, and silt was relatively similar for samples taken from all 3 use areas. Sand was the principal component ( $64.2 \pm 3.5\%$ ), with silt ( $24.5 \pm 3.5\%$ ) and

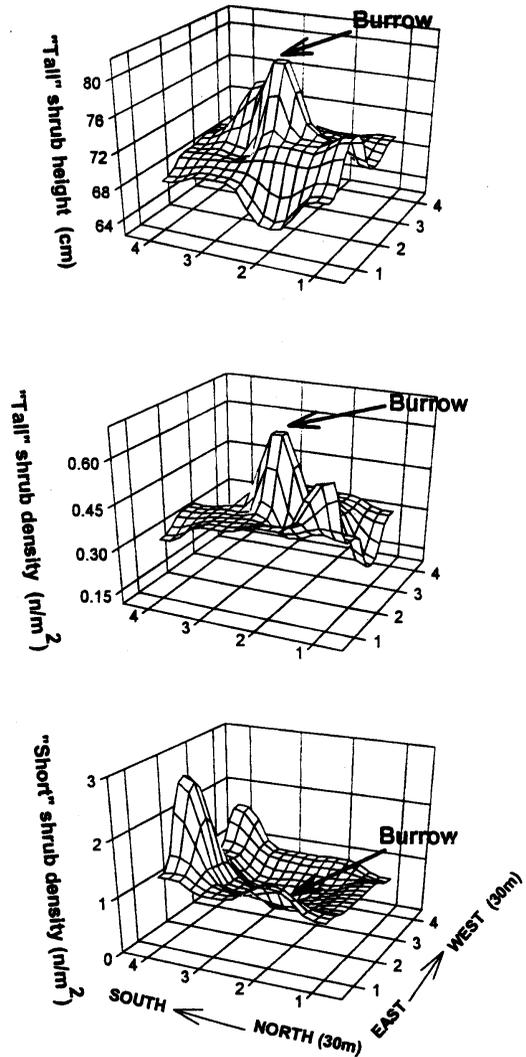


Fig. 4. Interpolated mesh plots of mean height and density of shrubs at 12 sampled burrow grids. The XY plane represents the 16-point sampling grid, with the 17th center point sampled at the burrow entrance. Arrows indicate the mean value measured at the burrow.

clay ( $11.3 \pm 2.8\%$ ) each contributing less, respectively, to total composition. However, a multiple analysis of variance indicated a difference in total soil composition between use areas ( $F = 2.77, P = 0.038$ ). Soil texture classes that predominated the 3 use areas were sandy clay loam and sandy loam. Burrow area soils consisted only of these 2 classes, while high-use areas also had a small percentage of sandy clay, and low-use area soils were also composed of sandy clay, clay loam, and loam.

TABLE 2. Results of paired *t* tests comparing vegetation characteristics of inner and outer points in burrow sampling grids of the home ranges of pygmy rabbits. Means  $\pm$  standard error are shown.

Habitat characteristic	Inner point mean ( <i>n</i> = 12)	Outer point mean ( <i>n</i> = 12)	<i>t</i> -score	Level of significance ( <i>P</i> )
Short shrub height (cm)	29.40 $\pm$ 1.35	27.47 $\pm$ 1.15	1.55	0.15
Tall shrub height (cm)	73.97 $\pm$ 2.55	68.43 $\pm$ 2.00	2.67	0.02*
Short shrub density ( <i>n</i> · m <sup>-2</sup> )	1.898 $\pm$ 0.453	1.155 $\pm$ 0.431	1.99	0.07
Tall shrub density ( <i>n</i> · m <sup>-2</sup> )	0.330 $\pm$ 0.032	0.408 $\pm$ 0.046	-3.77	0.003*
Short shrub canopy (m <sup>2</sup> )	0.098 $\pm$ 0.014	0.083 $\pm$ 0.011	0.90	0.38
Tall shrub canopy (m <sup>2</sup> )	0.476 $\pm$ 0.051	0.442 $\pm$ 0.037	0.79	0.45

\*Significant at *P* < 0.05 level.

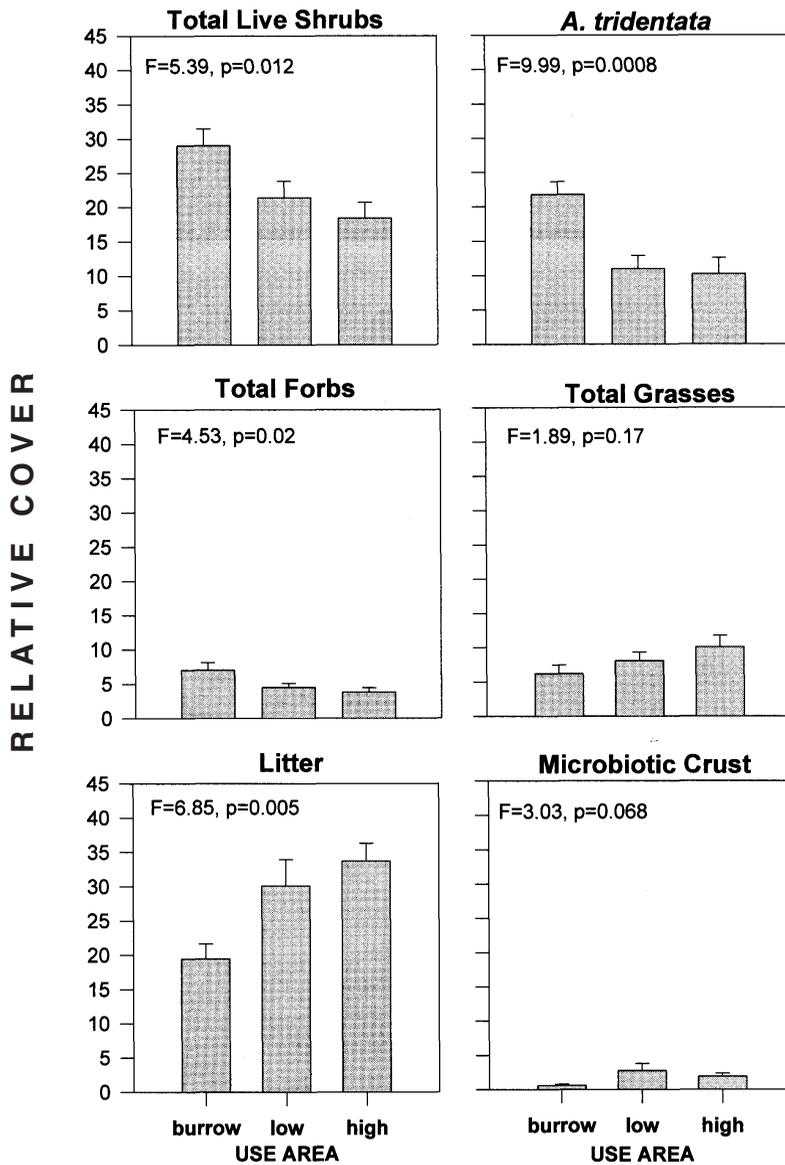


Fig. 5. Relative cover values (mean  $\pm$  *s<sub>x</sub>*) of live shrubs, *A. tridentata*, forbs, grasses, litter, and microbiotic crust in burrow, high-use, and low-use areas.

TABLE 3. Results of 1-way ANOVA tests ( $F$ ) for height, density, and canopy of the short and tall shrub community measured by point-quarter sampling. Kruskal-Wallis 1-way ANOVAs on ranks ( $H$ ) were calculated on data that were not normally distributed. Means  $\pm$  standard error are shown, and lowercase letters correspond to the results of Student-Newman-Keuls or Dunn's multiple comparison tests.

	Burrow areas ( $n = 12$ )	High-use areas ( $n = 10$ )	Low-use areas ( $n = 10$ )	$F/H$	Level of significance ( $P$ )
SHORT SHRUBS (height <50 cm)					
Height (cm)	28.0 $\pm$ 1.05 <sup>a</sup>	23.0 $\pm$ 1.04 <sup>b</sup>	23.1 $\pm$ 0.82 <sup>b</sup>	8.77	0.001*
Density ( $n \cdot m^{-2}$ )	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 <sup>†</sup>	0.07
TALL SHRUBS (height $\geq$ 50 cm)					
Height (cm)	70.0 $\pm$ 1.95	65.1 $\pm$ 3.01	63.8 $\pm$ 1.56	2.28	0.12
Density ( $n \cdot m^{-2}$ )	0.35 $\pm$ 0.04 <sup>a</sup>	0.24 $\pm$ 0.06 <sup>ab</sup>	0.19 $\pm$ 0.02 <sup>b</sup>	8.90 <sup>†</sup>	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.

<sup>†</sup>Kruskal-Wallis 1-way ANOVA on ranks was calculated.

TABLE 4. Principal component loadings derived from PCA of habitat variables from burrow, high-use, and low-use areas for pygmy rabbits in southeast Idaho.

Habitat variable	Principal component	
	1	2
Short shrub height	0.932	-0.076
Short shrub canopy	0.903	0.064
Short shrub density	-0.709	-0.465
Tall shrub height	0.879	0.195
Tall shrub canopy	0.786	0.479
Tall shrub density	0.683	-0.115
Big sagebrush—relative importance	0.760	-0.530
Total live shrubs—relative importance	0.514	-0.737
Total grasses—relative importance	-0.694	0.210
Forbs—relative importance	0.063	-0.817
Litter—relative importance	0.038	0.802
Microbiotic crust—relative importance	-0.556	-0.014
Sand composition	0.871	0.271
Clay composition	-0.930	0.089
PERCENT VARIANCE EXPLAINED	52.2	19.8

Relative to the PCA analysis of habitat characteristics, the first 2 components of the PCA explained 72% of the total variance seen. The 1st component explained 52.2% of the variation and emphasized the height of the tall and short shrub components as well as the short shrub canopy (Table 4). The 2nd component explained only 19.8% of the variation and was influenced most by ground litter (Table 4). When the Z1 and Z2 scores of these components for the 3 use areas are graphed, the habitat composition of the burrow area is distinctly different from the high- and low-use areas (Fig. 6).

#### DISCUSSION

Others have reported that pygmy rabbits exhibit restricted movements with relatively

small home ranges (Janson 1946, Wilde 1978, Gahr 1993, Katzner and Parker 1997). A pattern of restricted movement close to the burrow with decreasing activity at greater distances could be expected simply based on the behavior of a central-place forager. Although our sample size was limited, our data clearly demonstrate that within their small home ranges, pygmy rabbits restrict their movements to areas close to their burrows even more than predicted by the null model of a central-place forager (Rosenberg and McKelvey 1999). These results support the first prediction that pygmy rabbits do not use the home range area as expected; each individual's home range area could be dissected into areas of disproportionately high use at the burrow site and adjacent

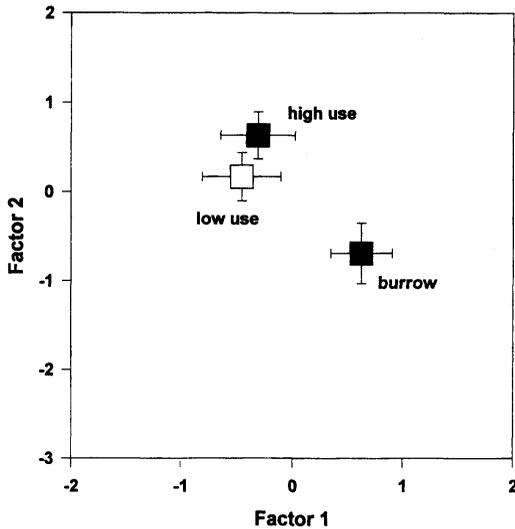


Fig. 6. Spatial relationship between mean factor scores for burrow, high-use, and low-use areas as defined by the PCA analysis.

areas. Beyond 60 m of the burrow, pygmy rabbits traveled little and spent less time than predicted in peripheral cells further from the burrow. The main reason for this affinity to the burrow is likely predation risk. Pygmy rabbits move slowly and are more vulnerable to predation than other leporids (Orr 1940, Gabler et al. 2001). Staying close to the burrow would enable pygmy rabbits to quickly retreat to their burrow when threatened. Other factors may also be involved. Regardless of the reason, our data suggest that, more than just central-place foragers, pygmy rabbits may be “burrow obligates” and rarely venture far from the burrow site. Consequently, their occurrence in an area could be limited to availability of burrow sites, which in turn seems limited by habitat characteristics.

Relative to habitat characteristics, various studies have documented the dependence of pygmy rabbits on big sagebrush (Green and Flinders 1980, Weiss and Verts 1984, Pritchett et al. 1987, Gahr 1993, Katzner 1994, Gabler et al. 2001). On the basis of these studies, we consider pygmy rabbits sagebrush obligates. However, even within the sagebrush community, not all sagebrush habitat is equal. Gahr (1993) reported greater height and percent cover of sagebrush at burrow sites than non-burrow areas. On closer investigation, Gabler et al. (2001) also found sagebrush density to be

higher at active burrow sites than in a  $360 \times 360$ -m area surrounding the burrows. Our study demonstrates that there are differences in habitat characteristics even on a smaller scale, e.g., between burrow sites and nearby ( $<30$  m) surrounding areas. Additionally, various habitat characteristics at burrow sites were significantly different from surrounding areas of high and low use. This result supported our 2nd prediction of habitat characteristics related to use levels. However, we found little difference in habitat structure between high- and low-use areas away from the burrow sites. Density of tall shrubs ( $\geq 50$  cm) in high-use areas was greater than in low-use areas. This difference might explain the selective use of these areas, but overall it is still unclear why pygmy rabbits will use some areas more than others. Consequently, the relationship between level of use and habitat characteristics seems restricted to burrow sites.

Because of their fossorial behavior, it is unclear whether observed vegetation characteristics at burrow sites are selected by pygmy rabbits or created by them. Wilde (1978) observed that mounds and terraces outside burrow entrances had fewer plants; in this study burrow sites had the greatest amount of bare ground (Fig. 5). Dobler and Dixon (1990) suggested that pygmy rabbits may be somewhat self-sustaining by increasing the density of sagebrush near their burrows via soil disturbance which would promote sagebrush seedlings. However, Gabler (1997) suggested that pygmy rabbit activity at burrows prevents new shrubs from growing and allows established shrubs to grow larger. As the density of shorter shrubs in our study was actually lower at the burrows, our data support the suggestion of Gabler (1997). Thus, the debate continues. Gabler et al. (2001) suggested that a temporal study of burrow systems as they change from occupied to unoccupied could help determine if pygmy rabbits are selecting preconditioned sites or creating them.

In conclusion, our data suggest that the burrow is the most important element of a pygmy rabbit's home range. Our findings reflect a species that must live close to its burrows, more than expected based on central-place foraging models. Additionally, our results indicate that these burrows have very specific habitat characteristics that differ greatly from nearby ( $<30$  m) surrounding areas. On the basis of this, the pygmy rabbit can be considered an

insular species living in a potentially dangerous sea of surrounding vegetation. Thus, not only are pygmy rabbits restricted to big sagebrush areas, but to big sagebrush areas with very specific structural characteristics. Whether they select these characteristics or create them via their activity, i.e., burrowing/foraging, is unknown. However, the amount of potential pygmy rabbit habitat that may exist in an area is clearly dependent on this factor. If pygmy rabbits are selecting from a very specific subset of habitat characteristics in the sagebrush community, then, indeed, the amount of usable habitat in an area would be much more limited (Gabler et al. 2001) than if they are able to modify a wider range of habitat to their specific needs. Thus, for the conservation of this species, further research is needed in this area.

#### ACKNOWLEDGMENTS

Funding for this project was provided by the Environmental Science and Research Foundation under contract DE-AC07-941D13268 with the U.S. Department of Energy, Idaho Operations Office. Additional funding was received from the U.S. Bureau of Land Management and the ISU Graduate Student Research and Scholarship Committee. Logistic support was also provided by the Environmental Science and Research Foundation and Idaho State University. We thank the following for assistance in the field and laboratory: Joe Sirotnak, John Roach, Kyle Merriam, Kelly Altendorf, Stacy McCord, and Paddy Murphy. We thank Chuck Trost and Victor Joe for their editorial comments.

#### LITERATURE CITED

- ABLES, E.D. 1969. Home-range studies of red foxes (*Vulpes vulpes*). *Journal of Mammalogy* 50:108–120.
- ANDERSON, J.E., K.T. RUPPEL, J.M. GLENNON, K.E. HOLTE, AND R.C. ROPE. 1996. Plant communities, ethnobotany, and flora of the Idaho National Engineering Laboratory. Environmental Science and Research Foundation Report Series 005, Lockheed Technologies Company, Idaho Falls, ID.
- BRADY, N.C. 1990. The nature and properties of soils. 10th edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.
- BROWER, J.E., J.H. ZAR, AND C.N. VON ENDE. 1998. Field and laboratory methods for general ecology. 3rd edition. Wm. C. Brown Publishers.
- CHAPMAN, J.A., J.E.C. FLUX, A.T. SMITH, D.J. BELL, G.G. CEBALLOS, K.R. DIXON, F.C. DOBLER, ET AL. 1990. Conservation action needed for rabbits, hares, and pikas. Pages 154–167 in J.A. Chapman and J.E.C. Flux, editors, Rabbits, hares, and pikas: status survey and conservation action plan. IUCN/SSC Lagomorph Specialist Group, Gland, Switzerland. 168 pp.
- DOBLER, F.C., AND K.R. DIXON. 1990. The pygmy rabbit *Brachylagus idahoensis*. Pages 111–115 in J.A. Chapman and J.E.C. Flux, editors, Rabbits, hares, and pikas: status survey and conservation action plan. IUCN/SSC Lagomorph Specialist Group, Gland, Switzerland. 168 pp.
- FLOYD, D.A., AND J.E. ANDERSON. 1982. A new point frame for estimating cover of vegetation. *Vegetatio* 50: 185–186.
- FOSSEY, D. 1974. Observations of the home range of one group of mountain gorillas (*Gorilla gorilla beringei*). *Animal Behavior* 22:568–581.
- GABLER, K.I. 1997. Distribution and habitat requirements of the pygmy rabbit (*Brachylagus idahoensis*) on the Idaho National Engineering and Environmental Laboratory. Master's thesis, Idaho State University, Pocatello.
- GABLER K.I., L.T. HEADY, AND J.W. LAUNDRÉ. 2001. A habitat suitability model for pygmy rabbits (*Brachylagus idahoensis*) in southeastern Idaho. *Western North American Naturalist* 61:480–489.
- GAHR, M.L. 1993. Natural history, burrow habitat and use, and home range of the pygmy rabbit (*Brachylagus idahoensis*) of Sagebrush Flat, Washington. Master's thesis, University of Washington, Seattle.
- GAUCH, H.G. 1982. Multivariate analysis in community ecology. Cambridge University Press, Cambridge, UK.
- GREEN, J.S., AND J.T. FLINDERS. 1980. Habitat and dietary relationships of the pygmy rabbit. *Journal of Range Management* 33:136–142.
- HEADY, L.T. 1998. Home range, habitat, and activity patterns of pygmy rabbits (*Brachylagus idahoensis*) in southeastern Idaho. Master's thesis, Idaho State University, Pocatello.
- JACKSON, J.E. 1991. A user's guide to principal components. John Wiley and Sons, Inc., New York.
- JANSON, R.G. 1946. A survey of the native rabbits of Utah with reference to their classification, distribution, life histories, and ecology. Master's thesis, Utah State University, Logan.
- KATZNER, T.E. 1994. Winter ecology of the pygmy rabbit (*Brachylagus idahoensis*) in Wyoming. Master's thesis, University of Wyoming, Laramie.
- KATZNER, T.E., AND K.L. PARKER. 1997. Vegetative characteristics and size of home ranges used by pygmy rabbits (*Brachylagus idahoensis*) during winter. *Journal of Mammalogy* 78:1063–1072.
- LAUNDRÉ, J.W., AND B.L. KELLER. 1981. Home range use by coyotes in Idaho. *Animal Behaviour* 29:449–461.
- MCNAUGHTON, S.J. 1989. Ecosystems and conservation in the twenty-first century. Pages 109–120 in D. Western and M. Pearl, editors, Conservation for the twenty-first century. Oxford University Press, New York. 365 pp.
- ORR, R.T. 1940. The rabbits of California. *Occasional Papers of the California Academy of Sciences* 19:1–227.
- PRITCHETT, C.L., J.A. NILSEN, M.P. COFFEEN, AND H.D. SMITH. 1987. Pygmy rabbits in the Colorado River drainage. *Great Basin Naturalist* 47:231–233.
- RONGSTAD, O.J., AND J.R. TESTER. 1969. Movements and habitat use of white-tailed deer in Minnesota. *Journal of Wildlife Management* 33:366–379.
- ROSENBERG, D.K., AND K.S. MCKELVEY. 1999. Estimation of habitat selection for central-place foraging animals. *Journal of Wildlife Management* 63:1028–1038.

- WASHINGTON DEPARTMENT OF FISH AND WILDLIFE. 1995. Washington state recovery plan for the pygmy rabbit. Wildlife Management Program, Washington Department of Fish and Wildlife, Olympia. 73 pp.
- WEISS, N.T., AND B.J. VERTS. 1984. Habitat and distribution of the pygmy rabbit (*Sylvilagus idahoensis*) in Oregon. *Great Basin Naturalist* 44:563–571.
- WHITE, G.C., AND R.A. GARROTT. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, CA. 383 pp.
- WHITE, S.M., J.T. FLINDERS, AND B.L. WELCH. 1982. Preference of pygmy rabbits (*Brachylagus idahoensis*) for various populations of big sagebrush (*Artemisia tridentata*). *Journal of Range Management* 35:724–726.
- WILDE, D.B. 1978. A population analysis of the pygmy rabbit (*Sylvilagus idahoensis*) on the INEL site. Doctoral dissertation, Idaho State University, Pocatello.
- ZAR, J.H. 1984. Biostatistical analysis. 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

*Received 20 May 2003*  
*Accepted 7 March 2005*