AN ABSTRACT OF THE THESIS OF

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Title: Habitat and Distribution of Pygmy Rabbits (*Sylvilagus idahoensis*) in Oregon

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Abstract approved: ______________________________
B. J. Verts

The objectives of this study were to determine the location and extent of populations of pygmy rabbits in Oregon, and to describe several biotic and physical components within communities that include pygmy rabbits. Interpretation of aerial photographs, and information obtained from soil maps and interviews with biologists and area residents, were used to direct the search for sites occupied by rabbits. This search was conducted June to October 1982 and generally was limited to areas where pygmy rabbits were collected previously. Sign of pygmy rabbits was observed at 51 of 211 sites examined. Soil and vegetation components were sampled July to October 1982 at 15 sites occupied by pygmy rabbits, and 21 sites adjacent there to. Mean soil depth at sites occupied by pygmy rabbits was 51.0±2.3 cm, and was significantly greater than at adjacent sites (31.0±3.1 cm). Soil strengths of surface and subsurface horizons at sites occupied by pygmy rabbits were 0.8±0.2 and 3.8±0.3 kg/cm^2,

respectively, and were significantly less than at adjacent sites (1.9 ± 0.4 and 4.6 ± 0.2 kg/cm^2). Soil depth and soil strength, more than soil texture, were physical properties that distinguished sites occupied by pygmy rabbits from adjacent sites. Soil properties associated with habitats of pygmy rabbits probably were related to excavation of burrows. Shrub height (84.4 ± 5.8 cm) and shrub cover (28.8 ± 1.4%) at sites inhabited by pygmy rabbits were significantly greater than shrub height (52.7 ± 5.3 cm) an shrub cover (17.7 ± 1.2%) at adjacent sites. The affinity of pygmy rabbits for greater shrub cover and shrub height possibly was related to avoidance of predators and availability of forage. No significant differences between sites occupied by pygmy rabbits and adjacent sites were obtained for percent basal area of perennial grasses, annual grass density, forb density, or cryptogam cover. Analysis of 472 samples of *Artemesia tridentata* collected at and near areas inhabited by pygmy rabbits in Oregon indicated presence of pygmy rabbits was not dependent upon distributions of specific subspecies of *A. tridentata*. A marked decrease in activity of pygmy rabbits at sample sites the second year of this study demonstrated populations of pygmy rabbits were susceptible to rapid declines and possibly local extirpation. Fragmentation of sagebrush communities poses a potential threat to populations of pygmy rabbits, but the severity of this threat presently is not known.

HABITAT AND DISTRIBUTION OF PYGMY RABBITS (*SYLVILAGUS IDAHOENSIS*) IN OREGON

by

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Professor of Wildlife in charge of major

Redacted for Privacy

Head of Department of Fisheries and Wildlife

Redacted for Privacy

Dean of Graduate School

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PREFACE

This thesis is a report on the geographic distribution of areas inhabited by pygmy rabbits in Oregon and the vegetative and edaphic characteristics of those areas. Because this document was prepared as a manuscript for publication, Dr. B. J. Verts was included as junior author. Citation of this thesis should include the principal author only.

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HABITAT AND DISTRIBUTION OF PYGMY RABBITS (*SYLVILAGUS IDAHOENSIS*) IN OREGON

Nondor T. Weiss[1] and B. J. Verts[1]

INTRODUCTION

Pygmy rabbits (*Sylvilagus idahoensis*), the smallest leporid, are endemic to the Great Basin and adjacent intermountain areas of western United States (Green and Flinders 1980a). The distribution of this species is disjunct within a geographic range that reaches its western-most extent in Oregon (Hall 1981). This range in Oregon includes seven counties south and west of the approximate line connecting Klamath Falls, Fremont, Redmond, and Baker (Olterman and Verts 1972). These rabbits typically are associated with clumped stands of big sagebrush (*Artemesia tridentata*) (Anthony 1913, Davis 1939, Orr 1940, Bradfield 1975) where soils usually are deep and friable (Orr 1940, Janson 1946, Campbell et al. 1982). Where habitat requirements are met, pygmy rabbits dig relatively shallow burrows usually in aggregations (Janson 1946). Because pygmy rabbits are the only native leporids in North America that excavate burrows (Janson 1946), the influence of soil characteristics upon their distribution likely is unique among rabbits and hares of this continent. Associations between

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[1]Department of Fisheries and Wildlife, Oregon State University, Corvallis, 97331

pygmy rabbits and habitat types, however, are based primarily on natural histories; quantitative descriptions of soil characteristics at sites occupied by pygmy rabbits do not exist, and quantitative descriptions of vegetation components at sites inhabited by pygmy rabbits are known from a single study conducted in Idaho (Green and Flinders 1980b). Because large areas of sagebrush lands are undergoing renovation for grazing or conversion to irrigated agriculture (Green and Flinders 1980b) and because the current status of pygmy rabbits in Oregon is undetermined (Olterman and Verts 1972), information regarding habitats occupied by this species should be of special interest to biologists and managers.

The objectives of this study were to determine the location and extent of populations of pygmy rabbits in Oregon, and to describe several biotic and physical components at habitats occupied by pygmy rabbits.

METHODS

Location of Areas Occupied by Pygmy Rabbits

The search for pygmy rabbits was conducted in areas where pygmy rabbits were collected previously. Olterman and Verts (1972) reported that museum collections contained pygmy rabbits from 37 sites in Oregon (Fig. 1), but locality descriptions obtained from these records lacked the precision needed to find populations of pygmy rabbits. Interpretation of aerial photographs and information obtained from soil maps were used to narrow the search for pygmy rabbits within

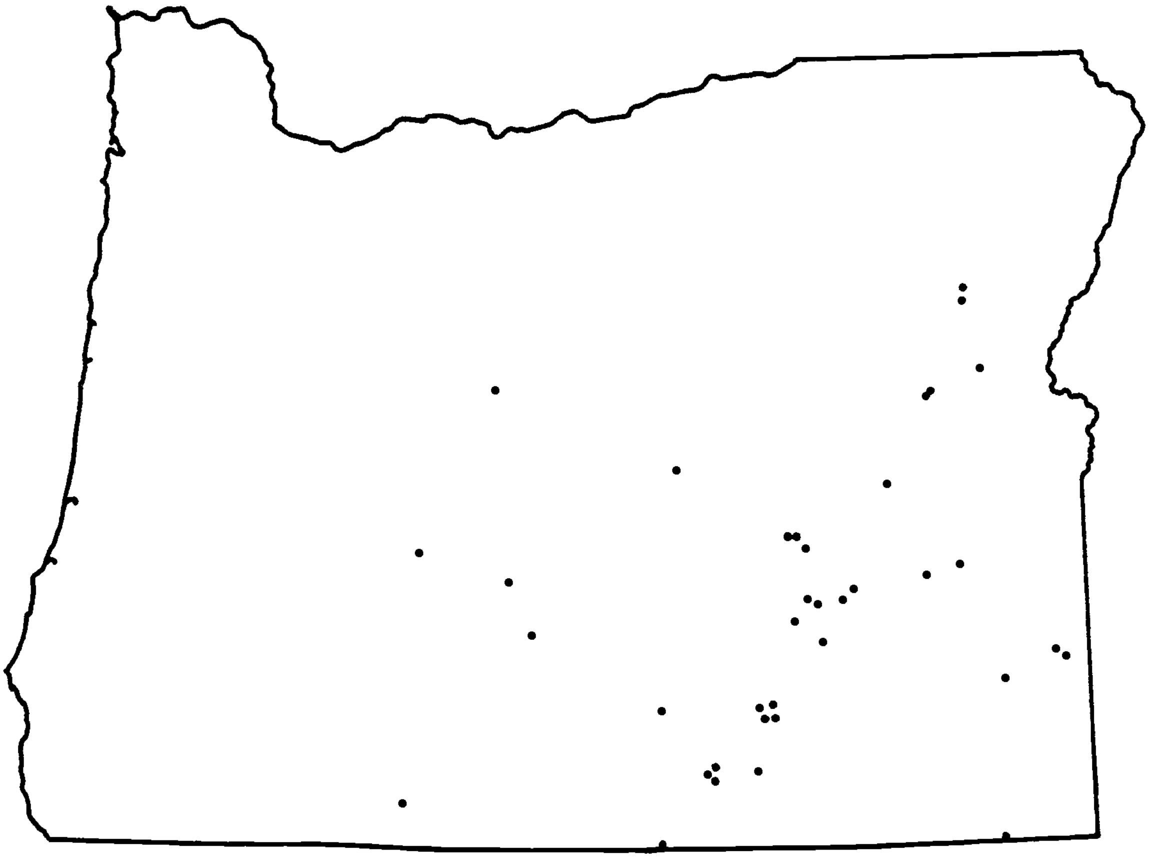

Figure 1. Thirty-seven sites (•) at which museum specimens of pygmy rabbits were collected in Oregon. (Map modified after Olterman and Verts [1972]. One map location without accompanying record of locality was deleted.)

general areas identified from locality descriptions of museum records. In cooperation with the Environmental Remote Sensing Applications Laboratory at Oregon State University, stereoscopic surveys of U-2 high-altitude infrared photos were used to locate areas that most likely supported rabbits. Locations of areas with photographic characteristics similar to sites with known populations of pygmy rabbits were recorded on U. S. Geographic Survey 1:250,000 topographic maps. Soil maps and soil descriptions (Oregon Water Resource Board 1969) were used to identify deep, friable, sandy-loam soils in southern and eastern Oregon. Correspondence and interviews with biologists and field personnel from state and federal agencies, and local residents, provided locations of known or suspected areas occupied by pygmy rabbits; these areas also were examined.

Use of soil information generally did not enable identification of small areas with deep and friable soils inhabited by pygmy rabbits. For portions of southern and eastern Oregon, high-altitude, infrared photographs were poor in quality and uninterpretable; of the remaining photographs, areas with rocky soils, areas with low shrubs, and areas that had undergone sagebrush removal sometime after the photographs were taken, occasionally were identified as potential habitats of pygmy rabbits. Prediction of pygmy rabbit occurrence improved considerably when soil information and photographic interpretation were used in concert. The best prediction of pygmy rabbit occurrence was obtained from information provided by biologists, field personnel, and local residents; however, reported sightings of pygmy rabbits were uncommon.

The search for sites occupied by pygmy rabbits was conducted June to October 1982. Two people on foot searched for evidence of pygmy rabbits at each site for approximately 30 min, and areas inhabited by pygmy rabbits were identified where pygmy rabbit burrows and fecal pellets were observed. Distribution, degree of weathering, and abundance of pygmy rabbit fecal pellets provided a basis for detecting burrows used by pygmy rabbits, and were an aid in estimating the physical limits of areas inhabited by pygmy rabbits. We considered a pygmy rabbit burrow to include all burrow entrances associated with it.

Communities occupied by pygmy rabbits and sampled in 1982 were examined during the following year to determine whether local rabbit populations remained active. The number of open burrows and occurrence of recently deposited fecal pellets were used to assess activity of pygmy rabbits at sample sites.

Sampling of Soils and Vegetation

Biotic and physical properties of sites inhabited by pygmy rabbits were sampled from July to October 1982. Sampling was conducted at a site if recent pygmy rabbit activity was observed, and four or more pygmy rabbit burrows occurred with a maximum distance of 200 m between burrows.

Three parallel line-transects 30 m long and 10 m apart were established at randomly selected starting points for each site sampled. At one site (site 13), sampling was repeated because of apparent vegetative heterogeneity. Transects were located parallel to contours of slopes when present. Shrub height and shrub cover were measured along line transects (Pieper 1978), and clippings were collected from all *Artemesia tridentata* shrubs that intercepted the transects. Ten 20- by 50-cm rectangular plots were placed uniformly along each transect to estimate basal area of perennial grasses, densities of annual grasses and forbs, and cryptogam cover (Daubenmier 1959). Soil samples were collected at five stations, uniformly spaced along each transect, at the surface and at 40 cm below the surface (soil depth permitting), and soil depth to 60 cm was recorded. Soil samples from a common depth were combined to obtain a single sample for each transect. Soil strength at the surface and at 40 cm below the surface (soil depth permitting) was measured at each station with a Soil Test Model CL-700 pocket penetrometer. When soil strength exceeded the limits of the penetrometer, a value of 5.0 kg/cm^2 was recorded. A clinometer was used to measure ground slope in the immediate vicinity of each rabbit burrow, and the number of entrances to each burrow was recorded.

Procedures for sampling soil and vegetative characteristics at rabbit communities were repeated at adjacent shrub communities where pygmy rabbit burrows were not found. The sampling of adjacent shrub communities was restricted to areas less than 100 m from a peripheral pygmy rabbit burrow. Pygmy rabbits were assumed to have had access to these adjacent sites, because pygmy rabbits reportedly traveled 100 m or more from their burrows in winter and summer (Bradfield 1975, Wilde et al. 1976). Because pygmy rabbit burrows often were distributed along the contours of slopes, adjacent shrub communities were oriented above and below slopes with respect to areas occupied by rabbits. Adjacent communities were not sampled if the shrub component was absent, or if evidence of recent habitat disturbance was detected.

Samples were returned to Oregon State University for analysis; soil samples were analyzed to determine soil texture (Bouyoucos 1962), and *A. tridentata* clippings were analyzed to identify subspecies of *A. tridentata*. For identification of subspecies of *A. tridentata*, five subsamples were selected at random from samples of big sagebrush collected along a single transect. Fifteen subsamples (when present) obtained from a set of three transects were analyzed to characterize the subspecies of big sagebrush at a sample site. Blue fluorescence of alcohol-leaf extracts viewed with long-wave ultraviolet light was used to separate *A. t. vaseyana* from *A. t. wyomingensis* and *A. t. tridentata* (Winward and Tisdale 1969). Analysis of remaining alcohol-leaf extracts with a Hitachi Model 100-60 spectrophotometer separated *A. t. wyomingensis* from *A. t. tridentata* (Shumar et al. 1982).

Two-tailed paired *t* tests were used to determine the probability that mean differences of the same habitat variables sampled at sites occupied by pygmy rabbits and adjacent sites were greater than zero. For areas occupied by pygmy rabbits where more than one adjacent site was sampled, data from adjacent sites were averaged to obtain a pooled sample. Square-root transformations were performed on all variables measured as percents. Because inferences drawn from statistical comparisons of transformed and nontransformed data did not differ, nontransformed data were reported. Discriminant analysis (Klecka 1975) was used to identify habitat components that best distinguished sites occupied by pygmy rabbits from adjacent sites. Habitat variables used in discriminant analysis were total shrub cover, shrub height, surface and subsurface soil strengths, soil depth, basal area of perennial grasses, density of annual grasses, density of forbs, and percent sand at surface and subsurface horizons. Interpretation of the discriminant function was based on pooled within-groups correlations between the canonical discriminant function and habitat variables. Pearson correlation coefficients were calculated for habitat variables measured at all sites. Stepwise-multiple regression was used to examine the relationship among number of burrow entrances and soil variables measured at sites inhabited by pygmy rabbits. For all statistical analysis, we accepted $P < 0.05$

as being significant.

RESULTS

Sign of pygmy rabbits was observed at 51 of 211 sites examined in Oregon (Figs. 2 and 3). Fifteen areas occupied by pygmy rabbits met the criteria for sampling (Table 1). Twenty-one areas adjacent to 13 sites occupied by pygmy rabbits also were sampled.

Shrub height, shrub cover, and soil depth were significantly greater at 13 sites occupied by pygmy rabbits than at 21 adjacent sites (Table 2). In contrast, no significant differences were obtained for percent basal area of perennial grasses, density of annual grasses, density of forbs, or cryptogam cover. Soil strengths at surface and subsurface horizons were significantly less at sites occupied by pygmy rabbits than at adjacent sites (Table 2). With exception of percent clay for subsurface soils, components of soil texture at surface and subsurface soils were not significantly different between sites occupied by pygmy rabbits and adjacent sites (Table 2). Green and Flinders (1980b) also reported shrub height and shrub cover at six sites inhabited by pygmy rabbits were significantly greater compared with shrub height and cover measured at 30 sites that represented small rodent, yellow-bellied marmot (*Marmota flaviventris*), and Unita ground squirrel (*Spermophilus armatus*) habitats, and one livestock exclosure. Mean shrub cover in areas occupied by rabbits was 28.8±1.4% (Table 2),

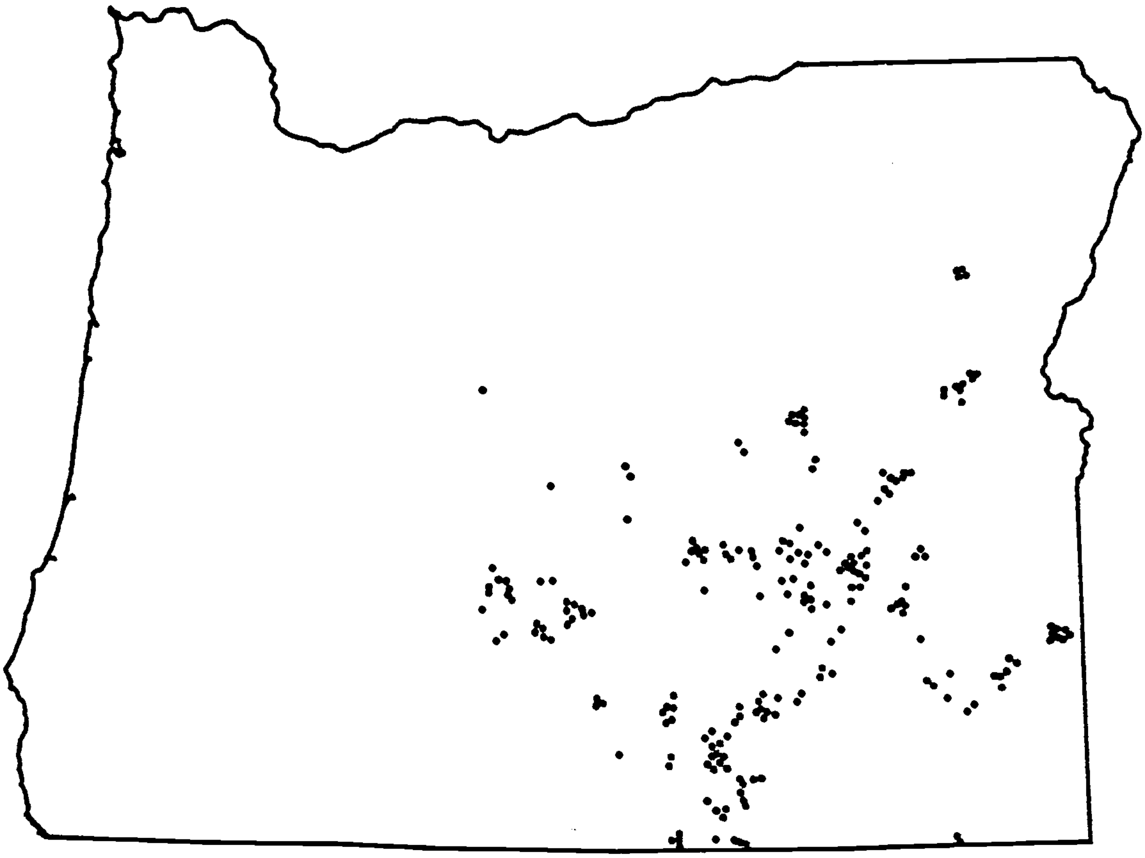

Figure 2. Two hundred and eleven sites (•) examined for evidence of pygmy rabbits, Oregon, 1982.

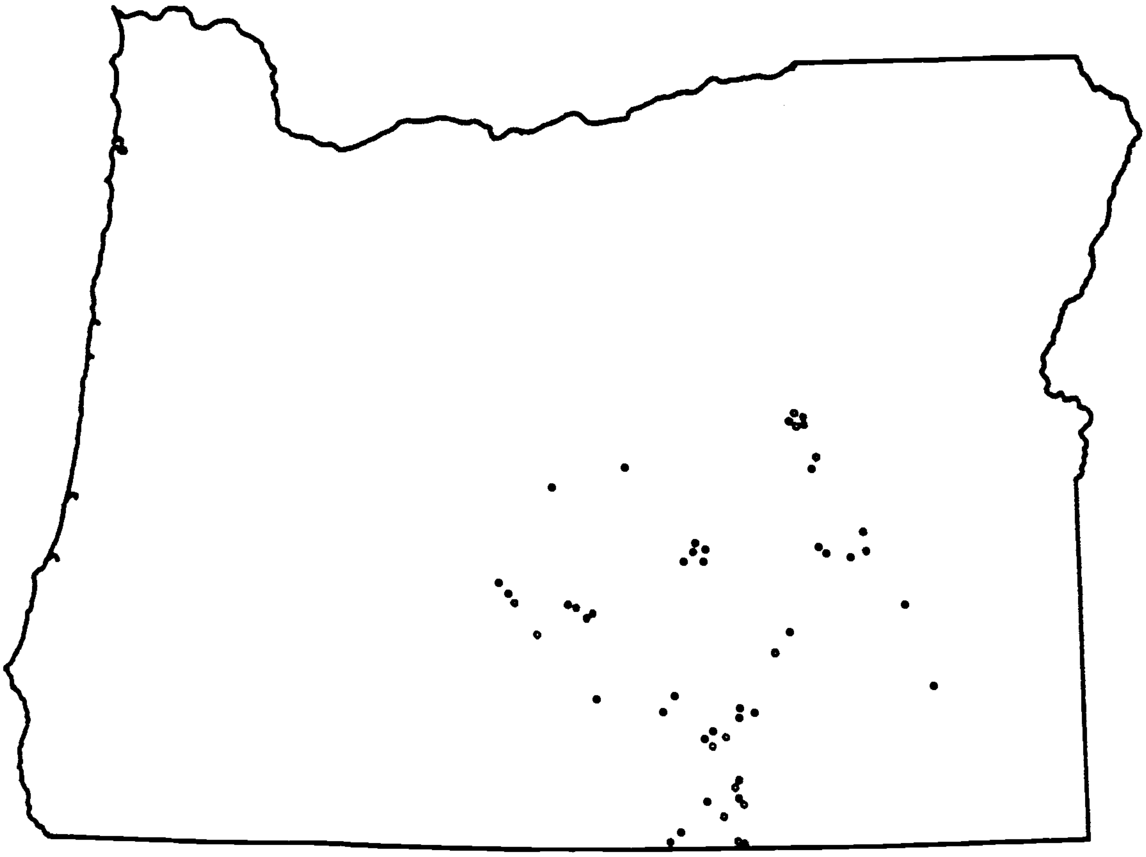

Figure 3. Fifty-one sites in Oregon at which evidence of pygmy rabbits was located, 1982. Open circles (∘) indicate those sites sampled; solid circles (•) indicate those sites not sampled.

Table 1.--Legal descriptions, elevations, and general descriptions of 15 sites occupied by pygmy rabbits, Oregon, 1982.

Site number	County	Location*	Elevation	Ownership or managing agency	Site Description
1	Lake	T38S, R28E, Sec. 34	1585 m	Private	Sixteen burrows distributed linearly across a gentle slope, merging into a flat.
2	Lake	T37S, R28E, Sec. 14 and Sec. 15	1675 m	BLM	Ten burrow systems scattered about gently sloping to flat terrain, located at the base of three converging slopes.
3	Lake	T39S, R27E, Sec. 2	1570 m	National Wildlife Refuge	Seven burrows distributed along the contour of a small slope
4	Lake	T40S, R27E, Sec. 36	1500 m	State	Eight burrows distributed linearly along a gentle slope at the base of Doherty's Rim.
5**	Lake	T39S, R25E, Sec. 33	1400 m	BLM	Seven burrows distributed across a moderate slope
6**	Lake	T35S, R26E, Sec. 28	1830 m	National Wildlife Refuge	Nine burrows dispersed across a broad slope with scattered large rocks. *Purshia tridentata* common.
7**	Lake	T34S, R26E, Sec. 36	1615 m	National Wildlife Refuge	Five burrows with large entrances distributed along a narrow and sloping band of deep soil.
8**	Lake	T38S, R26E, Sec. 9	1830 m	Private	Seven burrows distributed about a sloping island of tall sagebrush and deep soil. Area bordered by low brush and shallow soils.
9**	Harney	T29S, R29 1/2 E, Sec. 26	1540 m	BLM	Five burrows concentrated atop a small mound of relatively deep soil and tall sagebrush.
10**	Grant	T18S, R32E, SW corner, Sec. 29	1385 m	BLM	Five burrows scattered across a moderately sloped hillside.
11**	Grant	T16S, R31E, Sec. 6	1450 m	Private	Forty-five burrows, most with large entrances, broadly dispersed across a moderate to steeply sloped hillside.
12**	Grant	T16S, R31E, Sec. 28	1430 m	Private	Ten burrows dispersed along a moderately sloped hillside.
13	Harney	T24S, R34E, Sec. 18	1280 m	Private	Eight burrows dispersed across a large, relatively flat area with deep soil and tall sagebrush.
14**	Lake	T28S, R15E, Sec. 22	1380 m	BLM, Private	Twelve burrows broadly dispersed along a moderate slope with deep soil and tall sagebrush. Adjacent areas showed signs of recent disturbance.
15**	Lake	T26S, R14E, Sec. 22	1325 m	BLM	Nine burrows distributed along the upper slope of a sandy ridge where soil was deep and sagebrush particularly tall.

* Ranges, townships, and section numbers obtained from Bureau of Land Management 30 minute series maps.

** No sign of pygmy rabbit activity detected in 1983.

Table 2.--*Means, standard errors of means, and ranges of habitat variables measured at 13 sites occupied by pygmy rabbits, and 21 sites adjacent there to, Oregon, 1982.*

Habitat variables	Rabbit-occupied sites (n=13) Mean ± S.E. of mean	Range	Adjacent sites (n=13)* Mean ± S.E. of mean	Range
Shrubs				
Percent cover				
Artemesia spp.**	23.7±1.4	16.3 - 33.2	14.8±1.5	3.3 - 26.6
Total shrub **	28.8±1.4	21.0 - 36.2	17.7±1.2	13.9 - 27.1
Mean height (cm)				
Artemesia spp.**	90.8±5.8	67.7 - 126.6	56.9±6.1	26.2 - 103.7
Total shrub **	84.4±5.8	55.8 - 115.2	52.7±5.3	24.2 - 86.9
Understory				
Perennial grass percent basal area	3.7±0.9	0.0 - 9.8	4.2±0.7	0.0 - 9.4
Annual grass density n/1000 cm^2	5.2±2.1	0.0 - 20.6	5.6±3.6	0.0 - 46.2
Forb density n/1000 cm^2	3.4±0.6	0.2 - 6.3	4.3±1.0	0.2 - 11.4
Cryptogam cover (%)	2.4±0.5	0.1 - 5.4	2.3±0.4	0.0 - 4.5
Soil				
Soil depth (cm)**	51.0±2.3	36.2 - 60.0	31.0±3.1	16.3 - 52.6
Soil strength (kg/cm^2)				
Surface**	0.8±0.2	0.2 - 2.4	1.9±0.4	0.3 - 4.7
Subsurface (40 cm)**	3.8±0.3	1.2 - 5.0	4.6±0.2	2.0 - 5.0
Soil texture				
Surface				
Sand (%)	51.1±2.7	35.7 - 71.1	48.4±3.2	25.5 - 65.8
Silt (%)	30.4±2.1	16.6 - 44.7	31.8±2.3	20.7 - 45.3
Clay (%)	18.5±1.5	10.5 - 26.1	19.9±2.2	13.0 - 41.2
Subsurface (to 40 cm)				
Sand (%)	50.2±3.9	32.5 - 81.2	43.0±4.6	24.8 - 68.8
Silt (%)	27.0±2.1	12.0 - 35.8	26.4±2.3	16.6 - 44.1
Clay (%)**	22.8±2.7	6.8 - 36.9	30.5±3.5	10.8 - 48.2

* For areas occupied by pygmy rabbits where more than one adjacent was sampled, data from adjacent sites were averaged to obtain a pooled sample.

** Two-tailed paired *t* tests indicated means of differences of occupied and adjacent sites were significantly different ($P < 0.05$) from zero.

much less than the 46% total shrub cover measured at six sites inhabited by pygmy rabbits in Idaho (Green and Flinders 1980b). Mean shrub height at areas occupied by pygmy rabbits in Oregon was 84.4±5.8 cm, significantly taller than the mean of 56±2.8 cm measured at occupied sites in Idaho (Green and Flinders 1980b). We suspect observed differences in shrub cover, in part, were the result of different methods used to measure shrub cover in the two studies. A significant difference in shrub height possibly was the result of our decision to isolate sampling of adjacent areas. Mean shrub height for occupied and adjacent sites combined was 68.5±5.0 cm, and was not significantly different from shrub height reported in the Idaho study.

Marked differences in soil and vegetation characteristics between sites occupied by pygmy rabbits and adjacent sites were demonstrated graphically in a plot of discriminant scores for all sites (Fig. 4). Correlations between 10 habitat variables used in discriminant analysis and the discriminant function showed shrub cover best distinguished sites occupied by pygmy rabbits from adjacent sites (r = 0.71), followed by soil depth (r = 0.48), mean shrub height (r = 0.46), soil strength at surface (r = 0.27) and subsurface horizons (r = 0.19). Percent basal area of perennial grasses, density of annual grasses, density of forbs, and components of soil texture contributed little to the separation of the two groups ($|r| < 0.13$). Pearson correlation coefficients calculated for

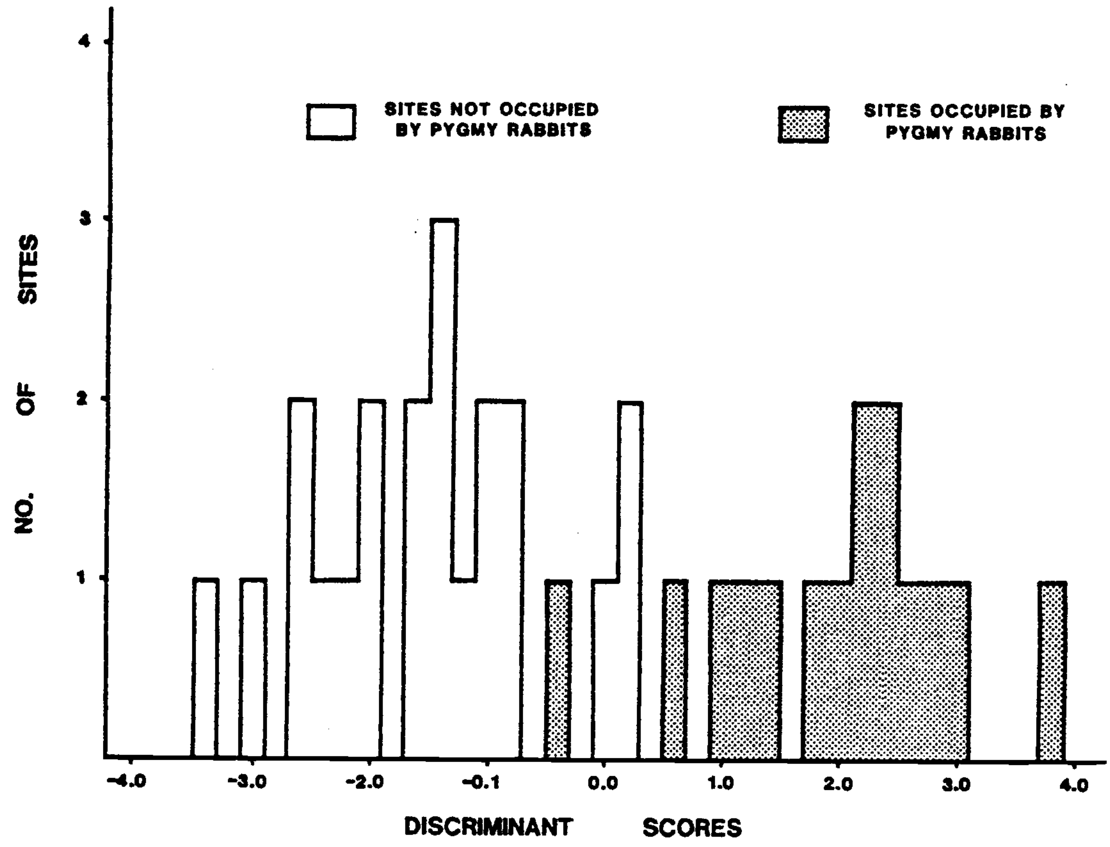

Figure 4. Frequency histogram of discriminant scores of 15 sites occupied by pygmy rabbits (centroid = 1.96), and 21 adjacent sites unoccupied by pygmy rabbits (centroid = -1.47), Oregon, 1982.

habitat variables measured at sites occupied by pygmy rabbits and adjacent sites showed soil depth was correlated positively with total shrub cover (*r* = 0.64), mean shrub height (*r* = 0.71), and correlated negatively with subsurface soil strength (*r* = -0.70). In addition, mean shrub height was correlated negatively with soil strengths of surface (*r* = -0.48) and subsurface (*r* = -0.57) horizons.

The number of entrances per burrow averaged for each of 15 sites occupied by pygmy rabbits was the dependent variable used in stepwise-multiple regression; soil depth, percent slope, surface and subsurface soil strengths, percent sand and percent silt at surface and subsurface soil horizons were the dependent variables. The best model (Neter and Wasserman 1974) showed number of burrow entrances varied inversely with slope and subsurface soil strength (R^2 = 0.55).

Four hundred and seventy-two sagebrush samples were analyzed to determine subspecies of *Artemisia tridentata*. Of these, 120 subsamples were identified as *A. t. vaseyana*, 101 subsamples were identified as *A. t. tridentata*, and 167 subsamples were identified as *A. t. wyomingensis*. Eighty-four (18%) subsamples could not be identified by criteria of Shumar et al. (1982). Shrubs associated with four sites seemed to be pure stands of *A. t. vaseyana* (Table 3). At remaining sites, stands were mixtures of *A. t. tridentata*, *A. t. wyomingensis*, and unknowns (possibly hybrids). Two sites had high densities of *A. t. tridentata*, compared with

Table 3.--Subspecific identity of 472 Artemesia tridentata samples collected at sites occupied by pygmy rabbits and adjacent sites not occupied by pygmy rabbits, Oregon, 1982. Subspecies of A. tridentata identified were A. t. tridentata (T), A. t. wyominensis (W), and A. t. vaseyana (V).

Sample Site Number	Rabbit-occupied sites				Adjacent to rabbit-occupied sites			
	T	W	V	Unknown	T	W	V	Unknown
1	15				10	5		
2	10	4		1	1	11		3
3	6	9			11			4
4*	7	5		3	5 (4)	7 (3)		3 (3)
5	4	9		2		14		1
6			15				15	
7*		13		2		14 (12)		1 (3)
8	11	1		3				
9		13		2		14		1
10			15				15	
11			15				15	
12			15				15	
13*	3 (13)	6		6 (2)				
14		4		11				
15*		4		11		(5)	(8)	14
Totals	69	68	60	43	32	99	60	41

* Values in parenthesis obtained from repeated sampling at site.

two sites where *A. t. wyomingensis* was predominant (Table 3).

No sign of recent activity of pygmy rabbits was evident at 10 of 15 sites occupied by pygmy rabbits in 1982 during a re-examination in April and July 1983 (Table 1). Of 51 active pygmy rabbit burrows located at five active sites in 1982, 19 were open in July 1983, and only 8 had relatively fresh fecal pellets of pygmy rabbits nearby.

DISCUSSION AND CONCLUSIONS

This study, the first attempt to quantify both soil and vegetative characteristics at sites occupied by pygmy rabbits, demonstrated that pygmy rabbits in Oregon inhabited areas where soils were significantly deeper and looser than soils at adjacent sites. Soil depth and soil strength, more than soil texture, were physical properties of soil that distinguished sites occupied by pygmy rabbits from adjacent sites. Soil properties associated with habitats of pygmy rabbits probably were related to the excavation of burrows. Mean soil depth at 13 sites occupied by pygmy rabbits (Table 2) approximated depths of pygmy rabbit burrows reported previously (Grinnell et al. 1930, Bailey 1936, Bradfield 1975), supporting the belief that pygmy rabbits burrowed only where soil depth was sufficient (Wilde 1978). In Oregon, the inverse relationship between number of burrow entrances and soil strength indicated softer soils facilitated burrow construction. However, the significant inverse relationship between number of burrow entrances and percent slope could not be explained on the basis of the present knowledge of the biology of the pygmy rabbit.

Identification of subspecies of *Artemesia tridentata* at and near areas inhabited by pygmy rabbits in Oregon indicated presence of pygmy rabbits was not dependent upon distributions of specific subspecies of big sagebrush. Because *A. tridentata* constituted a major portion of the diet of pygmy rabbits (Wilde 1978, Green and Flinders 1980b), and because preliminary observations indicated pygmy rabbits consumed specific subspecies of *A. tridentata* (Green and Flinders 1980b), we initially hypothesized distributions of pygmy rabbits were determined, in part, by distributions of subspecies of *A. tridentata*. Our findings did not support this hypothesis. White et al. (1982) reported consumption of *A. t. tridentata* and *A. t. vaseyana* by captive pygmy rabbits was not significantly different; we interpret this as additional evidence that the distribution of pygmy rabbits was not linked to specific subspecies of big sagebrush.

Basal areas and densities of grasses and forbs were not primary factors that distinguished sites occupied by pygmy rabbits from adjacent sites. A similar conclusion was reached by Green and Flinders (1980b) who compared masses of dry grasses and forbs at sites occupied by pygmy rabbits with those at unoccupied areas. In our study, however, pygmy rabbits seemingly did not inhabit areas where cheatgrass, *Bromus tectorum*, was abundant; high densities of *Bromus* *tectorum* were evident at only 2 of 51 sites where sign of pygmy rabbits was detected, and these sites were adjacent to asphalt highways. In areas where densities of *Bromus tectorum* and other annual grasses were great, our ability to locate pygmy rabbits, burrows, and fecal pellets, possibly was reduced. Relatively low densities of *Bromus tectorum* at sites inhabited by pygmy rabbits possibly resulted from foraging activities of pygmy rabbits. Green and Flinders (1980b) reported mean biomass of grasses was significantly less and biomass of forbs was significantly greater at sites where pygmy rabbits were most abundant, and concluded differences in biomasses of forbs and grasses were the result of greater consumption of grasses and less of forbs by pygmy rabbits. In Oregon, low densities of *Bromus tectorum* at sites occupied by pygmy rabbits likely were not the result of rabbit foraging, as annual grass density was not significantly different between occupied sites and adjacent sites (Table 2). We suspect more pygmy rabbits were supported in habitats with low densities of annual grasses, because open understories permitted unrestricted movement, especially in escaping from predators (Yahner 1982).

Affinity of pygmy rabbits for greater shrub cover and shrub height possibly is related to avoidance of predators and availability of forage. Compared with larger leporids, pygmy rabbits are relatively slow and vulnerable to predation in open habitats (Bailey 1936, Orr 1940), but demonstrate an ability to elude pursuers amidst shrub cover (Anthony 1913, Bailey 1936, Orr 1940, Severaid 1950, Wilde 1978). Because pygmy rabbits forage extensively on sagebrush and occasionally climb shrubs to forage (Janson 1946), greater Artemesia cover represents greater abundance of available forage. Shrub habitats reportedly reduced vulnerability to predation for relatively slow moving quadrupeds and small bipeds whose abilities to avoid predation in open areas especially were limited (Beatley 1976, Hallett 1982, Thompson 1982), and greater shrub cover provided a greater resource base for species able to climb shrubs (Rosenzweig et al. 1975, Hallett 1982). Shrub cover at communities occupied by rabbits may be especially critical in winter when up to 99% of the diet of pygmy rabbits consists of sagebrush (Green and Flinders 1980a), and snow accumulations permit easy access to distal parts of shrubs (Bradfield 1975) by rabbits poorly adapted for climbing.

A marked decline in pygmy rabbit activity at sample sites the second year of this study demonstrated pygmy rabbit populations were susceptible to rapid declines and possibly local extirpation. Other researchers detected similar declines in local populations of pygmy rabbits (Janson 1946, Bradfield 1975, J. Flinders personal comm.), but Wilde (1978), after a 2.5-year study of a population of pygmy rabbits in Idaho, concluded pygmy rabbits were a "high inertia" species, with reduced capacity for rapid population increases. The term "high inertia" was used by Murdoch (1970) to describe *K*-selected species, and although not explicitly stated by Wilde (1978), it could be inferred from his report that pygmy rabbits tended to be stable in number and populations were resistant to sudden declines. This inference was not supported by our observations, nor was it supported entirely by those of Wilde (1978), who abandoned one of three study sites when trapping success and number of active burrows declined.

Analysis of vegetation and soil components at areas associated with pygmy rabbits in Oregon, substantiated previous observations that pygmy rabbits occupied islands of habitat (Dice 1926, Davis 1939, Orr 1940) where dense or clumped stands of sagebrush (Anthony 1913, Grinnell et al. 1930, Bailey 1936, Severaid 1950, Bradfield 1975) grew in deep (Davis 1939, Campbell et al. 1982), loose soils (Orr 1940, Janson 1946). Because pygmy rabbits are associated with specific soil and vegetation conditions, and because communities of pygmy rabbits are susceptible to rapid declines and local extirpation, successful dispersal of pygmy rabbits into favorable habitats becomes crucial if populations of pygmy rabbits are to persist. Although dispersal abilities of pygmy rabbits are not understood clearly, some researchers suspect pygmy rabbits are reluctant or unable to cross open areas such as roads or desert lands cleared of sagebrush (Bradfield 1975, J. T. Flinders, personal comm.), and that dense stands of *A. tridentata* along streams, roads, and fencerows become avenues of dispersal for those rabbits (Green and Flinders 1980a). Concerns for pygmy rabbit populations traditionally have focused on habitat destruction associated with range and agricultural improvements (Green and Flinders 1980b, Holechek 1981). Fragmentation of sagebrush communities poses an additional threat to populations of pygmy rabbits by reducing the areas of these communities and increasing their interstitial distances, but the severity of this threat cannot be assessed without better understanding of the dispersal abilities of pygmy rabbits.

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