

# EVALUATING SHRUB-STEPPE HABITAT QUALITY USING THE PYGMY RABBIT (*Brachylagus idahoensis*) AS AN INDICATOR SPECIES

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## ♦ ABSTRACT

Relatively little is known about pygmy rabbits *Brachylagus idahoensis* except that they are typically associated with dense stands of big sage *Artemisia tridentata*. Because they are entirely dependent on sagebrush communities for survival, however, they may potentially serve as an effective means of environmental surveillance in shrub-steppe grasslands. The overall objective of this study is to clarify some of the ecological/physiological adaptations of the world's smallest leporid and define its obligate shrub-steppe association relative to structural, compositional, and micrometeorological features. We placed particular emphasis on the winter ecology of pygmy rabbits, and on understanding how such a small species (400 grams) that does not hibernate or significantly deposit fat, manages to survive in areas of extreme environmental temperatures, consuming primarily sagebrush.

## ♦ INTRODUCTION

Reductions in the quality and availability of sagebrush grasslands are threatening species of the shrub-steppe regions. Structurally-complex stands of sagebrush are rapidly disappearing because of conversion to irrigated agriculture, spraying and brush removal treatments, wildfires, and intensive grazing. Those sagebrush-dominated steppe habitats support a variety of wildlife species including

ungulates, raptors, predatory carnivores, and many small mammals. For some species, they serve as year-round home ranges; for others, as critical winter or transitional habitats. The pygmy rabbit *Brachylagus idahoensis* is an example of an extreme specialist, solely restricted in its distribution to sagebrush-dominated steppe habitats, and typically associated with dense stands of big sage *Artemisia tridentata*; (Green and Flinders 1980a; Weiss and Verts 1984) (Fig. 1). Pygmy rabbits are declining and/or are threatened in all known populations.

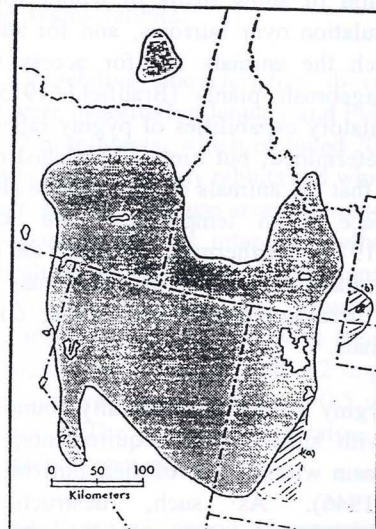


Figure 1. Geographic range of the pygmy rabbit *Brachylagus idahoensis* documented by Green (1978). Additions are from (a) Pritchette et al. (1987) and (b) C. Garber, pers. comm. Location of Fossil Butte National Monument is marked with an x.

The basis or extent of the shrub-steppe habitat dependency by pygmy rabbits is not fully understood. Sagebrush comprises a major portion of the diet, ranging from 51% in summer to 99% in winter (Green and Flinders 1980b). Among vertebrates, only the sage grouse *Centrocercus urophasianus* and some populations of mule deer *Odocoileus hemionus* and pronghorn antelope *Antilocapra americana* are known to consume such large amounts of sagebrush without detrimental effects (Severson et al. 1968; Braun et al 1973; Kufeld et al. 1973; Sundstrom et al. 1973). Sagebrush contains monoterpenoids (volatile oils) that may cause severe digestive disturbances. Yet the pygmy rabbit has a near obligate relationship with sagebrush (Green and Flinders 1980b). In winter, even when other woody vegetation is available, pygmy rabbits prefer to eat big sagebrush; in summer, even with unlimited availability of high quality grasses, sagebrush comprises a major part of the diet. Preferences by pygmy rabbits for certain populations of sage plants do not appear to be related to monoterpenoid content (White et al. 1982).

Tall stands of sage provide a dense "canopy" cover for protection of pygmy rabbits from raptorial predators and a dense sage "understory" structure that is important for protection from ground predators. Big sage also may provide an improved microclimate space and ease in food acquisition by contributing to the formation of snow drifts in winter for better ground insulation over burrows, and for subnivean trails, which the animals use for access to food between sagebrush plants (Bradfield 1975). The thermoregulatory capabilities of pygmy rabbits have not been determined, but limited published research has shown that the animals do not venture above the snow surface when temperatures are  $< -7^{\circ}\text{C}$  (Bradfield 1975). Furthermore, although the location of nests is unknown, a dense sage base may provide necessary thermoregulatory and hiding cover for young animals.

Pygmy rabbits are typically found in low numbers with small spatial requirements; animals usually remain within 30 m of their burrow systems (Janson 1946). As such, destruction and fragmentation of sagebrush grasslands may drastically affect their distribution, abundance, and dispersal abilities. Dense stands of sagebrush plants without a dense understory do not appear to support pygmy rabbits (C. Garber, Nature Conservancy, pers. comm), presumably because of the need for cover,

easy access to food, and/or nest protection. Because this species has small but specific spatial requirements, the isolation of small populations make it susceptible to rapid declines and possible extirpation. Also because of this extreme dependency on sagebrush-dominated habitats, the pygmy rabbit may serve as an indicator of the health and balance of the sagebrush ecosystem.

The objectives of this research were: (1) to investigate the relationships between the structural/compositional features of the shrub-steppe habitat, and the winter home range, habitat use, and activity patterns of pygmy rabbits, (2) to determine microhabitat selection by pygmy rabbits during winter in relation to microclimate and vegetation structure, and (3) to define large scale habitat features that are characteristic of areas inhabited by pygmy rabbits. Our particular emphasis was to understand how such a small species (400 grams) that does not hibernate or significantly deposit fat, manages to survive in areas of extreme environmental temperatures, consuming primarily sagebrush.

## ◆ STUDY AREA

Two research sites were selected in September 1992. The primary site was located near the Historic Quarry Trail in Fossil Butte National Monument, 16 km west of Kemmerer, Lincoln County, Wyoming. Preliminary observations suggested that this presently-ungrazed area supported a healthy population of pygmy rabbits. The study site was located on a steep southwest-facing slope, characterized by Basin Big Sagebrush Complex vegetation (Beetle 1974) and basic clay and silty clay soils. Annual precipitation averages 23 cm, with greatest amounts falling in May/June. Temperatures during winter months can range from  $-46^{\circ}\text{C}$  (Jan) to  $15^{\circ}\text{C}$  (Feb), averaging  $-9$  to  $-1^{\circ}\text{C}$  (USDA; SCS Cokeville, WY).

The second study site was located 14.5 km west of the Monument along Collett Creek. Although lacking a butte, the slope and elevation were comparable to the Fossil Butte site. The area was grazed heavily in past years (V. Phinney, BLM, pers. comm) and present vegetation appears trampled with shrubs well-spaced. Pygmy rabbit sign was much reduced. The general landscape at both sites can be characterized as high, cold, sage-dominated desert.

In October 1992, a grid system 1 km x 0.35 km was installed at both study sites for use during radiotelemetry monitoring and habitat assessment. The system consisted of twenty color-coded transects running perpendicular to a baseline, with 1.5 m metal stakes positioned every 50 m, resulting in 0.25 ha units.

## ◆ METHODS

### ANIMAL CAPTURE AND MONITORING

Eleven pygmy rabbits were captured in January 1993 at Fossil Butte National Monument using Tomahawk live traps modified with nest boxes, and baited with apple and alfalfa. Traps were set near burrows or other high-use areas (forms, runways) and covered with a fiberglass feed bag to provide wind and predator protection. Captured animals were tagged with numbered color-coded ear tags (Model #1841; National Band and Tag Co., Newport, KY), weighed, measured for morphological parameters, and equipped with radio collars (Model #CHP-1H with S9 sensor; Telonics, Inc., Mesa, AZ). Rabbits were located telemetrically one-two times daily from animal-specific radio signals; timing of radio locations was varied. Precise grid locations for rabbit sightings were determined by triangulating to the nearest 3 grid points with a compass rather than by measuring distances to the stakes, to minimize site impact (particularly in snow). Winter home range size was determined using adaptive kernel analysis (CALHOME program; USDA PSW Research Station). Activity sensors in the radio collars allowed for continuous chart recorder traces to document activity budgets in relation to environmental conditions. Numerous behavioral observations, lasting 45-180 minutes during daylight hours, were conducted to define when animals were above the snow surface, what portion of activity bouts were spent foraging, and how far pygmy rabbits travelled when they were active.

No animals were captured at the Collett Creek study site. Pygmy rabbits were observed within the grid system during October 1992 and early January 1993. Following unsuccessful trapping efforts, an intense systematic search of the area on snowshoes was made in mid-February; no animals or burrow systems were located. After continued search in all directions outside the grid, 3 burrows were

found 250-750m from the grid and approximately 1 km from where rabbits were previously observed. Only one burrow was within a logistically-attainable area for monitoring and sign of more than one animal was not found. Whether the severity of the winter caused exceptional mortality and/or dispersal from the low-quality site is unknown.

### METEOROLOGICAL AND VEGETATION MEASUREMENTS

Micro-meteorological variables (air temperature, wind, solar and thermal radiation) were continuously measured in open and sage/snow-covered environments by a portable weather station located near the center of the research site at Fossil Butte. All environmental variables were logged every minute (CR-21X; Campbell Scientific Inc., Logan, UT) and averaged over a 15-minute period. Snow depths at 1 m intervals along 40 m transects encompassing high- and low-use areas, and near pygmy rabbit burrow systems, were measured on a weekly basis and after significant snowfall events. Weather variables were combined into a standard operative temperature (Bakken 1981), or thermal index that incorporates the effects of wind and radiation. Operative temperature is more representative of the environment experienced by an animal than is air temperature alone, and may be particularly important relative to the benefits of solar gain for pygmy rabbits.

Vegetative characteristics above the snow surface were measured in January and February 1993 on the 40 m transects, which included 20 m in areas frequently used by pygmy rabbits and which extended 20 m into adjacent low-use areas. Canopy cover was estimated using the line intercept method. Canopy size, shrub height and width, and distances between shrub canopies were compared between high- and low-use areas. Foliage profiles were measured using a vertical intercept technique with a 2 m pole marked in 10 cm intervals positioned every 0.5 meters along each transect. The number of vegetative hits in each 10 cm interval was recorded.

A five-week period of vegetation sampling without snow began in early April 1993. After locating home range use areas of the rabbits on the ground, the longest straight-line axis in each area was determined (Fig. 2). Ten-meter transects were systematically placed perpendicular to this baseline

and placed at 10 m intervals in areas where the longest axis was  $\geq 50$  m, and at 5 m intervals in smaller areas. The direction of the transects off the baseline was randomly chosen. Vegetation sampling was adapted from Dueser and Shugart (1978) and M. Gahr (pers. comm., pygmy rabbit research, WA). On each transect, measurements of canopy characteristics and foliage profiles were similar to those made during winter except relative to bare ground instead of the snow surface. Percent herbaceous ground cover was calculated from Daubenmire square measurements. Shrub density, dispersion, and size were measured for dead and living components of all *Artemisia* shrubs rooted in a 1-m wide belt transect. Samples from *Artemisia tridentata tridentata* and *A. t. wyomingensis* plants that were observed to be primary foraging sites of pygmy rabbits were clipped for food quality assessment (energy, protein, fat, and fiber content).

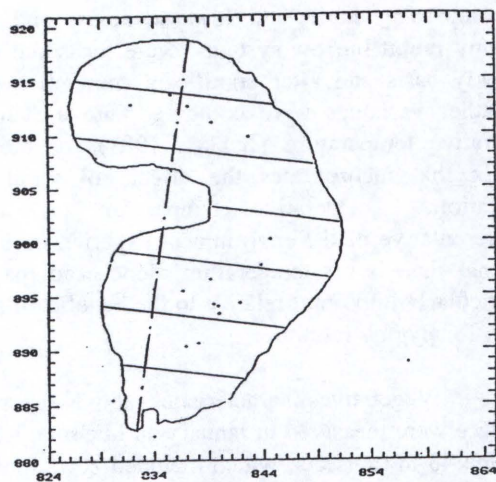


Figure 2. Example of vegetation transects located at 5 m intervals along the longest axis of a home range use area. Home range use area was calculated to encompass 95% of the locations (+) for animal #581 using the program CALHOME. X and Y coordinates represent grid increments in m.

## ◆ RESULTS AND DISCUSSION

### MICROMETEOROLOGICAL MEASUREMENTS

The 1992-1993 winter was characterized by high snow accumulation and cold temperatures. Weather monitoring at Fossil Butte National

Monument indicated that the combination of deep snow and cold temperatures was the most severe since the early 1970's with the exception of the 1983 season. The obvious visual effects were most noticed in terms of the vegetation at the research site. Most dense stands of sage were completely covered, resulting in an almost uniform, flattened surface broken only occasionally by the tops of the highest sagebrush plants. Snow depths ranged from 0.2m on windswept hillsides to  $> 1$ m in the sagebrush draws.

Average, maximum, and minimum temperatures; wind speeds; and solar radiation levels between 0615 and 1930 were similar between January and February 1993 (Table 1). The average standard operative temperatures, which combine the effects of solar radiation and wind, were much lower than  $-7^{\circ}\text{C}$ , previously thought to inhibit activity of pygmy rabbits (Bradfield 1975). The rabbits were observed during active periods at air temperatures in the open of  $-20^{\circ}\text{C}$ , and at standard operative temperatures of  $-30^{\circ}\text{C}$ . Temperatures under vegetation and snow canopies were usually within  $0.5^{\circ}\text{C}$  of open air recordings. Future analyses will assess the impacts of microclimate on specific activity patterns and define when activities are restricted by thermal parameters.

Table 1. Average, maximum, and minimum temperatures, wind speeds, solar radiation, and calculated standard operative temperatures ( $T_{so}$ ) for January and February 1993 at Fossil Butte National Monument. Daily values are based on averages obtained every 15 minutes.

	Temperature ( $^{\circ}\text{C}$ )	Wind speed (M/s)	Solar level ( $\text{W}/\text{m}^2$ )	$T_{so}$ ( $^{\circ}\text{C}$ )
<b>JANUARY</b>				
Average	-9.1	2.5	198	-13.6
Maximum	15.4	16.5	764	29.3
Minimum	-23.2	0.5	0	-31.0
<b>FEBRUARY</b>				
Average	-9.7	2.3	145	-13.3
Maximum	7.0	22.1	951	30.9
Minimum	-24.9	0.5	0	-37.2

### ACTIVITY PATTERNS

Pygmy rabbits appeared to regularly move more than 50m from their burrow systems. They usually remained under the snow surface during

inclement weather, but were influenced by severe storms. In all cases, animals moved 50-250 m just before or during the storms from the areas of dense sage, where there were many subnivean burrows that could easily be filled by major snowfalls, to snow and/or underground burrows on nearby hillsides. At open hillside locations, rabbits were more susceptible to predation than in the lower areas of deep snow that had some cover. Pygmy rabbits appeared to take advantage of solar gain for thermoregulatory purposes by sitting quietly at the burrow entrance - in the open. They may have been capable, therefore, of coping with cold and snow by behavioral and physiological adaptations, assuming food supplies were sufficient for them to gather food beneath the snow surface, but they had little control over the corresponding benefits that deep snows and increased visibility afford predators.

The collared pygmy rabbits did not survive past late February 1993. Most were taken by raptors, presumably golden eagles, with several other cases of ground predation (weasels, foxes). It is our belief that the severity of the winter and the consequential reduction in cover from predators, were primarily responsible for such high mortality rates.

Pygmy rabbits were generally more inactive than active during January and February. Analyses of radiotelemetric chart recordings, excluding questionable signals when animals were likely out of the home range use area, and when signal transmission was shielded from vegetation or snow/ground burrows, showed that on a daily basis, pygmy rabbits averaged 59% of the time inactive, and 41% active. From known behaviors above ground during the behavioral observations, the rabbits were inactive 64% of the time compared to 36% of the time active (Table 2).

Within active periods, pygmy rabbits spent the majority of their time feeding (52%). They also spent considerable time moving (29%), and lesser amounts of time eating snow (8%), preening (8%), digging (1%), and ingesting fecal pellets (1%) (Table 3).

#### HOME RANGE

Home ranges were determined for 7 pygmy rabbits for which there were 14 sightings (Table 4). Home range size varied from very small areas (548

m<sup>2</sup>) with only one main use area encompassing 95% of the observations to home ranges more than 6 times larger (3702 m<sup>2</sup>) with two concentrated use areas. The number of visual observations was not correlated with home range size ( $r = 0.047$ ).

Table 2. Percent time active and inactive determined from known behavioral observations ( $n > 4$  periods) and continuous telemetric monitoring of pygmy rabbits at Fossil Butte National Monument during January and February 1993.

Rabbit	% Active	% Inactive
<b>OBSERVED:</b>		
#508	43.0	57.0
#502	24.5	75.5
#550	26.1	73.9
#DN	49.6	50.4
#DOM	35.3	64.7
<b>CONTINUOUS MONITORING:</b>		
#508	43.3	56.7
#550	33.1	66.9
#581	68.0	32.0
#524	21.0	79.0

Table 3. Percent time engaged in specific activities during active periods in January and February 1993 for 5 pygmy rabbits at Fossil Butte National Monument.

Rabbit	Move %	Feed %	Eat snow %	Preen %	Dig %	Coprophagy %
#508	16.8	57.3	9.9	14.7	0.9	0.4
#502	36.1	43.9	8.4	5.5	2.4	3.7
#550	21.5	44.6	19.7	13.3	0.2	0.7
#DN	46.6	46.7	2.2	3.4	1.0	0.1
#DOM	23.8	69.0	1.4	2.0	1.6	0.2
Average	29.4	52.3	8.3	7.8	1.2	1.0
± SD	12.0	10.8	7.4	5.8	0.9	1.5

Although some individual animals remained fairly isolated, pygmy rabbits did not appear to be territorial because many home range use areas overlapped (Fig. 3). There was also considerable evidence of social behavior. Animals chased each other while playing on many occasions; others lived close enough that they were obviously aware of each other but did not visibly interact.

Table 4. Use areas and total home range sizes for 7 pygmy rabbits during January and February 1993 at Fossil Butte National Monument.

Rabbit	# Locations	Area #1 (m <sup>2</sup> )	Area #2 (m <sup>2</sup> )	Total area (m <sup>2</sup> )
#516	14	2073	1353	3426
#524	20	3309	393	3702
#532	22	2459	345	2804
#581	25	548		548
#502	46	1957		1957
#550	51	1511	547	2058
#508	63	2352	1156	3508

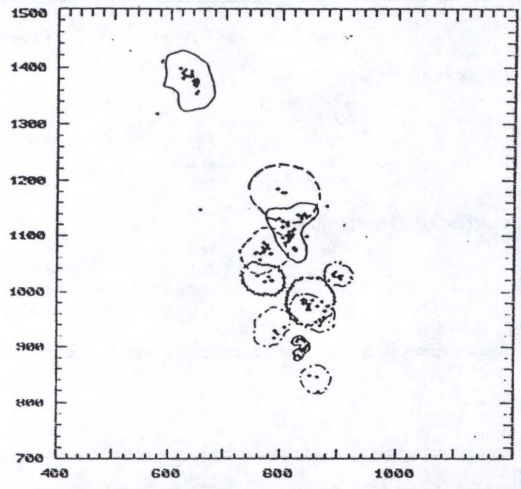


Figure 3. Home range use areas of the seven pygmy rabbits listed in Table 4. Axes represent grid increments in m.

**HABITAT MEASUREMENTS**

Principal vegetation during winter was dominated by *Artemisia tridentata*, of which two subspecies (*tridentata*, *wyomingensis*) were always present in the home ranges of all pygmy rabbits. Seven other shrubs were also documented (Table 5). Two grasses were commonly found, but provided minimal ground cover.

Snow depths were consistently higher in areas that were frequently used by pygmy rabbits compared with low-use areas (Fig. 4). Between January and March, average snow depths increased from almost 60 cm to more than 80 cm in the frequently used areas.

Table 5. Common plants found in winter home ranges of pygmy rabbits at Fossil Butte National Monument.

**SHRUBS:**

- Artemisia tridentata tridentata* (Basin big sagebrush)
- Artemisia tridentata wyomingensis* (Wyoming big sagebrush)
- Artemisia tridentata vasyana* (Mountain big sagebrush)
- Artemisia longiloba* (Alkali sagebrush)
- Chrysothamnus nauseosus* (Rubber rabbitbrush)
- Chrysothamnus viscidiflorus* (Low rabbitbrush)
- Purshia tridentata* (Antelope bitterbrush)
- Atriplex confertifolia* (Shadscale)
- Sarcobatus vermiculatus* (Greasewood)
- Symphoricarpos occidentalis* (Western snowberry)

**GRASSES:**

- Oryzopsis hymenoides* (Indian rice-grass)
- Elymus cinereus* (Basin wild rye)

**AVERAGE SNOW DEPTH  
LOW vs. HIGH USE AREAS (with 95% CI)**

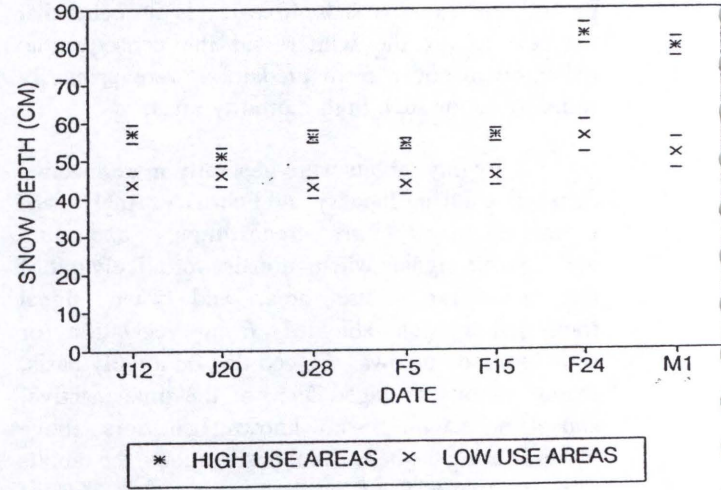


Figure 4. Average snow depths (with 95% confidence intervals) in areas that were highly used and infrequently used by pygmy rabbits at Fossil Butte National Monument. J=January; F=February; M=March.

Vegetative cover provided by shrubs above the snow surface declined on all transects in high and low-use areas between January and late February as snow depths increased. Generally, percent cover was almost three times greater in the high-use areas compared with areas of low use. Similarly, the average number of plant canopies along a 20-m transect declined from 24 to 14 during the same time

period in the highly-used areas, and from 14 to 8 in the low-use areas. Those trends resulted in larger open spaces between shrub canopies. Therefore, even though average height and width of shrubs were very similar in high- and low-use areas, vegetation was more dispersed in areas of low use (Fig. 5). Shrub dispersion increased with higher snow depths in late February. Canopy characteristics in the low-use areas were not different than in areas that were not inhabited by pygmy rabbits when measured in late February (Fig. 5).

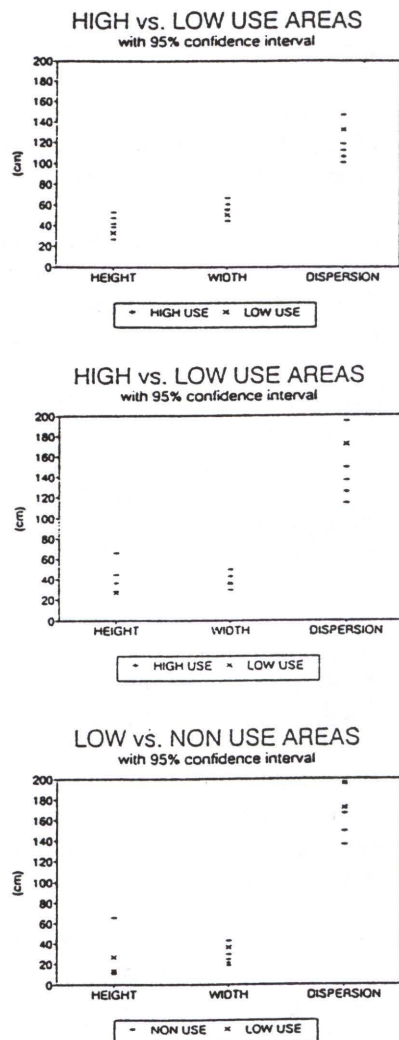


Figure 5. Average height and width of snow canopies above the snow surface, and distance between shrub canopies (with 95% confidence intervals), in areas that were highly used and infrequently used by pygmy rabbits in January (a) and February (b) at Fossil Butte National Monument. Low-use areas were compared to nearby areas not inhabited by rabbits in February (c).

Vegetation characteristics of *Artemisia tridentata* were measured after the snow had melted and compared between the home ranges used by pygmy rabbits and the areas available to the rabbits. The number of shrubs per 10-m transect, maximum and minimum heights for living and dead material, and average canopy width did not vary significantly (Table 6).

Table 6. Average number of shrubs, maximum and minimum heights for living and dead material, and average canopy width of *Artemisia tridentata* along 10-m transects (1-m wide) in winter home ranges used by pygmy rabbits compared with areas available to the rabbits at Fossil Butte National Monument.

	Shrubs (#)	Live max (cm)	Live min (cm)	Dead max (cm)	Dead min (cm)	Canopy size (cm)
<b>HOME RANGE:</b>						
Average	17.5	57.7	20.7	43.2	3.3	47.2
± SD	3.5	10.6	7.5	5.0	0.6	4.2
<b>AVAILABLE:</b>						
Average	20.2	43.1	14.1	36.7	3.2	40.7
± SD	1.9	11.7	5.8	7.8	1.6	7.3

Vertical foliage profiles, however, indicated that the home ranges selected by pygmy rabbits were consistently denser at all heights above the ground than were available areas (which encompassed both used and unused areas in the same vicinity) and non-use areas (never observed to have been used by pygmy rabbits) (Fig. 6). The one exception to the finding was the large number of vegetative hits recorded 10 cm from the ground surface in non-use areas; those reflect a large amount of dead grasses. Data from the vertical foliage profiles confirm previous visual observations that sagebrush stands without a dense understory do not support pygmy rabbits. Whether this requirement is for thermal cover, easy access to food, escape from predation, or a combination of all needs is still unknown.

◆ PRELIMINARY CONCLUSIONS

Definitive conclusions for our project can not be made until field research is concluded. We

documented an extreme case for survival by pygmy rabbits, with high rates of mortality during the 1993 winter. We are continuing field studies this winter (1994), under much less extreme environmental conditions. The comparison between a very harsh winter and a more average or 'representative' season, will help us understand the relative importance of environmental conditions and predation. If such high mortality rates are common, regardless of weather severity, structurally-complex sagebrush stands may be most important to pygmy rabbits as cover from predators. Fossil Butte National Monument represents the geographic limits of this species' range. Following the current field season, we hope to distinguish between limits imposed by thermal parameters and those caused by predation.

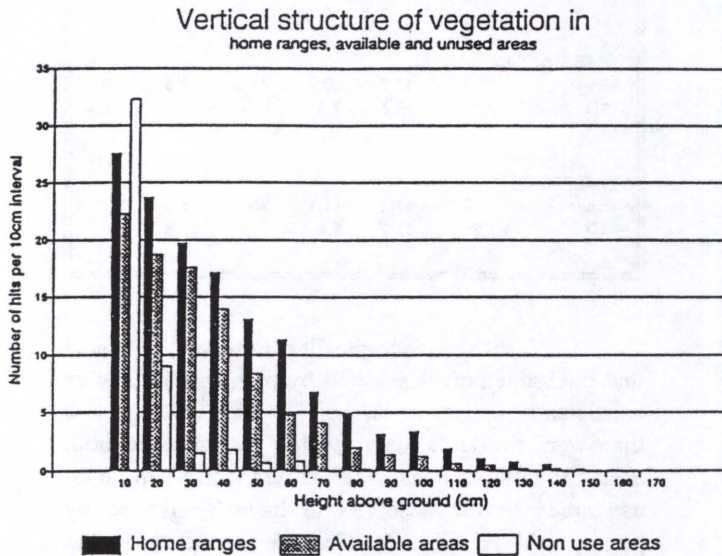


Figure 6. Vertical foliage profiles determined for pygmy rabbit home ranges, available areas, and areas not used by the rabbits during January and February 1993 at Fossil Butte National Monument.

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