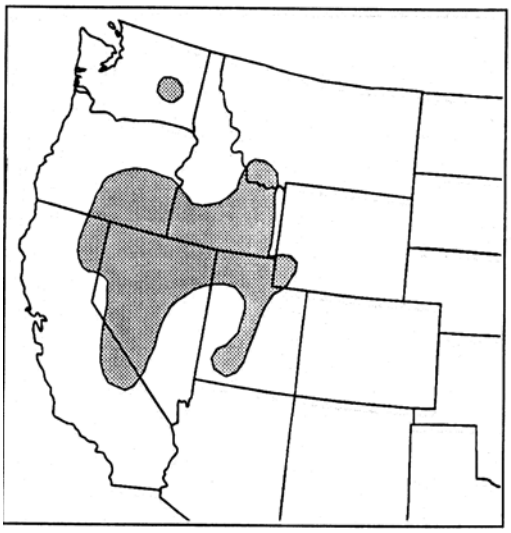
Abstract

Pygmy rabbits (Brachylagus idahoensis) have been documented in Montana since 1918. Historical distribution records are sparse at best. Concern over the status of the pygmy rabbit lead to a evaluation of its current distribution in Montana. The present distribution of the pygmy rabbit is defined and reflects historical distribution maps. Pygmy rabbits were present in all historical locations except one. Some evidence suggests a slight contraction in pygmy rabbit distribution. Habitat parameters are similiar to occuppied areas in other states. Big sagebrush was slightly shorter in occuppied sites in Montana and averaged 21.3 % coverage by line intercept method. In Montana, pygmy rabbits appear to prefer gently sloping or level floodplains where adequate sagebrush and soils exist. However, many different occuppied sites have been located. Loss of prefered habitat through sagebrush removal is probably the greatest threat to the species. One calculated density in good habitat in Montana of 3.03 rabbits/ha is higher than than reports from Washington and Oregon. Morphologically, pygmy rabbits are similar to those in other states with females weighing slightly heavier than males. Continued monitoring of pygmy rabbit's distribution is recomended.

Introduction

The pygmy rabbit occupies most of the Great Basin of western North America (Figure 1). The pygmy rabbit is not ubiquitous over the outlined range, being found primarily in big sagebrush (Artemisia tridentata) dominated plains and alluvial fans where plants occur in tall, dense clumps (Green and Flinders, 1980a).



The pygmy rabbit was first documented in Montana by Goldman in 1918 (Hoffman et al. 1969). The most recent specimen was collected by Neil Martin in 1963 in Big Sheep Basin (MSUZ 5510). Since then, there has been no additional documentation until this study.

The pygmy rabbit was formerly considered a C2 species for possible listing under the Endangered Species Act by the US Fish and Wildlife Service. Since deletion of this category, it is considered a *Species at Risk* by the US Fish & Wildlife Service (Fish and Wildlife Service, 1994). The pygmy rabbit is considered a *Species of Special Concern* by the Montana Natural Heritage Program (MNHP) and Montana Fish, Wildlife and Parks (MDFWP). The MNHP current status code for the pygmy rabbit is G4, S2S3. The G4 status is a Global Rank that states that the pygmy rabbit is apparently secure, though it may be quite rare in parts of its range, especially at the periphery. The S2S3 status is a State Rank indicating that the pygmy rabbit is imperiled or vulnerable to extinction and is found locally in a restricted range (a complete explanation of MNHP ranks is given in Appendix A). Loss of preferred habitat and habitat fragmentation is probably the most significant factor in any population declines the species may have suffered (Lyman 1991, Weiss and Verts 1984).

Concerns over the status of the pygmy rabbit in Montana led to an evaluation of the species' distribution, habitat and status beginning in 1993. Initially, MDFWP, Bureau of Land

Management(BLM) personnel, and volunteers conducted searches to locate occupied sites in Beaverhead and Madison counties. These preliminary efforts provided insight for further study of this species. In 1995, additional effort was initiated to better define distribution, describe vegetation on occupied sites, investigate population dynamics, and investigate ecological relationships with other lagomorphs. This report includes data collected from all previous efforts.

Objectives

The primary objectives of this study included:

A. Determine distribution of the pygmy rabbit in Montana and describe distributional fragmentation or cohesion.

B. Characterize and describe vegetation on occupied sites and assess condition.

C. Investigate natality rates and assess mortality rates and causes.

D. Investigate ecological relationships with other lagomorphs, particularly the mountain cottontail (Sylvilagus nuttallii).

Secondary objectives developed during initial efforts and literature review included:

E. Determine edaphic factors on occupied sites.

F. Determine burrow structure and classify burrow types.

G. Determine seasonal food habits, forage preferences and diet overlap with other lagomorph species.

Methods

Distribution: Previous search efforts in Montana demonstrated that walking searches were required to locate evidence of pygmy rabbit occupation in suspected habitats during summer (Flath and Rauscher, 1995). Walking searches were conducted in suspected habitat in southwest Montana and consisted of identifying and recording evidence of occupation. Evidence of occupation included fresh pellets, old pellets, visual observation, or burrows. Active burrows were defined as those burrow entrances with fresh pellets or other pygmy rabbit sign associated with the entrance. If no evidence of occupation was found, the site was classified as unoccupied. Once an occupied site was located, further walking surveys were conducted in the area to determine occupation boundaries. Locations of all sites classified as active were recorded in UTMs using a Garmin 45 GPS unit.

Additionally, areas where museum specimens were collected and historically occupied

sites (Hoffman et al. 1969 and Dan Gomez pers. comm.) were searched. The areas identified were:

① 3 miles SE of Leodore on the Donovan Ranch, 1918 (Exact location unknown)

② Sage Creek, 15 miles E of Dell, Beaverhead Co., 1963 (Exact location unknown)

③ R12W, T9S, Sec. 9, Beaverhead Co. 1977

④ Red Rocks Refuge, Beaverhead Co. 1949 (Exact location unknown)

⑤ Tash Ranch, near Dillon, MT. (Exact location unknown)

⑥ Centennial Valley, Beaverhead Co. (Exact location unknown)

Characterization of vegetation and edaphic factors: Shrub cover, height and density were measured using line intersect and belt transect methods. Grass and forb cover were established utilizing Daubenmire areal cover class method (Daubenmire, 1958). All major species present were identified. Five sites in 1996 and 13 sites in 1997 that were occuppied and active were selected for vegetation measurements. Vegetation sites were distributed across the occupied region of Montana (Figure 2). At each site, 3 parallel line transects, each 30 m long and 10 m apart, and one belt transect were established at right angles to the topographic contour. The starting point for the first transect was arbitrarily established and other starting points were established with reference to the first. At least one active burrow was included between the outer line transects. All shrubs intersecting the transect were measured to establish percent cover. The height and number of shrubs within the belt transect were recorded to establish average shrub height and shrub density. Ten plots (1m x 1m) were spaced evenly along each line transect. Cover class of the 8 dominant plant species was visually estimated to establish percent cover. Less dominant plant species were combined and grouped by vegetative class. The percent of each vegetative class were determined from the data.

Natality, mortality, biotype and population estimation: Data were collected by trapping rabbits using Tomahawk live traps and other capture methods described by Green and Flinders (1979). Breeding season, reproductive parameters, and biotype were determined from trapped individuals. Trapping efforts were concentrated in the Badger Gulch area southwest of Bannack in 1996. This area was divided into two distinct units, LB1 and LB2. Body measurements from all individuals captures were recorded. Measurements included: reproductive state (males:immature, mature-abdominal, mature-scrotal; females:immature, gravid, lactating), ear length (mm), weight (gm), hind foot length(mm). All individuals captured were ear tagged for individual identification. Litter size was estimated by palpation of gravid females, necropsies of trap mortalities, and spotlight counts. Mortality was documented by analysis of predator scat, pygmy rabbit remains, and sightings or evidence of occurrence of predators in occupied areas.

Two trapping areas in the Badger Gulch area were delineated where trapping efforts

continued throughout the 1996 field season. One area, LB1, was abandoned due to trap mortalities. The remaining area, LB2, was trapped at semi-regular intervals (n=14) during summer. Initially, 2 consistent trapping efforts were used in a Lincoln-Peterson population estimation. Additional trapping efforts were later conducted and used in the Noremark population estimation model (White, 1996). All burrows in both capture areas were counted and identified. Population estimation and number of burrows allowed calculation of rabbits per burrow. Only burrow density was recorded from the abandoned LB1 site. All burrow locations were recorded in UTM's using a Garmin 45 GPS unit. Accuracy of the GPS unit is within approximately 15m. The home range program Calhome was used to determine size of area measured using boundary waypoints. The measured area was then divided into the number of active burrows to determine density.

Relationships with other Lagomorphs: The only other lagomorph currently associated with pygmy rabbits that utilizes burrows and whose habitat overlaps is the Mountain cottontail. Degree of diet overlap (if any), spatial associations and social interactions are not known. To assess spatial associations, all evidence of occupation by mountain cottontails on pygmy rabbit sites were recorded.

Burrows: Burrow structure has been documented in other states but information on burrow assessment in Montana was lacking. To evaluate burrow structure and perhaps locate newborn pygmy rabbits, three active burrows were excavated where female rabbits were previously trapped in 1996. Number of entrances to each burrow, depth, slope, aspect, soil strength, and structure were recorded. Several burrows were smoked to determine subsurface connections between burrow openings. Smoking consisted of forcing smoke into the largest burrow entrance with a battery-powered fan and recording all openings that smoke exited from. Burrow opening dimensions and distance between openings were recorded. Burrow classification was attempted from trapping data. Additionally, 95 burrows were investigated in April, 1997 using a Peeper video probe (Christensen Designs, Manteca, CA) . Efforts to classify burrows to determine number of burrows used by each rabbit were attempted in the LB1 and LB2 areas. Classification types attempted were: pygmy rabbit single occupancy, pygmy rabbit shared, and pygmy rabbit/mountain cottontail shared.

Food Habits: To evaluate diet of pygmy rabbits in Montana and determine diet overlap with the mountain cottontail, fecal analysis of sympatric pygmy rabbit and mountain cottontail pellets will be conducted. Composite rabbit pellets were collected from active sites from summer, 1996 to spring, 1997. Fecal samples collected in May, 1996 were discarded because of difficulty distinguishing between pygmy rabbit pellets and juvenile mountain cottontail pellets based on size alone. Fecal samples during summer were collected only from trapped individuals for positive identification. Composite samples were collected from active sites where both species occupied the same local area. Analysis of food habits will allow determination of pygmy rabbit diets in Montana and degree of overlap with the mountain cottontail. Composite samples have been sent to Composition Analysis Laboratory, Fort Collins, Colorado. Results of analysis are expected by May 1998.

Results

Distribution: Walking searches documented locations of pygmy rabbits in Beaverhead, Madison and Deer Lodge counties in southwest Montana in 1996 and 1997 (Figure 2 (density of symbols does not represent density of burrows), Appendix B). Most occupied sites identified in previous efforts were revisited to verify continued occupation. Basic survey efforts are complete. However, given the patchy distribution of the species, every occuppied site has not been located. Therefore, pygmy rabbits may occur outside the defined range and will not occur in all sagebrush sites within the defined range. Pygmy rabbits occupy suitable habitat in the majority of Beaverhead county, the extreme southern end of Deer Lodge county and the western edge of Madison County. These occupied areas are shrub-grasslands and intermountain shrub-grasslands (Figure 2). The pygmy rabbit appears to be adapted to a variety of habitat features as long as adequate sagebrush cover and suitable soils exist. Pygmy rabbits occupy a wide variety of topographic features including alluvial fans, floodplains, plateaus, high mountain valleys, and mountain slopes. The preferred habitat in Montana appears to be gently sloping or level floodplains where adequate sagebrush and appropriate soils exist. However, many occupied sites have marginal sagebrush cover and shallow soils. These areas are generally associated with patches of tall, dense sagebrush and adequate soils. Areas of marginal sagebrush cover or stringers of sagebrush have been identified as important habitat features that allow movement into suitable habitat. In one area along Blacktail Deer Creek, pygmy rabbits crossed 500 yds of a relatively open grassland to occupy a sagebrush stringer located in the bottom of a coulee. Additionally, pygmy rabbits were located in high mountain valleys that were connected by narrow sagebrush stringers to occupied floodplains.

Although no direct searches were made, subnivian tunnels were encountered several times during this study. One tunnel never emerged above the snow and appeared to be well used. All other tunnels encountered emerged at least once to above snow. No measurements were taken on any subnivian tunnel although two were partially excavated. The two excavated tunnels extended from the ground level entrance to sagebrush plants in the near vicinity. Both tunnels branched at least once. Browsing was evident on all sagebrush plants connected by the tunnels. Near the entrance of one subnivian tunnel, drag marks in the snow appeared to be a sagebrush branch. The markings were intermittent from a nearby sagebrush plant and into the entrance of the tunnel suggesting that this rabbit clipped a branch and took it into the tunnel for consumption safe from surface predators. Other evidence of subnivian tunnels was encountered during summer field seasons. Several sagebrush plants showed signs of browsing consistent with pygmy rabbits well above the reach of erect pygmy rabbits. One plant near a pygmy rabbit burrow in Little Sheep Creek Basin was severely hedged approximately 60 cm above ground level. Also, pellets were encountered in the crotches of sagebrush plants at many locations. Logically, these pellets were deposited when snow levels allowed subnivian tunnels to be excavated through these areas.

All historical locations were visited except for 3 miles SE of Leodore to determine occupancy. Historical sites searched exhibited signs of occupation with the exception of the Tash Ranch. The probable location of the collection specimen from the Tash Ranch has been converted to irrigated cropland. However, occupied sites have been located approximately 10

km west of the Tash Ranch. The remainder of the historical sites appear to have active rabbit populations. However, some of these sites are considered marginal habitat due either to inadequate sagebrush cover or soil type and should not be used to typify preferred habitat in Montana. For example, one active pygmy rabbit site was located near Red Rock Lakes National Wildlife Refuge after an extensive search. The soil was composed primarily of sand and many of the burrows found at the site had collapsed. Only one open burrow was found. Another occupied area in the Centennial Valley was located where pygmy rabbits occupied a small island of big sage that was surrounded by threetip sagebrush (*A. tripartita*). Burrows were absent from the patches of threetip sage but abundant in the big sage.

No evidence of a significant range decrease has been found. However, several sites were located that appear to have been occupied in the past but are now vacant. West of Dillon, at the southern end of Dutchman Mountain, old collapsed burrows were found that had very old pygmy rabbit pellets by them. The nearest active burrow was approximately 7 km to the southwest. Additionally, at the northern edge of Frying Pan Basin, soils and sagebrush appear adequate but no evidence of pygmy rabbits was detected. Mountain cottontail and jackrabbit pellets were abundant. Some evidence suggests that pygmy rabbits once existed on the north side of McCarntey Mountain. A few old burrows and a few very old pellets were found but could not be positively identified as pygmy rabbit pellets. These areas are contained in the historical distribution maps (i.e. Figure 1) however there are no records to confirm pygmy rabbit occupation in the past.

Characterization of Vegetation: Five occupied sites in 1996 and 13 in 1997 were measured to establish percent vegetation cover class, height and density of big sage. The locations of the vegetation transects are shown in Figure 2.

Big sagebrush was the dominant shrub at all sites measured averaging 21.32 percent coverage by line intercept method and 22.60 percent by Daubenmire areal cover class method over all sites (Table 1). The highest average cover class was bare ground, and forbs were the lowest cover class (33.0% and 5.8% ,respectively). Percent cover by forbs may be under represented because transects were conducted in late summer when most forbs have completed their life cycle. Other shrubs (Chrysothamnus vicidiflourus, C. nausiousus, Tetradymia canescens) comprised 2.8 percent of shrub coverage. A variety of grasses were found at all locations, but all species were not present at every site (Appendix B). Sagebrush height averaged 37.28 cm, while other shrubs present averaged 23.0 cm. Sagebrush in occupied areas in Montana averaged slightly shorter than in other states (Table 2). Density of big sagebrush averaged 2.13 plants per m^2 while other shrubs combined averaged 0.70 plants per m^2. All shrubs present in plot transects were not represented in the line transects. The percent cover of big sagebrush is similar to occupied sites in other states (Table 2).

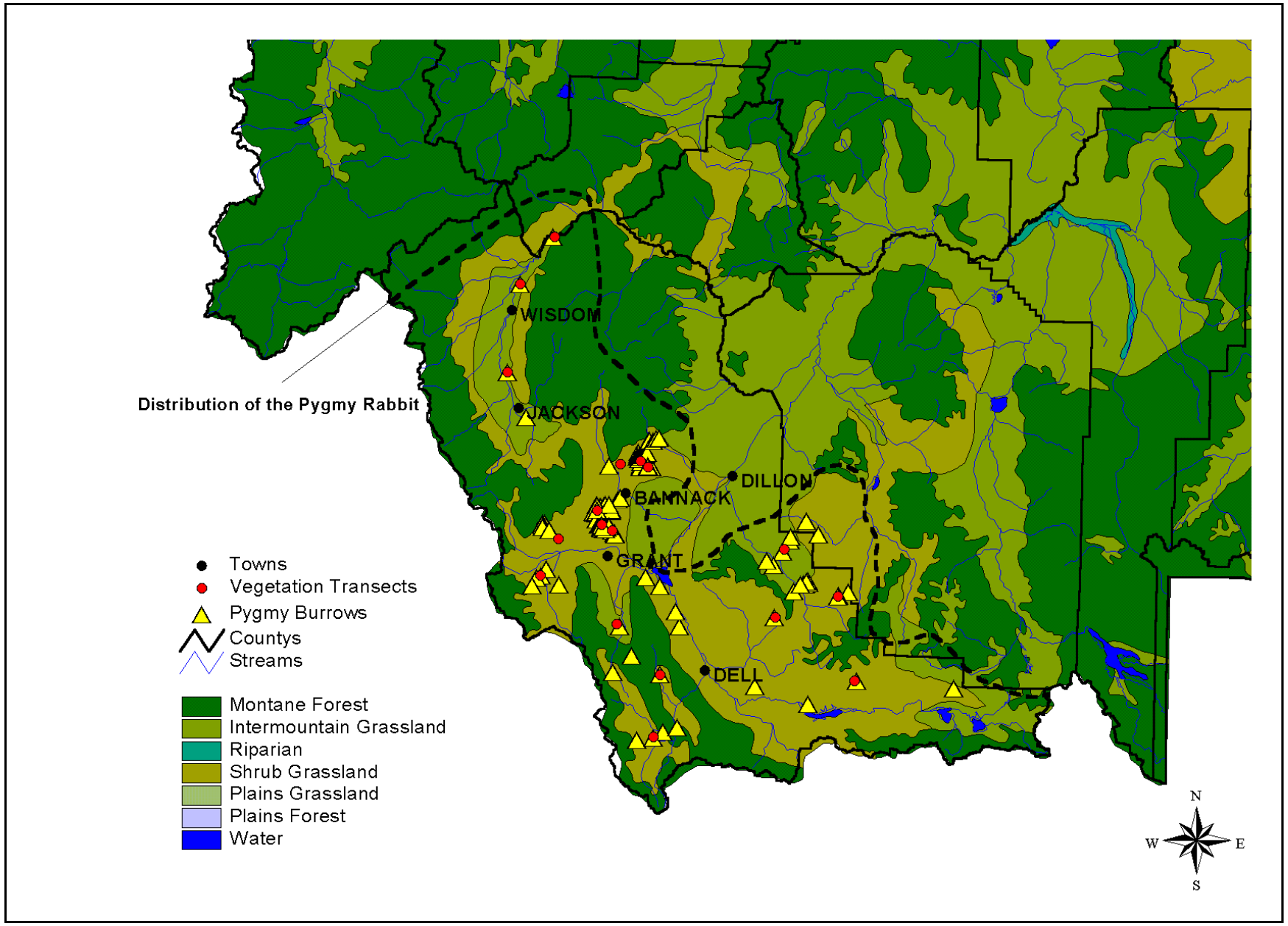

Distribution of the Pygmy Rabbit
WISDOM
JACKSON
DILLON
BANNACK
GRANT
DELL
Towns
Vegetation Transects
Pygmy Burrows
Countys
Streams
Montane Forest
Intermountain Grassland
Riparian
Shrub Grassland
Plains Grassland
Plains Forest
Water
N
W
E
S

Figure 2. Location of occupied pygmy rabbit burrows and cover transects with respect to vegetation type in Southwest Montana.

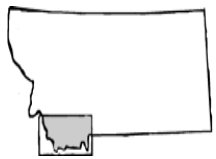


Table 1. Mean vegetative cover characteristics and (SD) of line intercept and plot transects at 18 occupied sites.

Cover Type	Height in cm.	Plants/m^2	Percent Cover
Big Sage[1]	37.28 (14.27)	2.13 (1.15)	21.32 (7.25)
Big Sage[2]			22.60 (8.84)
Other Shrubs[1]	23.01 (7.80)	0.70 (1.00)	2.77 (3.78)
Total Shrubs[1]		2.82 (1.29)	23.92 (7.39)
Total Shrubs[2]			25.15 (8.07)
Total Grasses[2]			24.99 (10.49)
Total Forbs[2]			5.99 (2.76)
Litter[2]			5.75 (2.73)
Bare Ground[2]			32.96 (16.32)

[1] Line Intercept and Belt Transects
[2] Daubenmire Areal Cover Estimation

Table 2. Comparisons of big sagebrush cover, density, and height between pygmy rabbit burrow sites and non-burrow sites in other states and burrow sites in Montana.

Location	Mean sagebrush cover (%)	Mean sagebrush density (plants/m^2)	Mean sagebrush height (cm)	Reference
WA burrow	32.7	unknown	82	Gahr (1993)
WA non-burrow	17	unknown	53	
ID burrow	19	unknown	56	Green and
ID non-burrow	unknown	unknown	25	Flinders (1980a)
OR burrow	23.7	unknown	90.8	Weiss and Verts
OR non burrow	14.8	unknown	56.9	(1983)
MT burrow (a)	21.3	2.13	37.28	This study
MT burrow (b)	23.9	na	na	

(a) sagebrush cover using line intercept method
(b) sagebrush cover using Daubenmire cover class method

Soil depth and strength were not measured at all sites due to varying moisture conditions. Soil depth at all sites measured exceeded 60 cm. Average surface strength at five transect locations and burrow excavations (n =3) was 1.41 kg/cm^2. Soil strength at 40 cm below the surface was generally greater than 4.5 kg/cm^2. Average soil strength for all subsurface measurements ($\bar{x}$ = 47.1 cm) taken including transect locations and burrow excavations was 4.31 kg/cm^2. At two of the burrow excavations, burrows extended below the hard pan. In Oregon, Weiss and Verts (1984) recorded a mean surface strength of 0.8 kg/cm^2 and a soil strength at 40 cm of 3.8 kg/cm^2.

Biotype, reproduction, burrow density, population estimation, and mortality: Fourteen trapping efforts were conducted from May until August and resulted in 113 rabbit captures in 1996. Fifty-eight individual pygmy rabbits were captured and ear tagged (Appendix C). Additionally, 19 individual mountain cottontails were captured and ear tagged with 33 total recaptures. Exact capture rates were not measured but appeared to be similar to other states averaging approximately 5 - 10 percent. Eleven trap mortalities of pygmy rabbits reduced recaptures in the Lower Badger Gulch area (LB1). The majority of trap mortalities appear to have been caused by stress, exposure and/or rapid weight loss. Several juveniles died when their heads became caught in the 1" x 1" mesh of the cage. One juvenile died from stress while body measurements were being taken. Capture rates of pygmy rabbit sexes appear equally distributed with 16 adult males and 18 adult females being captured. Thirty four adults and 24 juvenile pygmy rabbits were captured. Morphological measurements did not differ significantly between sexes ($P > 0.05$) except for weight ($P=0.005$). Non-gravid females averaged 104 gm heavier. Adult females in Montana averaged slightly heavier and adult males averaged slightly lighter than specimens from other states (Table 3) while other measurements were similar.

Females were reproductively active prior to initiation of trapping in May. One female trap mortality on May 8 showed 5 placental scars and no signs of lactation indicating that either the first litter was fully weaned at that time or had been lost. Another female trap mortality on May 16 was carrying 7 fetuses. Palpation methods were evaluated on this female to determine accuracy of determining litter size in-utero. Only five fetuses were detected by palpation, indicating that this is not a reliable method for determining litter size in the field, but could be used to determine pregnancy if fetuses were large enough to detect. Spotlight litter counts were attempted in late May but proved futile. Only two rabbits were observed and one juvenile captured. The juvenile was estimated to be approximately 10 - 14 days old. The last female that showed obvious signs of nursing was captured on June 19. Some females continued to show signs of lactation, but not nursing, in August. Adult males were scrotal when trapping began. The first male whose testes were receding was captured on June 7. One adult male captured on July 7 was fully abdominal. Sample sizes of juvenile pygmy rabbits were too small to determine the number of litters per year, however it appears that two litters were produced.

The trapping area LB1 measured 15.27 ha and contained 67 active burrows for a density of 4.39 burrows per ha. Population estimation using a mark recapture technique was abandoned due to trap mortalities and a wide confidence interval. The second area, LB2, located approximately 0.5 km from LB1 measured 5.95 ha and contained 27 active burrows for a density of 4.53 burrows per ha. Population estimation using mark-recapture methods resulted in an estimate of 18 pygmy rabbits with a 95% confidence interval of 15-26 rabbits. This results in a

density of 0.67 rabbits/burrow or 3.03 rabbits/ha. This estimate is higher than densities reported by Green and Flinders (1980a) of 0.7 - 1.4 rabbits/ha, and also higher than densities in Washington of 0.217 rabbits/ha in grazed areas and 0.269 rabbits/ha in ungrazed areas (Gahr, 1993). An unusual density of 45 rabbits/ha was reported by Green (1978) in ideal habitat in Idaho.

Table 3. Comparisons of morphological data of adult females[a] and adult males from six states.

State	Ear (mm)		Hind Foot (mm)		Weight[a] (gm)		Reference
	—	—	—	—	—	—	
Montana	46	47	68	67	474[b]	370[b]	This study
Washington	49	50	72	74	426[b]	391[b]	Gahr 1993
Idaho	49	49	72[b]	70[b]	462[b]	418[b]	Wilde 1978
Oregon[c]	-	-	67	70	-	-	Bradfield 1975
Utah[c]	-	-	69	67	436	405	Bradfield 1975
California[c]	-	-	72	70	398	409	Green and Flinders 1980a

[a] Only non-gravid (by palpation) females were used in measurements.
[b] Indicates a significant difference ($p<0.05$)
[c] Indicates no test for significance.

These results are ambiguous as only two areas were measured with one population estimation. It should be noted that individual pygmy rabbits may have occupied both areas. One male captured initially in LB1 was recaptured in LB2 and again in LB1. The distance between capture locations was approximately 800m. Trap mortality also occurred in LB2 which could have influenced results. Additionally, pygmy rabbits occupy more than one burrow and share several (Gahr,1993). The number of occupied and shared burrows may vary in different areas. One female pygmy rabbit was captured at 4 different burrow locations a total of 8 times. At one particular burrow, two different adult females, one adult male pygmy rabbit and one juvenile mountain cottontail rabbit were captured in a three week period. The population estimation was conducted in early summer when populations of both pygmy rabbits and mountain cottontail rabbits were expanding. Population estimation would be more precise if conducted in late summer or early fall. Additionally, juvenile trap mortality would be reduced at this time.

Mortality of pygmy rabbits is difficult to quantify. Wilde (1978) found that mean annual adult mortality can be as high as 88 percent. Juvenile survival can be quite low with greater than 50 percent mortality in the first 5 weeks (Wilde, 1978). Disease is probably not a significant mortality factor (Green, 1979), however, starvation and environmental stress may account for some mortality (Washington Dept. of Fish and Wildlife, 1995). Hunting does not appear to be a significant mortality factor in Montana. Some sportsman have reported harvesting pygmy

rabbits in southwest Montana. In Washington, sportsmen do not distinguish between cottontail and pygmy rabbits (Washington Dept. of Fish and Wildlife, 1995) and they probably do not distinguish between them in Montana either.

Green (1979) reported the chief cause of mortality was predation. Wilde (1978) reported long-tailed weasels (Mustela frenata) were the major predator of pygmy rabbits in his study. During previous snow-tracking efforts in winter (Rauscher, 1996), numerous tracks of long-tailed weasels were noted going from burrow to burrow in the Badger Gulch area. One suspected pygmy rabbit mortality by a long-tailed weasel was encountered during field surveys in winter, 1996 (Rauscher, 1996). Additionally, one long-tailed weasel was captured in a trap at an active pygmy rabbit burrow in summer, 1996. Near the capture site, two pygmy rabbit carcasses were found consistent with predation by long-tailed weasels. In the Badger Gulch area, skeletal remains of pygmy rabbits were found at 2 sites. Bones had been crushed in a manner consistent with either coyote (Canis latrans) or badger (Taxidea taxus) predation. A lower jaw of a pygmy rabbit was recovered from coyote scat in this area. Johnson and Hanson (1979) reported that body parts of various rabbits accounted for a larger proportion of fragments recovered from coyote scat than any other taxon at the INEL site in Idaho. Gahr (1993) documented two mortalities due to raptors. Other possible predators have been observed in occupied areas including: skunk (Mephitis mephitis), bobcat (Lynx rufus), golden eagle (Aquila chrysaetos), red-tailed hawk (Buteo jamaicensis) and a burrowing owl (Athene cunicularia). Ferruginous hawk (Buteo regalis) nests have been reported in occupied areas and may be a significant predator in summer. Rough-legged hawks (Buteo lagopus) and other raptors and owls may also take pygmy rabbits. Additionally, it is possible that rattlesnakes (Crotalus viridis) and gopher snakes (Pituophis catenifer) could take juvenile pygmy rabbits.

Relationship with other Lagomorphs: Mountain cottontails, and jack rabbits were observed on most pygmy rabbit sites. No jack rabbits (adult or juveniles) were caught in traps. Mountain cottontails were caught at burrows where pygmy rabbits were previously caught. Most of these captures were juvenile mountain cottontails. After capturing mountain cottontails at pygmy rabbit burrows, pygmy rabbits were seldom captured there during the trapping period. This suggests that mountain cottontails may take over pygmy rabbit burrows. However, trap mortality of pygmy rabbits at the site may have left open burrows available for mountain cottontails. It is unclear if mountain cottontails evicted pygmy rabbits or if mountain cottontails were simply making use of an available resource. Mountain cottontails also suffered lower trap mortality. Previously, mountain cottontails have been captured the same night at the same burrow system as pygmy rabbits (Flath and Rauscher, 1995). It appears that mountain cottontails and pygmy rabbits may actually share some burrows.

Burrows: Three burrows systems were excavated in 1996. Burrows were located generally at the base of sagebrush plants. Two burrows had a single opening and one had two openings. Excavated burrows were uncomplicated in structure and did not have any chambers. All excavated burrows had a turn-around area near the entrances. Two burrows extended below the hard pan. The other burrow was relatively shallow (35 cm). None of the burrows contained any nest material or debris. No rabbits were in any of the burrows excavated. The maximum length

of an excavated burrow was 1.5 m. Internal dimensions varied from 8 cm x 8 cm to 30 cm x 20 cm.

Thirteen burrow systems were smoked in 1996. Slope at smoked burrow sites averaged 6.5 percent. The maximum distance between openings of a smoked burrow was 3.5 m. Burrow systems had an average of 2.25 openings (range 1 - 5) and average distance between openings was 1.29 m (range 32 cm - 3.5 m). Average slope of all entrances was 34.5 degrees. Burrow openings averaged 16.6 cm x 14.6 cms. One sagebrush clump (30 m diameter) contained 8 different burrow systems. Generally, only one burrow system was located in a sagebrush clump.

Attempts to classify burrows in LB1 and LB2 were unsuccessful due to low capture rates and trap mortalities. Additionally, not all burrows within each area were trapped. Classification types attempted were: pygmy rabbit single occupancy, pygmy rabbit shared, and pygmy rabbit/mountain cottontail shared. However, some generalizations can be drawn from the data. Pygmy rabbits are known to share burrows among themselves (Gahr, 1993). Trapping data from LB1 and LB2 support this finding. Most burrows in the LB1 and LB2 areas appear to be shared between pygmy rabbits.

Between April 23,1996 and April 28, 1996, 96 burrows were examined using a Peeper video probe. Rabbits were observed in 15 separate burrows; mountain cottontails were observed in 2 and 13 were occupied by pygmy rabbits. It was felt that very few, if any, burrows were completely examined. Therefore, this method could not be used for population estimation. No nests or newborn pygmy rabbits were observed. No other vertebrate species were detected in any burrows.

The majority of burrows examined had at least one dead end tunnel. Several pygmy rabbits were found in these blunt end tunnels. This may be a predator defense mechanism. The only exposed part of the rabbit is the rear legs and tail. The main predator of the pygmy rabbit, the long-tailed weasel, attacks and kills prey by biting at the back of the neck or strangulation. This posture would prevent weasels from reaching this vital area. Rabbits encountered in this position refused to move even when prodded with the probe. Only after several minutes had passed without disturbance, did the rabbits turn around. Given the high-strung nature of weasels and their need to constantly be in motion, weasels could become bored given this situation and pursue move vulnerable prey.

A composite ectoparasite sample was collected in June, 1996 from 8 pygmy rabbits in the LB1 area. The sample was sent to Center for Disease Control (CDC) for identification and testing for sylvatic plague. Two flea species were identified, Cediopsylla inaequalis and Odontopysllys dentatus. Ticks (spp. unidentified) were also observed on pygmy rabbits. No ticks were included in the sample sent to CDC. All tests for sylvatic plague were negative. Two bot fly larva (Cuturebra spp.) were found on one pygmy rabbit trap mortality. One bot fly larva was also observed on a mountain cottontail. Flea densities were not measured but appear higher in spring when trapping began than at any other time during the trapping effort. Wilde (1978) reported similar results during his study in Idaho.

Discussion

The pygmy rabbit seems to occupy much of its historic range in Montana. Although few records exist, previous distribution maps, i.e. Figure 1, show occurrence in a larger area in Montana than historical records. It is unknown how the historic range was defined. Therefore, it can not be positively determined if the species' distribution has decreased. However, evidence exists that some range contraction has taken place. Additionally, pygmy rabbits were found at four of the six locations where museum specimens were collected or historically occurred based on reliable reports. As no exact locations were given on five of the six sites, it is unclear exactly where the specimens were collected.

Pygmy rabbits inhabit the majority of suitable habitat in Beaverhead county. However, in other counties, the distribution is limited, not only by sagebrush cover, but by also by edaphic factors and habitat fragmentation. The distribution in Madison County appears to be limited by a combination of these factors. Some areas that appear to have suitable sagebrush cover do not have deep enough soils to support rabbit burrows. Additionally, some suitable areas are distantly isolated from occupied sites. Some areas in Beaverhead county that appear to have adequate sagebrush cover also lack adequate soils. Two areas were located where pygmy rabbits have been present but no fresh evidence of occupation could be found. Both of these areas were in higher elevation mountain slopes. Thus, these areas may be occupied only when local population levels are high and preferred habitat is limited.

Pygmy rabbits do not occur in every sagebrush patch within their known distribution in Montana. Currently, it is unclear what exact features make a sagebrush patch suitable for pygmy rabbits. Other authors (Gahr 1993, Wilde 1978, Green and Flinders 1980a) have suggested that a combination of thick, dense sagebrush and soft deep soils are required for occupation. From work conducted during this study, this appears to be the case in Montana. Sagebrush coverage on occupied sites in Montana is slightly lower than reported in Washington and Oregon and approximates the coverage in Idaho. Sagebrush height in Montana is lower than any of these states. However, from the limited density estimation, pygmy rabbit population density is higher than other reported densities. Therefore, it appears that pygmy rabbits in Montana are thriving in that particular area. Burrow densities appear lower in most areas other than LB1 and LB2. Therefore, this status cannot be applied to the entire species distribution in Montana. Thus, the Horse Prairie region and Badger Gulch may be a stronghold for the species in the state. In several areas (e.g. Big Sheep Creek Basin, north of Jackson, and Sage Creek) the sagebrush coverage has been reduced by herbicide application, burning, or livestock damage. The burrow densities in these areas appear lower than either LB area. In fact, in these areas, the pygmy rabbit appears to be just barely surviving. Given the wide variety of habitat and physiographic areas occupied, the MNHP rank of S2S3 may be overly cautious.

Sagebrush removal seems to be a popular method of perceived rangeland improvement in southwest Montana. The reliance of pygmy rabbits on relatively large, dense stands of sagebrush has been well documented in the literature. Sagebrush removal has resulted in fragmentation of pygmy rabbit habitat and perhaps isolation of some populations of pygmy rabbits. Once isolated, small populations could be extirpated by stochastic and demographic events (Weiss and Verts, 1984). In the Coyote Creek area in Big Sheep Creek basin, sagebrush has been treated extensively. Only one active pygmy rabbit burrow was located under a small clump of sagebrush. In areas nearby where sagebrush has not been treated, pygmy rabbits are more abundant. In the lower Badger Gulch area, where BLM lands border private land, pygmy

rabbits are abundant on BLM property and totally absent from private land where sagebrush has been removed. In one area where a museum specimen was collected, the Tash Ranch, the suspected location has been converted to irrigated farmland. In Washington, loss of habitat by conversion of sagebrush to farmland and grazing practices have been credited for listing the species as endangered in that state (Washington Dept. of Fish and Wildlife 1995).

It does appear that pygmy rabbits are somewhat resilient. Near Badger pass, the sagebrush canopy was burned in 1980. Pygmy rabbits have recolonized the area. It is unknown how long this process took and if the density of pygmy rabbits in this area is equal to that prior to the prescribed burn. Recolonization of disturbed habitat has also been reported in Washington (Washington Dept. of Fish and Game, 1995) when sagebrush re-established adequate cover. Therefore, it is reasonable to expect pygmy rabbit populations to increase as sagebrush health and coverage increases in heavily treated areas provided the local population isn't extirpitated initially. Weiss and Verts (1984) suggested that in addition to large, dense stands of sagebrush, pygmy rabbits require sagebrush corridors for dispersal into new areas and recolonization. Therefore, recolonization of heavily treated areas could occur if travel corridors are established and maintained. The response of pygmy rabbits to sagebrush manipulation needs further study.

The use of subnivian tunnels appears to be an important method of foraging secure from above ground and avian predators. Snow tunnels may also be used to immigrate into new areas during the winter by moving from snow drift to snow drift in sparse sagebrush. Also, using snow tunnels may allow the explotation of areas that are unsuitable during the summer, i.e. where inadequate soils for burrows exist but adequate sagebrush does. Therefore, areas of sagebrush somewhat distant from burrows may be important for winter survival. Near Blacktail Deer Creek, pygmy rabbit pellets were very abundant at the base of a heavily-hedged sagebrush plant 200 m from the nearest known burrow. The rabbit may have used snow cover to reside under this plant for an extended period of time without the need for a below ground burrow. Also, near Badger Pass, a subnivian tunnel extended across a back country road suggesting the rabbit used this tunnel to access distant sagebrush forage instead of emerging from the tunnel and starting a new one at the distant sagebrush.

Pygmy rabbit response to grazing is not well understood. Some authors (Green 1978, Green and Flinders, 1980b) have speculated that pygmy rabbits may compete with cattle and sheep for grasses and forbs, while another (Chilson, 1996) has reported that grazing may benefit pygmy rabbits by improving sagebrush stands. Gahr (1993) found that pygmy rabbit home range sizes on her study area were larger and population densities lower where grazing is allowed . Grazing does affect the sagebrush canopy (Daubenmire, 1970). The magnitude of the effect is determined by season, timing, duration and intensity of the grazing event, among other factors. Over-grazing can disrupt the sagebrush community by breaking down individual plants and opening interstitial spaces and allowing invasion of annual grasses and forbs (Daubenmire, 1970). Additionally, cattle have damaged individual burrow systems in the lower Badger Gulch area by collapsing burrows. Most pygmy rabbit sites currently located in Montana are grazed to some extent. Although the pygmy rabbit has evolved under grazing by deer, antelope, elk and bison, it is unlikely the effect is the same.

The results of vegetation measurements are limited to only 18 sites. These results are very similar to those reported in other states, with the exception of the average height of sagebrush. Results from two methods used to evaluate sagebrush cover varied by only 1.28

percent. Daubenmire (1959) reported variations of up to 5 percent but generally much closer. Either method would be reliable for comparison to other states and between occupied and unoccupied areas. With the exception of Washington, sagebrush coverage at Montana sites is practically the same as other reporting states. It appears that pygmy rabbits prefer sites with approximately 20 - 25 percent canopy coverage by big sagebrush. The major difference in Montana is the average sagebrush height is much shorter than other states. The limited population estimation and information from Washington (Peggy Bartels, pers. comm.) suggests that Montana population densities are higher than other areas. Therefore, it appears that not only is sagebrush coverage important, but also sagebrush structure. Very tall (70+ cm) sagebrush allows for a more open understory than shorter stands. This open understory may expose pygmy rabbits to increased predation, and may also limit food availability in winter until snow depths approach the canopy. The sagebrush canopy in one occupied area in Limekiln Canyon was approximately 2 m tall with limited sagebrush available for forage and a very open understory. In these areas, pygmy rabbit abundance could possibly be increased by removal of some of the very old, tall sagebrush plants and allowing new growth to replace it.

Population or burrow density has not been previously reported in Montana. It is unclear if the population has remained stable or has varied since first reported in Montana. It can be assumed that populations have decreased since sagebrush has been eliminated in some areas and reduced in other areas. Sample sizes of population and burrow density calculations are too small for a reliable comparison to other states. Methods were evaluated in this study to determine density. With additional study, a base line population density in selected areas can be established for future reference and monitoring population trends, however the method is labor and time intensive. Active burrow density may prove to be a method of monitoring population trend. However, the number of shared burrows and burrows used by a single pygmy rabbit may vary with population density, i.e. a pygmy rabbit may share more burrows and occupy more burrows when the population is lower. This area needs further study to determine if active burrow density indeed reflects population density, and to develop methods to assess population density from burrow density. Pygmy rabbit populations are known to be susceptible to local declines and extirpations. Therefore, a more practical approach to monitoring pygmy rabbits may be to establish monitoring stations looking only for presence or absence at the periphery of the range and several selected sites within the center of the range. Once established, these stations would quickly provide data on range contraction or expantion and call attention to areas requiring further study.

Productivity and mortality could not been adequately addressed during this study. The results of trapping data did show that the breeding season appears similar to other northern states, beginning in late March and ending in June. Litter size appears to be within the range describe by Wilde (1978) of 2-8 young based on two female trap mortalities. A much more comprehensive study must be undertaken to determine litter sizes and productivity.

Morphologically, pygmy rabbits in Montana are similar to pygmy rabbits from other states. Body measurements did not vary much between females and males except for weight. Females were slightly heavier than males. This may be a climatic factor or due to timing of trapping. Most males were caught early in the summer and could have weighed less due to reproductive activity. Weight should be taken when this is not a factor.

Mountain cottontails are found in most occupied pygmy rabbit areas. Mountain

cottontails have been caught at the same burrow as pygmy rabbits. Mountain cottontails make use of burrows and crevices in rocks for protection in areas of less dense vegetation and spend most their time above ground in areas of dense sagebrush (Chapman 1975). Most captures of mountain cottontails at pygmy rabbit sites have been juveniles. Mountain cottontails may force pygmy rabbits out of burrows or share burrows temporarily. Juvenile mountain cottontails may inhabit pygmy rabbit burrows during late spring and early summer and vacate the burrow late summer making it available for pygmy rabbits. No interactions between species was recorded. The spatial interaction of these two species needs further study.

Management Implications

The status of the pygmy rabbit varies widely across its geographic range and within Montana from secure populations in large areas of sagebrush to vulnerable in islands of marginal habitat. Vulnerability stems from the species reliance upon a unique habitat that combines big sagebrush and soft deep soils. Sagebrush is critical to the pygmy rabbit for both food and cover and deep soils are required for burrows. Pygmy rabbit reliance on large, tall, dense stands of sagebrush is well documented in the literature, consequently loss of habitat is the greatest threat to pygmy rabbits in Montana. The loss of habitat from conversion to agricultural fields is probably minimal in southwest Montana due the large expanse of public lands and reliance of private landowners on ranching. However, rangeland is often "improved" by removal of sagebrush by various means. Either event will perform the same function, rendering the habitat unsuitable for use by pygmy rabbits. In addition, fragmentation of sagebrush communities poses potential additional threats to populations of pygmy rabbits by reducing the size of these communities and isolating populations. Contrary to the literature, pygmy rabbits have been found to cross relatively small open areas to reach suitable habitat in Montana. However, dense stands of sagebrush growing next to streams, along fence rows, and borrow ditches are considered essential avenues of dispersal for pygmy rabbits and should be maintained. Without these corridors, isolated populations become subject to principles of island biogeography and stochastic events thereby reducing the occupied range in Montana. Additionally, the species is known to be susceptible to rapid declines and possible local extirpation. However, it is important to note that the pygmy rabbit is somewhat resilient and has the ability to use sites that were previously disturbed. This fact should be taken in account when planning long-term rangeland management by allowing sites to recover from sagebrush removal before adjacent sites are manipulated.

As areas of southwestern Montana are undergoing sagebrush removal treatments, sagebrush stands inhabited by pygmy rabbits should be of special concern to biologists and managers. Sagebrush removal may isolate or eliminate pygmy rabbits in some areas. Mountain slope and high mountain valley populations would probably perish if connections to larger expanses of sagebrush in the floodplains were severed. Because pygmy rabbits have a patchy distribution, areas of planned sagebrush removal should be evaluated for impact to pygmy rabbits prior to the manipulation. Care should be taken to leave a mosaic of sagebrush cover rather than complete removal. Areas occupied by pygmy rabbits should not be damaged. Travel corridors should be maintained. These facts should be considered before brush removal treatments are applied within the pygmy rabbit range.

Overgrazing can also impact populations of pygmy rabbits. Livestock may compete with rabbits for forbs and grasses during spring and summer. Cattle can also damage sagebrush structure by breaking plants and opening the canopy. Most sites occupied by pygmy rabbits are grazed to some extent. Increasing grazing to the extent that the sagebrush coverage is reduced will have a negative impact on populations of pygmy rabbits. However, sagebrush density and coverage could be increased by certain levels of grazing. Pygmy rabbits are surviving and even thriving at the current grazing levels in certain areas. These may be important factors to consider when planning stocking rates.

Literature Cited

Bradfield, T. 1975. On the behavior and ecology of the pygmy rabbit *Sylvilagus idahoensis*. M. S. Thesis, Idaho State Univ., Pocatello. 43 pp

Chapman, J.A. 1975. *Sylvilagus nuttallii,* Mammalia Species. 56: 3pp

Chilson, P. 1996. Can cattle save the pygmy rabbit? High Country News. Apr. 29, 1996.

Daubenmire, R. F. 1958. A canopy coverage method of vegetational analysis. Pages 72-73 in Rex D. Pieper ed. Measurement Techniques for Herbaceous and Shrubby Vegetation. 1978. New Mexico State University. Las Cruces, New Mexico.

_____. 1970. Steppe vegetation of Washington. Wash. Agric. Exp. Stn., Tech. Bull. 62. 131pp.

Flath, D. L. 1994. Progress Report. Status of the pygmy rabbit (Brachylagus idahoensis) in Montana. Montana Dept. of Fish, Wildlife and Parks. Unpubl. Report. 4pp

_____ and R. L. Rauscher. 1995. Progress Report. Status of the pygmy rabbit in Montana. Montana Dept. of Fish, Wildlife, and Parks. Unpubl. Report. 7pp

Fisher, J. W. 1979. Reproduction in the pygmy rabbit in southeastern Idaho. Unpublished thesis. Idaho State Univ. 32pp.

Gahr, M. L. 1993. Natural history, burrow habitat and use, and home range of the pygmy rabbit (Brachylagus idahoensis) of Sagebrush Flat, Washington. M.S. Thesis, Univ. of Wash. Seattle. 125pp.

Green. J. S. 1978. Pygmy rabbit and coyote investigations in southeastern Idaho. Ph. D. Dissertation, Brigham Young Univ., Provo, Utah 88 pp.

Green, J. S. and J. T. Flinders, 1979. Techniques for capturing pygmy rabbits. Murrelet 60:112-113

Green, J. S. and J. T. Flinders, 1980[a]. *Brachylagus idahoensis.* Mammalian Species 125:4 pp

_____, 1980[b]. Habitat and Dietary Relationships of the Pygmy Rabbit. J. Range. Mgmt. 33:136-142.

Hoffman, R.S., P.L. Wright and F.E. Newby. 1969. The distribution of some mammals in Montana I. Mammals other than bats. J. Mamm. 50(3):579-604.

Johnson, M. K. and R. M. Hansen. 1979. Coyote Food Habits on the Idaho National Engineering

Laboratory. J Wildl. Mgmt. 43:951-956

Lyman, R. L. 1991. Late Quaternary Biogeography of the Pygmy Rabbit (*Brachylagus idahoensis*) in Eastern Washington. J. Mamm. 72:110-117

Rauscher, R. L. and D. L. Flath. 1996. Progress Report. Pygmy rabbit winter survey, January 1996. Montana Dept. of Fish, Wildlife and Parks. Unpubl. Report. 8pp.

US Fish and Wildlife Service. 1994. 50 CFR Part 17. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species; proposed rule. Fed. Reg. 59(219): 58982-59028.

Washington Department of Fish and Wildlife. 1995. Washington state recovery plan for the pygmy rabbit. Wildlife Management Program, Wash. Dep. Fish and Wildl., Olympia. 73pp.

Weiss, N. T and B. J. Verts. 1983. Habitat and distribution of Pygmy Rabbits (*Sylvilagus idahoensis*) in Oregon. Great Basin Naturalist 44:563-571

White, G. C. 1996. Program NOREMARK Software Reference Manual. Colorado State University, Fort Collins. 25pp.

Wilde, D. B. 1978. A population analysis of the pygmy rabbit (*Sylvilagus idahoensis*) on the INEL Site. Unpubl. Ph. D. Dissertation. Idaho State Univ., Pocatello, 172pp.