<u>2005 FINAL RESEARCH REPORT:</u>

HABITAT USE, BEHAVIOR, AND LIMITING FACTORS AFFECTING THE PYGMY RABBIT (*Brachylagus idahoensis*) IN GRASS VALLEY, UTAH

Prepared by

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In Co-operation With:
The Bureau of Land Management, Richfield Office
The Utah Department of Natural Resources
Brigham Young University

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Submitted to

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EXECUTIVE SUMMARY:

Impaired sagebrush ecosystems are a dilemma facing managers across the Western US. These ecotypes are being treated to either (a) create alternate habitats for species such as sage-grouse, elk, and mule deer, (b) increase livestock forage production, or (c) reduce fire fuels by replacing sagebrush with grasses. Current data are incomplete on the impacts of these treatments on state sensitive species and federally petitioned species, and in particular the pygmy rabbit. In Grass Valley, Utah, well-meaning treatments of sagebrush habitat include: federally-funded wildfire fuel reduction operations and sagebrush canopy reductions that remove most or all of the sagebrush canopy and replace this with grasses, forbs and even shrubs favored by mule deer, elk, domestic sheep and domestic cattle. The objective of this study was to determine if such activities were impacting pygmy rabbits and to elucidate habitat use, occurrence and abundance of the pygmy rabbit. Additionally species composition and abundance of bird and leporid populations were recorded using line transects.

Pygmy rabbit abundance in Grass Valley was found comparable to estimates found in Idaho (0.79 rabbits/ha; 0.54 rabbits/ha respectively). These values likely represent a lower abundance estimate than historical values, though both areas probably represent the highest abundances in their respective state. The distribution of pygmy rabbits throughout the Valley was comprehensively studied yet some colonies may have been missed. Research into where rabbits are, their abundances, movement behavior, and habitat use ideally needs to be studied further.

Pygmy rabbits in Grass Valley were found to select areas for burrow sites that comprised taller, more decadent, and larger canopied shrubs than surrounding habitat ($p < 0.05$; $T = -6.54$, $T = 2.98$, and $T = -2.33$ respectively) or comparable, random habitat (($p <$

0.05; T = -7.04, T = -2.78, T = -5.14). Occupied and unoccupied habitat locations had shrubs similar in height and decadence, however shrub canopy area was significantly larger in occupied habitat ($p < 0.05$; T = -7.76). Shrub spatial pattern was more uniform (i.e. more open) in unoccupied random sites than in occupied sites where habitat was more clumped in dispersion pattern (and index of 0.471 and 0.601 respectively).

Big sagebrush comprised one third to almost half of the understory (33.19% to 46.99%) found at burrow sites while in random, unoccupied habitat understory consisted of much less a proportion (11.85% to 31.00%). Instead, grasses and forbs were more abundant in random, unoccupied locations (cumulatively 17.10% to 67.31%) than in burrow system locations (cumulatively 6.13% to 12.80%). This suggests a lack of summer foraging species in occupied pygmy rabbit habitat. In comparing big sagebrush density at burrow sites to other shrubs, big sagebrush is much more abundant (average of 2.97 plants/m^2 to an average of 0.14 plants/m^2 big rabbitbrush). Sagebrush was also more abundant at burrow sites than at random, unoccupied sites (average = 2.97 plants/m^2 and 0.88 plants/m^2 respectively). Big rabbitbrush was more abundant on average at burrow sites than at random, unoccupied sites (burrow sites: 0.14 plants/m^2; random sites: 0.01 plants/m^2), though not at the densities of big sagebrush. Pygmy rabbits appear to utilize habitat based on predator avoidance and browse forage needs. Other species also utilize sagebrush as a forage and cover species and habitat use data were compared to pygmy rabbit data reported here. Among these are several species that are considered sagebrush obligate species (i.e. besides the pygmy rabbit, the sage thrasher, sage sparrow, Brewer’s sparrow, and mule deer). All but the sage sparrow were encountered in Grass Valley and were found in large patches of sagebrush also occupied by pygmy rabbit burrows.

Burrow systems were more commonly only one opening (49.2%; N = 32) and burrows with two or more openings comprised 50.8% of the burrows observed (N = 33). Single opening burrows were more commonly associated with a nearest neighbor burrow with multiple openings. Distance was correlated with whether burrows were one opening or multiple openings (Pearson = 0.414; $p = 0.018$). Burrows with one opening are more likely to be closer together when the nearest neighbor is a single opening as well. Burrows were farther apart when a multiple entry burrow was nearest another multiple entry. This correlation is like a function of predator escape and valuable in habitat where foraging home range is larger than previously documented, as is likely in Grass Valley.

This study was established to be a multi-year project and conclusions drawn from the results should take this into consideration. Data reported here are inconclusive until more research can be added to this study.

INTRODUCTION.

Throughout the Intermountain West the pygmy rabbit (*Brachylagus idahoensis*) has seen severe population declines (Flinders 1999; Janson 2002). These have primarily occurred due to anthropogenic threats and the limited knowledge available to properly manage this specialized lagomorph. The pygmy rabbit is an obligate sagebrush-steppe resident that inhabits self-made or self-altered burrows in sagebrush habitats (Green and Flinders 1980a and 1980b). This rabbit is the smallest leporid in North America. The home range of an individual pygmy rabbit consists of 30 km5 in relatively high sagebrush cover (21 - 36%) and loose, alluvial soils (Green and Flinders 1980a; Green and Flinders 1980b; Weiss and Verts 1984; Katzner and Parker 1997; Flinders 1999). In some areas, pygmy rabbit burrow sites may be circumscribed by a mounded area with the tallest shrubs ranging from 53-75 cm in Wyoming or Great Basin big sagebrush (*A. tridentata wyomingensis* and *A. t. tridentata* respectively - - White et al. 1982). Sagebrush comprises 99% of a pygmy rabbit=s winter diet and 51% of their summer diet (Green and Flinders 1980a; Green and Flinders 1980b; Gahr 1993). Summer diet also includes 39% grasses and 10% forbs (Green and Flinders 1980a).

Due to the recent decline of pygmy rabbit population numbers and the severe diminution and degradation of their habitat, a petition was filed in 2003 to the United States Fish and Wildlife Service (USFWS - - Western Watersheds 2003). This petition calls for the listing of the pygmy rabbit as Threatened or Endangered under the Endangered Species Act of 1973. Before this petition, other states had initiated efforts for conservation. Throughout its range this species has been listed as a state species of special concern (CA, ID, WY, MT, NV, and UT). Washington populations are listed state and federally as an Endangered Species (Federal Register 2003).

Current and past research has been directed at identifying pygmy rabbit abundance, distribution, forage and habitat use, genetics, and dispersal patterns (Green 1978; Green and Flinders 1981; Katzner et al. 1997; Katzner and Parker 1997; Katzner and Harlow 1998; Heady et al. 2001; Bartels and Hays, 2001; Siegel et al. 2002). However, no information yet exists on the current limiting factors facing this petitioned species and no data have been collected on pygmy rabbit populations in Utah since the 1970's, excepting limited surveys (Janson 2002). In particular, information does not exist on how many well-meaning habitat improvement practices are affecting pygmy rabbit habitat use and population densities. Little research is available on the occurrence, abundance, and habitat use of bird species utilizing sagebrush habitats as well (Knick and Rotenberry 2000; Dettmers 2003; Knick et al. 2003).

This cooperative study was initiated to aid land and resource managers with the data necessary to manage this petitioned species. Investigators incited a four-fold, long-term approach to research. First, we attempted to identify extant populations of pygmy rabbits on Bureau of Land Management (BLM) land. Second, in selected areas in Grass Valley, Utah, we examined habitat use and pygmy rabbit abundance. Third, we worked to determine the limiting factors, if any, affecting pygmy rabbits in Grass Valley, Utah. In particular, we investigated if sagebrush treatments instigated by land managers are posing a negative factor in pygmy rabbit population sustainability. Sagebrush treatments are here in defined as big sagebrush ecotypes currently being treated to either (a) create functioning habitats for species such as Sage-grouse (*Centrocercus urophasianus*), Rocky Mountain elk (*Cervus elaphus*), and mule deer (*Odocoileus hemionus*), (b) increase livestock forage production, and/or (c) are involved in fuels reduction programs. Such treatments remove most or all of the sagebrush canopy and replace the sagebrush with grasses, forbs and exotic shrubs.

Current data are incomplete on the impacts of sagebrush treatments on state sensitive species and federally petitioned species, forefront among these is the pygmy rabbit. Such data require pre-treatment and post-treatment monitoring at multiple scales and with multiple species; therefore all wildlife species were monitored in Grass Valley on micro- and macro-habitat scales. Products from our long-term research are anticipated to aid managers with knowledge of the habitat requirements utilized by pygmy rabbits, limiting factors in its conservation, alternatives to recovery, and identify the positive and negative effects of habitat manipulation.

STUDY AREA.

This study was conducted in south-central Utah in Grass Valley (Piute, Sevier, and Wayne Counties). Grass Valley is located between Monroe Mountain and the Awapa Plateau, just southwest of the Fish Lake Mountain Range and immediately north of Otter Creek Reservoir. Otter Creek itself runs the width of the Valley until it reaches the reservoir. Koosharem, Sevier County and Greenwich, Piute County are located in the center of the valley with a cumulative population estimate of 276 people (US Census 2000). The elevation of Koosharem and Greenwich is approximately 2,113 m (6,930 ft) and annual, average precipitation is 24.08 cm/year (WRCC 2005). Temperatures range from 29.3°C in the summer to -12.2°C in the winter. Recreational activities in pygmy rabbit habitat primarily include hiking, hunting, and off-road vehicle (ORV) use. Grass Valley is commonly known for access roads to the Piute Trail, a popular ORV trail. Other land uses include several cattle and sheep grazing allotments. Vegetation includes a relatively strict succession of wet, grassy valley bottoms (primarily agricultural fields), big sagebrush (*Artemisia tridentata tridentata*) foothills, juniper (*Juniperus* spp.) and pinion pine (*Pinus edulis*) hillsides and spruce (*Picea* spp.), fir (*Abies* spp.) and aspen (*Populus tremuloides*) mountain tops. The research on this study, however, only focused on the big sagebrush foothills, areas where pygmy rabbits were likely to occur.

METHOD AND MATERIALS.

Occurrence and Distribution

Walk transects were preformed in habitat suspected of pygmy rabbit presence throughout Grass Valley and BLM lands. Two types of line transects were used. First, transects of straight lengths of 250 m were developed to assist with abundance estimates and give the best estimate of true abundance possible. Second, transects of no set length were walked in more imperfect line transects. Longer transects were used in discontinuous pygmy rabbit habitat such as sagebrush removal sites or patchy sagebrush sites and used to compare to pre-treatment surveys by the BLM. All animals were recorded 15 m on each side of the line transect, creating a 30 m survey strip.

Where pygmy rabbit sign was encountered a Global Position Unit (GPS) location was taken and data such as the type of sign, if a burrow then the number of openings, the activity level of the burrow, and the number of individual animals were recorded. Burrow activity level is a scale defined by Rachlow and Whitham (2004) with a “1” representing Active (known by open/intact burrow entrance, fresh pellets, and fresh diggings); “2” representing Recent (known by intact/open burrow entrance, old/weathered pellets, and absent/old/few tracks); “3” describing Old (intact/open/debris present burrow entrance, pellets absent, diggings absent/old/few); and "4" recorded for Very Old (burrow collapsed, pellets absent, diggings absent/old/few).

All vertebrate wildlife observed were recorded to assist with identifying species communities and to elucidate if there were any differences in species habitat use. ARCGIS (ESRI 2004) software was used to view pygmy rabbit distribution based on the walk transect data and to map active and inactive burrows in Grass Valley.

Trailmaster (TM1550) digital track cameras (i.e. remote cameras) were used to identify species as well. Remote cameras also assisted in looking at burrow use, verify activity levels, study pygmy rabbit behavior, and identify timing of rabbit movements outside the burrow. An active or recently active burrow system was chosen at random and a camera was set up approximately 1 m from a burrow opening. These cameras were set to take a picture every 30 seconds when an animal crossed the infrared trigger beam. Cameras were kept on the burrow opening for two weeks and then moved to another site.

Abundance

Walk transects also assisted in determining abundance of pygmy rabbits in Grass Valley. Within the 30 transect strip, all wildlife were identified and the distances from the transect line recorded. Distances from burrow systems were analyzed using the software DISTANCE 5.0 Beta 3 (released: January 6, 2005) to obtain crude density estimates. Model selection in this software was preformed using Akaike's Information Criterion (Buckland 1992; Akaike 1973).

Habitat Use

Habitat Use data were collected by two different means. First, shrub data were collected on walk line transects and were assumed to be associated with animals documented nearest the GPS location of the shrub data. This assumption was based on using a GPS location to select the shrub data taken nearest to where the animal was recorded. Second, more intensive habitat data were collected on randomly selected burrows encountered on transects. These latter data were collected at a different time when the observer would return to the location and identify a random burrow to perform more fine scale habitat measurements. By both means T-square shrub dispersion analyses were conducted (Ludwig and Reynolds 1988). The dispersion analyses estimated the density, pattern, and occurrence of the 2 closest woody plants to the center of the burrow (i.e. nearest neighbor). Other relevant data were collected simultaneously on each shrub (i.e. species, degree of shrub decadence, shrub canopy area calculated as an ellipse, and shrub height). Decadence is defined here as the proportion of the plant yellowed, dead, or dying and is an ocular estimate. Statistics used in habitat assessments are by and large descriptive, as this is only one year of research and more definitive conclusions from sophisticated statistics could be misleading.

Fine scale habitat measurements were taken at randomly selected burrow sites. Habitat was only collected on burrows that were categorized as active or recently active. At these sites, a center location was identified by averaging the distance between all openings in the system and choosing this average as the middle for habitat data collection. If a system was a single entrance burrow, then the center of the opening was the center point. Six main habitat data collection methods were used once the center was identified; understory quadrat data, macrohabitat parameters (measured as distances from the burrow system), T-square shrub dispersion analysis (previously discussed), horizontal obscurity estimates, all shrub density at burrow sites, and plant canopy cover using line intercept. Data were collected similarly in randomly chosen locations in unoccupied habitat for habitat selection comparisons.

Understory quadrat data were collected by laying a one-quarter m^2 quadrat square at the center location of the burrow system and then identifying plant species, bare ground, litter, moss, and bare rock within the quadrat. Each category is estimated as a percentage of the whole quadrat, giving the measurements a proportional density. Once the center point is calculated, random locations were measured with the same methods 0-15 m away in each cardinal direction. Macrohabitat was measured by using a rangefinder to record distances of the nearest: natural habitat edge, human caused edge (i.e. habitat treatment or overgrazing site), human structure (i.e. buildings or telephone poles), ORV tracks, big rabbitbrush (*Chrysothamnus viscidiflorus*) or greasewood (*Atriplex confertifolia*), predator sign, ungulate sign, pygmy rabbit pellet pile, cliff or rock outcropping, and raptor perch. The type of human caused edge, human structure, and ORV tracks were also identified and recorded categorically.

Horizontal cover is important as a function of predator avoidance for many animals. Horizontal cover is defined as high vegetation or boulders on flat terrain that limits an animal's view of their close surroundings (Beck et al. 1996). Horizontal obscurity was measured using a 1 m^2 cover board. The obscurity board was placed at the center point and counted from each cardinal direction at 2.5 m, 5 m, and 10 m away from the center. The board was counted by kneeling (i.e. terrestrial predator height) and counted in 3 sections- bottom, middle, and top- each with 12 squares and totaling 36. The number of squares devoid of any visual obstruction was recorded and set in proportion to the total number of squares.

All shrub species were measured in a randomly chosen quadrant from the center point and measured between the transect tapes spread in 4 cardinal directions. Shrubs rooted within 3 meters from the center point were identified to species and the number per species, each individual height, widths, and decadence were recorded. Plant canopy cover was measured using the line intercept method. The transect tape was then spread across the habitat in 4 cardinal directions from the center and read 15 m each way from the center point. Each species encountered was measured as a distance in which it intersected the transect tape. Distances were then analyzed as a proportion to the entire distance (15 m) of the tape.

Burrow Configuration

Burrow systems or clusters were measured in order to identify any pattern in the number of burrow openings, the distance between systems, or the geometric shape of burrow clusters. At each burrow system where fine scale habitat was measured, distances between openings and between burrow systems were also measured. Once the average center point between burrow openings was identified, the distance to the nearest opening was measured. The next nearest opening to that one is measured and so forth until all openings have been measured. The 2 farthest burrows from each other (usually the first and the last) were measured to give an estimate of the size of the system. A geometric shape of burrow opening placement was also drawn and recorded. The nearest burrow system from the initial system was found by walking concentric, ever-widening circles on the outskirts of the burrow until the closest burrow system was found. The distance from the center point of the initial burrow system to the center of the second burrow system was measured with a rangefinder. The same measurements are then made on the second burrow system as on the first, as well as the activity classification recorded.

RESULTS.

Occurrence and Distribution

Walk transects were conducted for pygmy rabbit presence November 2004 to September 2005. All evidence of pygmy rabbit presence (burrows, pellets, tracks, and visuals of rabbits) were recorded. In Grass Valley, pygmy rabbits were recorded in areas slated for treatments (fig. 1) where surveys had not occurred previously. Surveys were also conducted in areas where pre-treatment surveys had been conducted by the BLM and were resurveyed by the investigators (fig. 2). These areas included Oak Springs and Praetor Slopes. BLM surveys identified 118 active burrow systems and 85 inactive systems. In BYU studies, only 14 active burrow systems were identified and all others in treatments were acknowledged as inactive systems in the same areas. Locations of active burrows recorded by the BLM were revisited using a GPS and were found abandoned or plowed. Areas where pygmy rabbits still occurred in treatment sites were wide sections of intact sagebrush that were connected to adjacent patches of remaining sagebrush. In undisturbed sagebrush habitat, pygmy rabbits occurred in isolated patches.

Statewide occurrence surveys were also accomplished concomitantly with the funds secured by the cooperator, the Utah Division of Wildlife Resources (UDWR). Surveys were accomplished throughout the state south of I-80 and many areas were also on BLM lands. A list of the general locations of these surveys areas can be viewed in Appendix I.

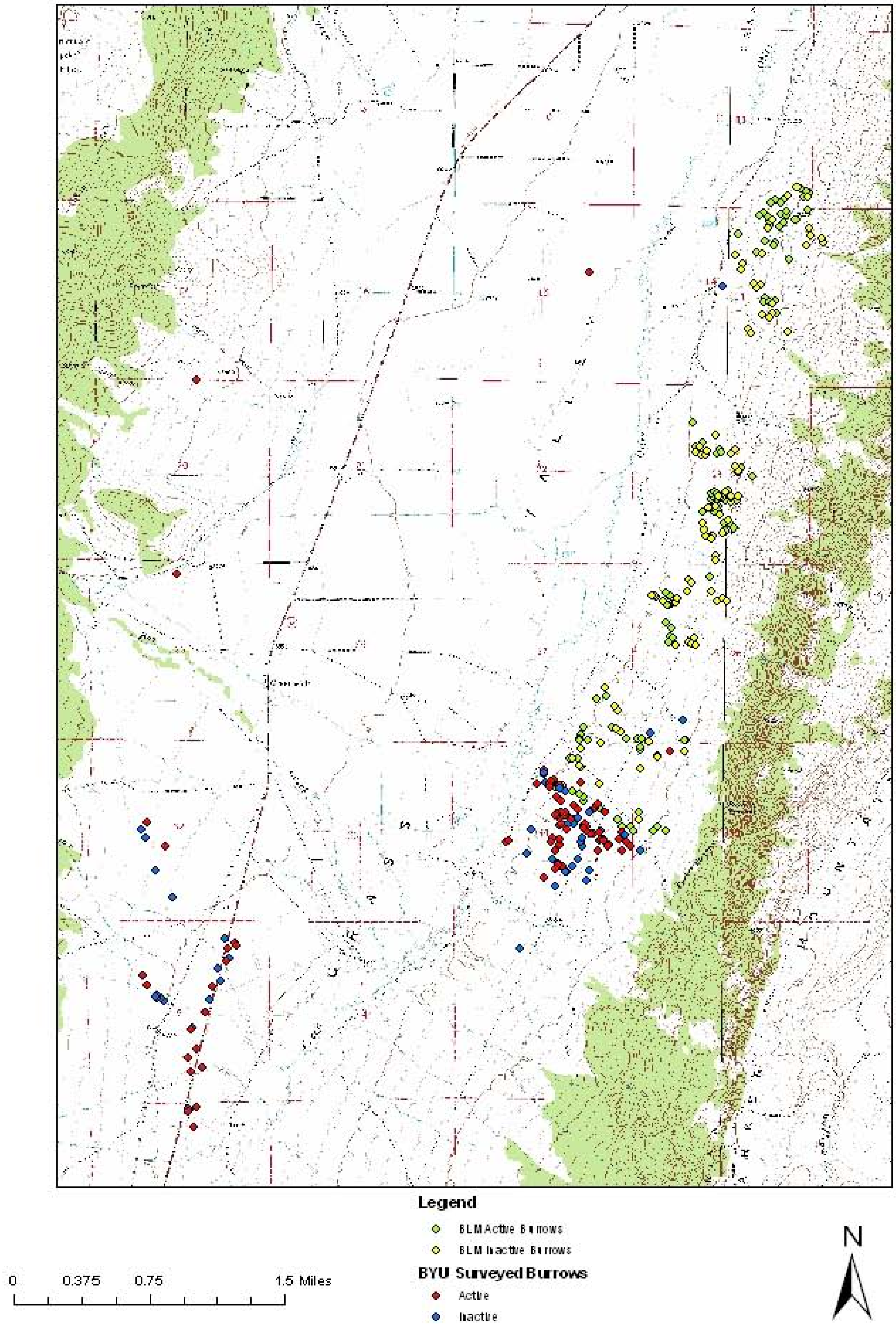

Figure 1. A comparison of BLM and BYU surveys. All burrows marked as surveys by the BLM were also rewalked by BYU and if still active, are indicated by red circles.

Concurrently with pygmy rabbit surveys, other species observed were recorded. Thirteen species were identified using Trailmaster remote cameras and 20 were recorded on walk transects. These species were found in known pygmy rabbit habitat and were encountered in big sagebrush. Species names and the number of occurrences are listed in Appendix II.

Abundance

Derivations of pygmy rabbit abundance estimates have been documented in various ways through out their range (Rachlow and Whitham 2004; Bartels and Hays 2001; Green 1978). However most of these estimates have included indirect surveys using burrow evidence and likely overestimate abundance since individual rabbits seasonally utilize more than one burrow system (Rachlow and Whitham 2004; pers. obs.). Rachlow and Whitham (2004) have developed an extrapolation method from their live trapping data and line transect surveys of active burrows. These methods allow for crude density estimate comparisons by using their estimate of 1.84 active burrows per rabbit (Table 1). The investigators here recorded burrow density from walking 250 m line transects through homogenous big sagebrush habitat and, using a GPS, recorded where all active and inactive burrows were seen. Active burrow measurements were recorded and then analyzed using the software Distance 5.0 Beta 3. Burrow densities with this method were estimated at 1.46 burrows/ha using Akiake's Criterion for a Half-normal key function with a hermite polynomial adjustment for a detection function model (N = 212; CI = 1.24; 1.72; AICc = 1028.8). Using this value and Rachlow and Whitham's (2004) extrapolation, the abundance values can be compared to values found in Idaho (Table 1).

Table 1. Burrow abundance was measured in Utah on line transects and then extrapolated to live trapping data used in Idaho (Rachlow and Whitham 2004). Abundance data can then be compared in the two states.

	Location	Burrow Density	Extrapolated Mark/Recap. Density
1.	Cedar Gulch, Leadore, Idaho	0.7 burrows/ha	0.38 rabbits/ha
2.	Rocky Canyon, Leadore, Idaho	1.0 burrows/ha	0.54 rabbits/ha
3.	Warm Springs, Leadore, Idaho	5.0 burrows/ha	2.72 rabbits/ha
4.	Grass Valley, Utah	1.46 burrows/ha*	0.79 rabbits/ha

* Based on investigations of burrows encountered on line transects and calculated using Distance 5.0 software.

Habitat Use

At burrow locations, habitat characteristics were similar to characteristics found at random, unoccupied habitat with slight variations (Table 2). Shrub height was higher at burrow locations and individual shrub canopy area was significantly larger than shrubs in random sites and unoccupied sites (Tables 2 and 3). Sagebrush spatial pattern index measures the uniformity of plant spacing and any measurement greater than 0.5 suggests a clumped pattern (Ludwig and Reynolds 1988). At burrow systems and unoccupied random sites spatial pattern was slightly below a clumped dispersion pattern (SPI = 0.47). However, occupied habitat was a clumped pattern (SPI = 0.60). Average shrub density also gives an indication of dispersion and spacing between shrubs and burrow systems had the lowest value (2,630.71 cm²), indicating the most clumped pattern and random sites as the most open dispersion (4,168 cm²),

Species composition in all three categories is predominantly big sagebrush (i.e. ARTR). Occupied pygmy rabbit habitat (home range measurements) had notably more big sagebrush than did burrow locations or unoccupied habitat (97%, 88%, and 83% respectively). Black sagebrush (i.e. ARNO) was only found intermixed in areas where pygmy rabbits did not occur. Big rabbitbrush (i.e. CHNA) is noted as a disturbance species and was found more common at burrow sites than in unoccupied habitat.

Table 2. Descriptive statistics for habitat measurements taken at burrow sires, habitat from transect data found within a pygmy rabbit's home range, and compared with data found at random, unoccupied habitat.

	Shrub Composition	**Shrub Ave. Height**	**Shrub Ave. Decadence**	**Shrub Ave. Density**	**Shrub Spatial Pattern Index**	**Shrub Canopy Area**
Burrow Locations (3 m radius)	ARTR N = 205 (88%) CHNA N = 28 (12%) No other shrubs	69.75 cm N = 288	55.74% N = 288	2630.71 cm² N = 24	0.474 N = 24	10711.88 cm² N = 144
Identified Pygmy Habitat/ Home Range (transect data)	ARTR N = 967 (97%) CHNA N = 27 (3%) No other shrubs	45.68 cm N = 1000	50.94 % N = 1000	3385.26 cm² N = 500	0.601 N = 500	14542.17 cm² N = 1000

Random Sites (unoccupied)	ARTR N = 99 (83%) CHNA N = 1 (1%) CHVI N = 4 (3%) ARNO N = 15 (13%)	44.61 cm N = 152	47.33 % N = 152	4168.82 cm² N = 11	0.471 N = 11	3314.01 cm² N = 76

A subsample was derived from shrub variables measured and reported in Table 2. These subsamples were then used to compare shrub characteristics in occupied pygmy rabbit home range, at burrow locations, and in unoccupied habitat. Burrow sites were significantly different than occupied and unoccupied habitat in all three parameters identified. Shrubs found at burrows were higher, more decadent, and were closer together. In occupied and unoccupied comparisons, shrub decadence and height were not significantly different, but shrubs were closer together than unoccupied sites.

Table 3. Paired-t test results for 3 distinctive parameters found in pygmy rabbit habitat compared with random, unoccupied habitat

N = 146	Burrow to Home Range Habitat Comparison	Burrow to Unoccupied Habitat Comparison	Unoccupied to Home Range Habitats Comparison
Percent Shrub Decadence	T = 2.98 **P = 0.003** CI = 3.88; 19.18	T = -2.78 **P = 0.006** CI = -20.00; -3.36	T = -0.04 P = 0.970 CI = -7.93; 7.63
Shrub Height	T = -6.54 **P = 0.000** CI = -34.67; -18.56	T = -7.04 **P = 0.000** CI = -34.62; -19.45	T = 0.12 P = 0.902 CI = -6.31; 7.14

Shrub Canopy Cover Area	T = -2.33 **P = 0.021** CI = -9064; -752	T = -5.14 **P = 0.000** CI = -9993; -4441	T = -7.76 **P = 0.000** CI = -15214; -9036

Species composition was further investigated using quarter-meter understory plots at burrow locations compared with unoccupied, random habitat (Table 4). Burrow locations had consistently more big sagebrush than random locations, and had little understory of forbs and grasses (less than 13% total understory). Unoccupied, random habitat was partially dominated by big sagebrush and dominated by forbs and grasses, though more forb species were identified at burrow locations. However, many of the species identified in the forb and grass category are invasive and/or exotic species and unpalatable at burrow sites and random, unoccupied sites (Appendix III).

Table 4. Spring-summer plant species composition at burrow sites and unoccupied, random sites in understory ¼ m^2 plots are compared here. Shrub species are separated for dominant species comparisons and grasses and forbs are clumped because of variation between treatment sites and active burrow sites. Residual proportions of materials were moss/lichen or abiotic factors, including bare ground, litter, and rock.

DIRECTION	BIG SAGEBRUSH	BIG RABBITBRUSH	LITTLE RABBITBRUSH	BLACK SAGEBRUSH	FORBS AND GRASSES
N = 24 Burrow center	**46.99%**	5.17%	0.00%	0.00%	7.76%
N = 24 North of Burrow	**39.38%**	3.24%	0.00%	0.00%	9.47%
N = 24 East of Burrow	**33.19%**	0.60%	0.00%	0.00%	6.13%
N = 24 South of Burrow	**39.90%**	4.02%	0.00%	0.00%	10.56%

N = 24 West of Burrow	**35.20%**	3.23%	0.00%	0.00%	12.80%
N = 11 Random center	**28.35%**	0.00%	0.00%	7.43%	17.10%
N = 11 North of Random Center	**24.39%**	0.00%	0.63%	0.00%	**23.44%**
N = 11 East of Random Center	31.00%	0.00%	0.90%	0.45%	**67.31%**
N = 11 South of Random Center	11.85%	0.00%	0.44%	0.00%	**20.20%**
N = 11 West of Random Center	18.80%	0.00%	0.00%	0.00%	**22.56%**

The abundance of shrub species at burrow sites was investigated using an area count method and then compared to similar data in unoccupied, random locations (Table 5). Over 95% of plants observed in the randomly chosen quarter of a burrow site (area = 7.07 m²; r = 3 m) were big sagebrush plants while only 57.86% of plants were big sagebrush in random, unoccupied sites. More shrub species were found in unoccupied, random locations; however these species are virtually unpalatable to pygmy rabbits (Table 5). The most abundant shrub per m² was big sagebrush for burrow sites (2.97/ m²) and random locations (0.88/ m²). Black sagebrush was also encountered in random sites (0.52/ m²) but only at limited sites measured. Burrow sites had collectively more shrubs present than did unoccupied, random sites (0.78/m² and 0.38/m² respectively).

Table 5. All shrub density was measured in a 3 m quarter radius (7.07 m²) in a random direction from a burrow site. These measurements were then compared to random sites in unoccupied habitat.				
SHRUB SPECIES	**Burrow Species Count (plants/m²)**	**Proportion of Total Burrow Shrub Species**	**Random Species Count (plants/m²)**	**Proportion of Total Random Species**
Big Sagebrush	N = 504 Ave = 2.97/m²	95.45%	N = 81 Ave = 0.88/m²	57.86%
Big Rabbitbrush	N = 24 Ave = 0.14/m²	4.55%	N = 1 Ave = 0.01/m²	0.71%
Little Rabbitbrush	N = 0 Ave = 0.00/m²	0.00%	N = 10 Ave = 0.11/m²	7.14%
Black Sagebrush	N = 0 Ave = 0.00/m²	0.00%	N = 48 Ave = 0.52/m²	34.29%
Total Shrubs	**N = 528** **Ave = 0.78/m²**		**N = 140** **Ave = 0.38/m²**	

Horizontal obscurity was also measured at burrow locations and compared to random, unoccupied habitat (Table 6). Burrow locations consistently had a higher proportion of obscured squares on the cover board than did random, unoccupied locations at all distances (paired t-test; $T = 10.84$; $p < 0.001$ $N = 12$; CI = 25.57%; 38.60%). Obscurity differed in cover percent at different distances as well. In random sites, distances 2.5 m away from the center location had lower obscurity values than distances 10 m away (paired t-test; $T = 5.50$; $p < 0.001$; $N = 52$; CI = 14.28%; 30.72%). Values at burrow sites 10 m away from the center average greater than 90% and are significantly different at the 2.5 m and 10 m distances (paired t-test; $T = 5.20$; $p = 0.000$; $N = 95$; CI = 11.30%; 25.27%). In burrow locations, obscurity estimates at 2.5 m from the center of the burrow entries are even larger than values found at 10 m on random sites (2 sample t; T = 2.20; p = 0.028; CI = 1.4%; 24.10%).

Table 6. Average percent horizontal obscurity from selected distances from burrow sites and compared to random sites in unoccupied habitat.

Direction and Distance	Percent Obscurity at Burrow Sites (N = 24)	Percent Obscurity at Random Sites (N = 13)
North @ 2.5 Meters	66.00%	29.06%
North @ 5 Meters	77.00%	44.02%
North @ 10 Meters	91.00%	53.21%
East @ 2.5 Meters	75.00%	41.45%
East @ 5 Meters	84.00%	59.62%
East @ 10 Meters	86.00%	67.74%
South @ 2.5 Meters	76.00%	26.07%
South @ 5 Meters	87.00%	43.80%
South @ 10 Meters	94.00%	54.06%
West @ 2.5 Meters	71.00%	50.85%
West @ 5 Meters	84.00%	65.17%
West @ 10 Meters	91.00%	62.39%
t-test:	**T = 10.84; P = 0.000**	

Macrohabitat was measured quantitatively by measuring the distances of specific parameters from the center point of the burrow and then compared to random, unoccupied habitat measurements. Sample sizes were too small to analyze any important data; however averages are reported (Table 7).

Table 7. Average distances from 8 macrohabitat parameters are shown here. Nearest known parameter was measured.		
Macrohabitat Parameter	**Burrow Site Habitat**	**Random, Unoccupied Habitat**
Distance from Human-caused edge	**48.5 m (N = 24)**	**25.3 m (N = 11)**
Distance from Natural edge	**413.8 m (N = 23)**	**405.8 m (N = 10)**
Distance from Human Structure	**102.5 m (N = 24)**	**52.0 m (N = 11)**
Distance from ORV trails	**93.3 m (N = 23)**	**32.5 m (N = 11)**
Distance from big sagebrush plant	**0.51 m (N = 23)**	**0.53 m (N = 7)**
Distance from big rabbitbrush plant	**119.1 m (N = 22)**	**79.4 m (N = 9)**
Distance from ungulate sign	**12.9 m (N = 15)**	**13.8 m (N = 2)**
Distance from predator sign	**13.8 m (N = 15)**	**65.5 m (N = 2)**
Distance from nearest raptor perch	**302.3 m (N = 24)**	**245.7 m (N = 11)**

Burrow System Configuration and Activity Levels

Burrow system configuration (i.e. geometric shape), activity level classification (Rachlow and Whitham 2004), number of entries, and the distance between burrow openings and between systems were measured. Burrow systems were recorded and given an activity classification and the number of openings recorded as well (Table 8). The number of burrow openings averaged 1.98 per system (N =250) with 7 as the maximum openings in line transect surveys. The proportion of active burrows (category 1) was almost as much as all other classifications combined (47.44% of burrow systems were category 1 and 52.56% total burrow systems were in categories 2-4).

Burrow Classification	Total Burrow Systems Encountered	Proportion of Total Burrow Systems Encountered
Cat. 1 = Active burrow openings	N = 102	47.44%
Cat. 2 = Recently active burrow openings	N = 49	22.79%
Cat. 3 = Old burrow openings	N = 23	10.70%
Cat. 4 = Very old burrow openings	N = 41	19.07%
TOTAL:	**N = 215**	

Table 8. Number of burrows observed and the total per activity classification.

The number of burrow openings was recorded on each burrow system included in habitat analyses (Table 9). The most abundant type were single opening burrows and 49.2% were found with only one entry (N = 32) while multiple entry burrows were only slightly more common (50.8%; N = 33). Single opening burrow systems were the most common nearest neighbor of the random burrow being measured (N = 33). On the nearest neighbor measurements, 75.76% (N = 25 of 33) of burrows had a single opening burrow adjacent to it. Of these nearest burrows, single entry burrows were 60.6% more common adjacent to a multiple entry burrow system (N = 20 out of 33) while a multiple entry, adjacent burrow was not as common next to a multiple entry burrow (24.2% or N = 8 out of 33). Using a Chi-square maximum likelihood test, a nearest neighbor burrow was 99.7%

more likely to be a single entry burrow next to a multiple opening burrow than a multiple entry burrow system ($p = 1.00$; $X^2 = 0.997$; $N = 65$).

Distance to the nearest neighbor burrow system also appeared to be correlated with whether the burrow system was a single opening or multiple opening burrow system (Pearson = 0.414; $p = 0.018$; $N = 65$). Burrow systems with multiple entries averaged 114.0 m away from the next nearest burrow system where there were multiple entries while nearest systems with multiple entries to single entry burrows averaged 52.2 m away. Single entry burrow systems averaged 12.8 m away from the nearest systems with one entrance.

Table 9. The number of burrow openings or entries per burrow system encountered as well as the geometric shape of the burrow systems are reported here.

No. Openings/ Entries	**Total Observed**	**Proportion**	**Burrow System Shape**	**Number**
1 Entry	32	49.2%	One opening	9
2 Entries	7	10.6%	Triangle Shaped	9
3 Entries	8	12.3%	“Y” Shaped	1
4 Entries	9	13.8%	Oval Shaped	7
5 Entries	6	9.2%	Boot Shaped	2
6 Entries	3	4.5%	“T” Shaped	1
No habitat completed on 7 entries to date			Diamond Shaped	1
Total Multiple Entries	33	50.8%	Box/Square Shaped	1
Total:	**65**		**8 General Shapes**	**31**

Within a burrow system the distances between openings were measured. Burrows with multiple entries had nearest to next nearest entrances measured until all burrows were measured. Burrow openings became increasingly farther apart as the number of burrows increased (Table 10). Though sample size is relatively small (Table 10), the variation in distances between the first and second entries to further out openings (i.e. third to fourth, fourth to fifth and fifth to sixth openings) is significantly different, with first and second openings closer than the progressive openings (t-test: $T = -3.92$; $p = 0.001$; CI = -151.5; -47.3; N = 28).

Direction of the next nearest burrow system was also recorded. The most common direction for a nearest burrow system from the randomly chosen burrow system was southwest (N = 7 out of 23 or 30.43%) and no burrows were found in a northwest direction (N = 0 out of 23). Additional information needs to be collected on this, as the sample size is too small to investigate these data further.

Table 10. Average distances in burrow configurations both between openings per cluster (i.e. burrow system) and next closest cluster are reported.

	Average Distance	Sample Size
Average distance from center of the burrow system to the first opening	66.20 cm	N = 35
Average distance from the first opening to the second opening	100.53 cm	N = 34
Average distance from the second opening to the third opening	160.69 cm	N = 26
Average distance from the third opening to the fourth opening	174.83 cm	N = 18
Average distance from the fourth opening to the fifth opening	185.11 cm	N = 9
Average distance from the fifth opening to the sixth opening	216.00 cm	N = 3
Average distance between the nearest and farthest openings	193.86 cm	N = 90
Average distance from one burrow system to the next nearest burrow system	58.84 m	N = 32
Major direction of nearest burrow system (S, SE, SW, N, NE, NW, E, or W)	Southwest	N = 7 southwest N = 23 total directions recorded

Camera Data

Aside from identifying species utilizing pygmy rabbit burrows, remote cameras were useful in recording times of use. Pygmy rabbits caught on camera were also recorded with a time and date log. Pygmy rabbits were more often active during crepuscular times (Table 11) and were seen 71.76% more frequently at these times. Using a binomial probability distribution depicting crepuscular activity, pygmy rabbits were 51.70% more likely to be found active at crepuscular hours than at night or day ($z = 0.517$, $N = 665$). Time and temperature likely play a factor in activity patterns, however summer sample size was too small to see if there was seasonality to the activity times.

Table 11. Pygmy rabbit activity at burrows was observed using Trailmaster 1500 digital cameras and the time of capture recorded. Crepuscular was defined as two hours before or after daylight.

	Count Number	**Proportion**
Night Activity	42	16.03%
Crepuscular Activity	188	71.76%
Day Activity	32	12.21%
TOTAL:	**262**	

Other Species

Habitat use data were also collected on all species encountered during 250 m walk transect surveys. Since data were collected in known pygmy rabbit habitat, there are little comprehendible differences in species to species habitat comparisons (Table 12). However, with species to species analyses comparisons, some significant variation is notable (Appendix IV). Desert cottontail habitat was found to have lower decadence values than black-tailed jackrabbit (*Lepus californicus*), pygmy rabbit, greater sage-grouse, Brewer's sparrow (*Spizella breweri*), and horned lark (*Eremophila alpestris*) habitat ($p <$

0.05; t-test values can be seen in Appendix IV). Pygmy rabbit habitat had significantly shorter shrubs than black-tailed jackrabbit, Brewer's sparrow, and horned lark habitat (t-test $p < 0.05$), while shrub dispersion density was not as dense in pygmy rabbit-identified transects than as on desert cottontail, black-tailed jackrabbit, greater sage-grouse, sage thrasher, and Brewer's sparrow ($p < 0.05$; t-test values in Appendix IV). Greater sage-grouse habitat was less clumped in dispersion pattern than was pygmy rabbit, black-tailed jackrabbit, sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow and horned lark habitat (t-test $p < 0.05$). Other distinctive differences were identified in each species comparisons and are reported in Appendix IV.

Table 12. Other wildlife species can also be attributed with habitat use data and the averages (along with standard deviations) of six parameters are compared here with pygmy rabbit data. All data were collected on 250 m walk transects.

SPECIES	Sample Size	Shrub Decadence	Shrub Height	Shrub Canopy Area	Shrub SPI	Shrub Density	Shrub Species
Pygmy Rabbit (*Brachylagus idahoensis*)	N = 500	50.94% ± 34.67	45.68 cm ± 33.37	14,542.17 cm² ± 19,773.47	0.601 ± 0.250	3,385.26 cm² ± 7,094.75	ARTR = 97%; CHNA = 3%
Desert Cottonatil (*Sylvilagus audubonii)*	N = 18	20.79% ± 22.76	51.54 cm ± 31.21	17,072.05 cm² ± 21,644.31	0.589 ± 0.181	2,270.08 cm² ± 1,677.61	ARTR = 100%
Black-tailed Jackrabbit (*Lepus californicus*)	N = 152	50.82% ± 32.06	53.14 cm ± 32.00	17,608.05 cm² ± 19,695.46	0.615 ± 0.240	2,593.08 cm² ± 2,639.66	ARTR = 91%; CHNA = 8%; CHVI = 1%
Greater Sage-grouse (*Centrocercus urophasianus*)	N = 26	47.13% ± 41.23	44.88 cm ± 25.71	12,342.72 cm² ± 11,182.78	0.483 ± 0.179	1,804.50 cm² ± 989.20	ARTR = 100%
Sage Thrasher (*Oreoscoptes montanus)*	N = 16	36.19% ± 29.92	49.59 cm ± 27.08	15,873.96 cm² ± 17,241.53	0.641 ± 0.187	2,506.69 cm² ± 1,897.338	ARTR = 94%; CHNA = 6%
Brewer's Sparrow (*Spizella breweri*)	N = 206	55.98% ± 31.33	48.99 cm ± 31.84	15,226.73 cm² ± 16,537.50	0.621 ± 0.241	1,883.63 cm² ± 1,788.52	ARTR = 87%; CHNA = 5%
Horned Lark (*Eremophila alpestris*)	N = 68	43.25% ± 60.28	78.75 cm ± 60.88	24,507.54 cm ± 17,432.19	0.689 ± 0.555	3,972.00 cm² ± 3,839.81	ARTR = 85%; CHNA = 15%
Lizard (*Scleroperus spp.)*	N = 20	35.69% ± 32.27	38.22 cm ± 15.25	12,288.62 cm² ± 8,805.59	0.541 ± 0.217	2,760.50 cm² ± 1,824.98	ARTR = 97%; CHNA = 3%

CONCLUSIONS.

Occurrence and Distribution

The occurrence and distribution of pygmy rabbits appeared to be patchy and site specific. Fewer active burrows remained than previously recorded by BLM surveys on re-walked treatment sites. However, some GPS locations could have been incorrect because some were in the middle of treatment areas where all sagebrush had been removed, the soil disturbed, and no burrows could be found. The numbers of active burrow systems were much smaller in areas where investigators re-surveyed former BLM surveys prior to sagebrush treatments. In undisturbed habitat, pygmy rabbits occurred in a patchy distribution and select specific areas based on very distinct habitat requirements.

Abundance

Our density estimation value for Grass Valley is intermediate in comparison to recent (2002-2003) data in Idaho. However, these data may be considered a low density population because it only documents areas where pygmy rabbits were active during this study and not areas where rabbits were formerly found. This estimate is subsequently of patchy areas at a small scale and loss of metapopulations and connectivity is not attributed in this estimate.

The comparable Idaho densities were also considered by Rachlow and Whitham (2004) as low at all of their study areas yet represented some of the most robust pygmy rabbit populations in Idaho. By reference, these abundance estimates also likely represent the largest in the entire range as Idaho is thought to have the largest distribution, highest densities and best habitat. Caution should also be used in using the density estimations, as not all areas may have 1.84 burrow systems per rabbit. Months where no young are present an individual rabbit can likely use 3-10 different burrow systems per season

(Rachlow and Whitham 2004). Camera data have elucidated such likely behaviors in our study, however individual identification tags on rabbits are needed to validate camera data as only one rabbit had identification on it this year.

Habitat Use

Burrow sites were significantly different than occupied and unoccupied habitat in all three parameters identified. This suggests a site selection process for burrow placement by pygmy rabbits, though surrounding habitat is also utilized for foraging and cover (i.e. home range habitat). Within the three parameters, the only significant difference between occupied and unoccupied habitat was shrub canopy cover size.

Shrub habitat characteristics at burrow sites compared with occupied and unoccupied pygmy rabbit habitat support a selection pattern of pygmy rabbits for areas where shrubs are higher and have a larger canopy than surrounding habitat. This could be a function of older shrubs, but is more likely a function of cover from predators, as more big rabbitbrush (only useful for cover) was encountered at burrow sites than in the other two habitats. However, shrubs at burrows were significantly more decadent than those at the other habitats and are likely older as well as taller. In the future, sagebrush should be aged by counting growth rings to answer this question.

Grass Valley is unique to other pygmy rabbit habitats the investigators have observed in that pygmy rabbits heavily utilize former Utah prairie dog (*Cynomys parvidens*) burrows when they occur in sagebrush-dominated habitat. This behavior likely skewed nearest neighbor measurements of shrubs and thus is why parameters such as shrub overstory (i.e. shrub canopy cover) seem on average higher estimates at burrow sites than in surrounding home range habitat. However, consistent with other pygmy rabbit habitat studies, shrubs are significantly taller at burrow sites than in the other habitat categories and cover is likely more important in foraging areas (i.e. home range habitat category) than at the burrow where escape into the burrow is available.

Shrub species at burrow locations, occupied home range habitat, and unoccupied habitat were all predominantly big sagebrush (greater than 83% shrub composition). Little rabbitbrush was observed as1% of the shrubs in unoccupied habitat. No little rabbitbrush or black sagebrush was recorded in pygmy rabbit habitat. Big rabbitbrush was the next most common shrub and was more abundant at burrow locations than the other habitat types. A larger proportion of big rabbitbrush at burrow sites (12%) can likely by accounted for by (1) soft soils that would be present since big rabbitbrush is an indicator of soil disturbance and (2) big rabbitbrush may not be a palatable species to pygmy rabbits but is an excellent cover species with a wide overstory canopy. Big rabbitbrush also folds over when it becomes older making ideal above ground tunnels that rabbits may use temporarily and therefore may occasionally be selected for by pygmy rabbits (pers. obs.).

Almost all shrubs encountered in pygmy rabbit home range habitat were big sagebrush. Big sagebrush is most important in these foraging grounds, since pygmy rabbits rely on sagebrush as their primary food source. It should also be noted that though there is little diversity of other shrubs in all 3 categories, the other 2 species identified were more undesirable, disturbance species and that big sagebrush was the species most conducive to long-term cover, foraging, and a positive, dominant ecotype species for most wildlife. Shrub density data support this and show big sagebrush as the most common shrub species 95.45% of the time and big rabbitbrush occurring only 4.55% of the time. With other wildlife species identified on line transects, big sagebrush contributed greater than

85% of all shrub species identified and illustrates the value of this shrub for other wildlife as well.

While big sagebrush dominated all burrow sites, there was a lack of forbs and grasses in understory data. Forbs and grasses were more common in random locations and collectively dominated the ratio of big sagebrush on average. While some of these forbs are exotic and/or are unpalatable, the presence of forbs and grasses in pygmy rabbit diet in the summer is critical. The disparity of forbs and grasses in pygmy rabbit burrow habitat is likely a negative factor and could explain why individual rabbits appear to have such large home ranges compared to former studies (Smith and Flinders 1980b).

Shrub cover was also directly measured with the horizontal obscurity board. Obscurity was significantly denser at burrow locations than at random, unoccupied habitat. Pygmy rabbits likely select habitat with the most cover and rely on this as a major function of predator avoidance. As expected, in both burrow and random locations horizontal cover is heavier farther away from the center point (i.e. 10 m versus 2.5 m). However, cover at burrow systems is so thick that estimates close to the burrow (2.5 m) are comparable to estimates at the densest points (10 m) at the random sites.

Burrow Configuration

Active burrows were much more common than other activity classifications and support the assertion that pygmy rabbits maintain more than one burrow system. However, inactive burrows likely play a crucial role in escape cover, as seen by video from remote cameras. Cameras have been placed on burrows classified as old or very old and pygmy rabbit use has been recorded.

Single entry burrow systems were more common than expected, particularly since they are so much harder to detect than multiple entry burrows. Former surveys took single entry burrows into little consideration (Greenwood, pers. comm.) because they were thought to not be important to pygmy rabbit habitat needs. However, single burrows maybe a function of a larger distance needed for foraging and habitat data collected here elude to this. Anecdotal evidence supports that rabbits, particularly juveniles, will flee observers to a nearest burrow (usually only one opening). Often these burrows are shallow and less than half a meter in depth and could likely be used exclusively for escape cover. Distance between a burrow system and its nearest neighbor also supports the use of single entry burrows as escape cover. The fewer openings the burrow system had, the closer the system was to its next nearest burrow.

Multiple burrow systems were more often in a triangular or oval shape. The distance between openings also increased with the increase in number of openings. Both the system shape and the distance between openings may be a function of the burrows being former Utah prairie dog burrows. Pygmy rabbit burrow systems outside of Grass Valley would have to be looked at to draw any conclusions about burrow shape and size selection.

Camera Data

Pygmy rabbit activity times were examined using remote cameras. Pygmy rabbits were primarily crepuscular, but appeared to be active at other times as well. Seasonality and/or temperature likely play a strong role in activity times, however our sample size was too small to break the data into seasons or climatic changes.

Other Species

Species to species comparisons appear complicated in nature and difficult to analyze, given some species' small sample sizes and only one year of data. The nuances in comparisons were rarely one species significantly different than all others, but rather one significantly different than one and not of another. The few that were identified as the former were unexpected. In pygmy rabbit transects, shrubs were not as high or as dense as those where black-tailed jackrabbits and Brewer's sparrows were found. In the case of jackrabbits, this was likely because jackrabbits were not identified in the transect strip until they had been flushed and this would place them in the more dense cover. Horned larks were included in this analyses to represent a more grassland species, however, the only difference in habitat selection of this species from pygmy rabbit habitat was that shrubs found on horned lark transects had notably higher shrubs.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS.

This study was established to be a multi-year project and conclusions drawn from the results should take this into consideration. Data reported here are inconclusive until more research can be added to this study. Occurrences of pygmy rabbits throughout the Valley were comprehensively studied yet some colonies may have been missed. Research into where rabbits are, their abundances, movement behavior, and habitat use ideally needs to be studied further.

The abundance of pygmy rabbits in Grass Valley, Utah were found to be midrange when compared to values estimated in Idaho. In the habitat most similar to Grass Valley (i.e. Rocky Gulch), estimated density was 0.54 rabbits/ha and is comparable to our extrapolated value of 0.79 rabbits/ha. These values likely represent a lower abundance estimate than historical values, though both areas probably represent the highest abundances in their respective state. This is based on the observation by managers and researchers that these two areas have the most rabbits in each of their states (Rachlow and Whitham 2004).

Pygmy rabbits appear to utilize habitat based on predator avoidance and browse forage needs. This puts big sagebrush in a critical role in pygmy rabbit habitat use (Green and Flinders 1980b). Rabbits rely on this shrub for cover and food and at least three-quarters of all shrubs found in pygmy rabbit selected habitat was big sagebrush. Other species also utilize sagebrush as a forage and cover species. Among these are several species that are considered sagebrush obligate species (i.e. besides the pygmy rabbit, the sage thrasher, sage sparrow, greater sage-grouse, Brewer’s sparrow, and mule deer are also considered obligate - - McEwan et al. 1987; Braun et al. 1976). All but the sage sparrow were encountered in Grass Valley and were found in large patches of sagebrush also occupied by pygmy rabbits.

Some data that needed to be collected on the pygmy rabbits in Grass Valley could not be completed in one year. For example, pygmy rabbits appeared to move seasonally between sites and these movements were likely south to north/winter to summer along the eastern side of the Valley. Areas where pygmy rabbits were relatively abundant were suddenly sparse on line transects performed just after juvenile dispersal (approx. June). Around this time habitat to the north appeared more abundant with rabbits. No reports of migration patterns have been reported for pygmy rabbits to date, however Idaho studies intimated that migration occurred when localized groups would also head north across the sagebrush foothills (Sanchez, pers. comm. 2005). Further movement research should be completed using radio instrumented animals since these rabbits are possibly moving north into treatment locations. This study attempted to trap and instrument rabbits, however the amount of time and man power needed to do this in the space of one year made this impossible. Two animals were captured and outfitted with ear tags and radio-collars, One individual died due to a loose radio-collar and the other bit the radio-collar off in the space of a month. The latter rabbit, however, was captured by a remote camera (identified because of the ear tag) a month later (2 mos. from capture) on a burrow 310 m away from its initial capture point.

Burrows that were formerly prairie dog mounds were more open in overstory cover. However, horizontal cover was consistently denser at all burrows systems. This implies the importance of wide strips in sagebrush removal projects so that cover is still available from terrestrial predators. Burrow locations also had significantly taller shrubs and suggests the need to leave patches of taller brush standing for habitat expansion and not just areas where burrow openings occur.

Forb and grass species richness at burrow sites was significantly lower than at random sites. Grasses in particular are important summer diet materials for pygmy rabbits. Forbs and grasses are important to get back into pygmy rabbit home range, but caution should be used in sagebrush removal. Treatment projects would likely be beneficial if sagebrush stands were left in wide, connected corridors for rabbits to utilize sagebrush as cover for movement and browse forage. Connectivity appears to play an important role in whether pygmy rabbit will still occupy sagebrush treatment mosaics. Active burrows encountered on re-walked surveys of BLM treatment surveys were only found in sagebrush treatment mosaics connected to remaining stands of sagebrush or areas where swaths of removal were much smaller and distances between one treatment to the next were minimal. Smaller, patchy removal of sagebrush was likely the natural fire regime historically anyway. Big sagebrush is naturally fire-limiting and can retard swift, large blazes more efficiently than can grass-dominated ecotypes (Miller and Rose 1999; Winward 1991; Winward 1984; Lommasson 1948).

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APPENDIX I. Statewide (south of I-80) surveys conducted in 2004-2005 are reported here. Lists of locations are reported on a coarse scale here and many locations had several to many transects per site.

Table 1. Locations searched for pygmy rabbits in 2004-2005 under a cooperative contract with the Utah Department of Natural Resources.						
Location	**Confirmed**	**Probable**	**Possible**	**Unconfirmed**	**Unlikely**	**Comments**
NW of Enoch, Iron Co.	X					Pygmy rabbit, active burrows and pellets seen
Highway 130 to Minersville, Iron Co.		X				Old pellets and burrows seen
Tebbs Ponds, Hwy 130 marker 30, Iron Co.	X					Pygmy rabbit, active burrows and pellets seen
Schoppeman Road, Enoch, Iron Co.	X					Pygmy rabbit, active burrows and pellets seen
Minersville Highway 130, mi. marker 30, Iron Co.	X					Pygmy rabbit, active burrows and pellets seen
S of Jcntn I-15 and I-70, Iron Co.				X		No evidence seen
1 mi. SW of Jct. I-15 and state Hwy 20, Iron Co.				X		No evidence seen
W Buckskin Mtrn, 5 mi. SE I-15 Junction with Hwy 20, Iron Co.				X		No evidence seen
Indian Creek, 7 mi W of Beaver, Beaver Co.				X		No evidence seen
Antimony, Garfield Co.	X					Pygmy rabbit, active burrows and pellets seen
Between Circleville and Spry, Garfield Co.				X		No evidence seen
S of Antimony, Highway 22, Garfield Co.	X					Fresh pellets and intace burrows seen
N of Osiris, Highway 22, Garfield Co.			X			No evidence seen
Panguitch Municple Airport, Garfield Co.				X		Sagebrush Habitat Altered
NE of Panguitch, Garfield Co.				X		Sagebrush Habitat Altered
SW of Antimony, Garfield Co.	X					Pygmy rabbit, active burrows and pellets seen
Bear Creek, 11 mi SE Jct. I-15 and Hwy 20, Garfield Co.				X		No evidence seen
Brush Creek, Circleville, Garfield Co.				X		No evidence seen
NW Loa Dump, Parker Mountain, Wayne Co.	X					Fresh pellets and intace burrows seen
Parker Mountain, off Highway 24, Wayne Co.			X			Old pellets and burrows seen
TV Tower Road, Parker Mountain, Wayne Co.			X			Old, Collapsed burrows seen
Jake's Knoll, Parker Mountain, Wayne Co.	X			X		No evidence seen

Flossie Lake, Parker Mountain, Wayne Co.				X		Cottontail and Jackrabbit seen
Big Rocks Rd & Loa Dump Rd, Parker Mtn, Wayne Co.	X					Pygmy rabbit, active burrows and pellets seen
Abe's Knoll Road, Parker Mountain, Wayne Co.			X			Cottontail and Jackrabbit seen; 1 burrow likely rodent
Black Point Road, Parker Mountain, Wayne Co.			X			Old, Collapsed burrows seen
Riley Canyon, Parker Mountain, Wayne Co.				X		No evidence seen
Blackridge, Parker Mountain, Wayne Co.			X			Old, Collapsed burrows seen
Deadman Hollow, Parker Mountain, Wayne Co.		X				Burrow likely seen in hillside of gully
The Narrows, S of Greenwich, Piute Co.				X		No evidence seen
Forshea Mountain, Monroe Mountain, Piute Co.					X	Unlikely habitat
S of Oak Creek, Piute Co.			X			Old, Collapsed burrows seen
Angle, N of Otter Creek Reservoir, Piute Co.	X					Pygmy rabbit, active burrows and pellets seen
W of Otter Creek Reservoir, Piute Co.	X					Pygmy rabbit, active burrows and pellets seen
Otter Creek Reservoir, Piute Co.				X		No evidence seen
E of Greenwich, Piute Co.	X					Pygmy rabbit, active burrows and pellets seen
Greenwich, Piute Co.	X					Pygmy rabbit, active burrows and pellets seen
E of Koosharem, Sevier Co.		X				Old, Collapsed burrows seen; jackrabbit seen
Koosharem, Sevier Co.			X			No evidence seen
W of Koosharem Cemetary, Sevier Co.			X			Old, Collapsed burrows seen; jackrabbit seen
W NW Koosharem Reservoir, Sevier Co.				X		Cottontail and Jackrabbit seen
NW Koosharem Reservoir, Sevier Co.			X			Cottontail and Jackrabbit seen
N Koosharem Reservoir, Sevier Co.				X		No evidence seen
The Elbow, Monroe Mountain, Sevier Co.				X		No evidence seen
Burrville Cemetary, Sevier Co.				X		Jackrabbit seen
Burrville, W of Highway 62, Sevier Co.			X			Burrows seen, likely rodent not pygmy rabbit
Milo's Kitchen Road, Box Creek, Sevier Co.				X		No evidence seen
W of Soldiers Pass, Utah Lake, Utah Co.					X	Sagebrush Habitat Altered
W of Yuba Lake State Park, Juab Co.					X	Sagebrush Habitat Altered

S of Painted Rocks, 6 mi. E Yuba State Park, Juab Co.					X	Sagebrush Habitat Altered
Willow Cr., 2 mi. ESE of Mona Cemetary, Juab. Co.					X	Sagebrush Habitat Altered
Old Canyon, 3.6 mi W Mona Cemetary, Juab Co.					X	Sagebrush Habitat Altered
Goshen Canyon, 6 mi S of Goshen, Juab Co.					X	Sagebrush Habitat Altered
S. of Callao, Juab Co.					X	Sagebrush Habitat Altered
Wash half way between Callao CCC camp and Trout Creek, Juab Co.					X	Sagebrush Habitat Altered
Road from Callao to Trout Creek, Juab Co.					X	Sagebrush Habitat Altered
Off Raod in Partoun, Juab Co.					X	Sagebrush Habitat Altered
Above Little Sahara, Juab Co.				X		No evidence seen
Near Little Sahara, Juab Co.				X		No evidence seen
West of Little Sahara, by Chicken Rock, Juab Co.				X		No evidence seen
Tidwell Springs near Gilson Mtn, Juab Co.				X		No evidence seen
West of Little Sahara, Juab Co.				X		No evidence seen
South Trout Creek, town of Partoun, Juab Co.					X	Sagebrush Habitat Altered
Old Lincoln Hwy on way to Ibapah, Tooele Co.				X		No evidence seen
Ibapah Foothills, Tooele Co.				X		No evidence seen
Road to Gold Hill, in wash, Tooele Co.					X	Sagebrush Habitat Altered
Wash off the Road above Gold Hill, Tooele Co.					X	Sagebrush Habitat Altered
Road to Faust and W of Fivemile Pass, Tooele Co.				X		No evidence seen
Benmore Pastures, Tooele Co.				X		No evidence seen
Benmore, Tooele Co.				X		No evidence seen
Rd by Vernon Reservoir, Tooele Co.				X		No evidence seen
Round Canyon, S Stansbury Mountains, Tooele Co.					X	Sagebrush Habitat Altered
Road over Spor Mtn, Tooele Co.					X	Sagebrush Habitat Altered
3 mi. S of Stockton, Tooele Co.				X		No evidence seen
Lakeside Mountains, Tooele Co.					X	Sagebrush Habitat Altered
Five Mile Pass, 8 mi. SW of Cedar Fort, Tooele Co.			X			Old, Collapsed burrows seen; jackrabbit seen

APPENDIX II. Two lists of identified wildlife species are listed here.

	Species Idenitfied Using Trailmaster Cameras at Pygmy Rabbit Burrows	Number seen
1	Pygmy Rabbit *(Brachylagus idahoensis)*	241
2	Desert Cottonatil (*Sylvilagus audubonii)*	7
3	Black-tailed Jackrabbit (*Lepus californicus)*	12
4	White-tailed Antelope Ground Squirrel (*Ammospermophilus leucurus)*	2
5	Rock Squirrel (*Spermophilus leucrus)*	1
6	Deer Mouse (*Peromyscus maniculatus)*	30
7	Pinyon Mouse (*Peromyscus truei)*	4
8	Desert Woodrat (*Neotoma lepida)*	7
9	Ord's Kangaroo Rat (*Dipodomys ordii)*	5
10	American Badger (*Taxidea taxus)*	5
11	Long-tailed Weasel (*Mustela frenata)*	2
12	Lizard (*Scleroperus spp.) - likely Common Sage Lizard*	3
13	Sage Thrasher (*Oreoscoptes montanus)*	1
	Species Identified in Walk (Line) Transects	**Number seen**
1	Pygmy Rabbit *(Brachylagus idahoensis)*	250
2	Desert Cottonatil (*Sylvilagus audubonii)*	3
3	Black-tailed Jackrabbit (*Lepus californicus)*	30
4	Chipmunk (*Tamias* spp.)	2
5	American Badger (*Taxidea taxus)*	2
6	Coyote (*Canis latrans*)	17
7	Mule Deer (*Odocoileus hemionus)*	2
8	Lizard (*Scleroperus spp.) - likely Common Sage Lizard*	10
9	Greater Sage-grouse (*Centrocercus urophasianus*)	3
10	Sage Thrasher (*Oreoscoptes montanus)*	8
11	Horned Lark (*Eremophila alpestris*)	4
12	Chipping Sparrow (*Spizella passerina*)	5
13	Brewer's Sparrow (*Spizella breweri*)	56
14	Green-tailed Towhee (*Pipilo chlorurus*)	2

15	Pinyon Jay (*Gymnorhinus cyanocephalus*)	2
16	Mourning Dove (*Zenaida macroura*)	6
17	Black-billed Magpie (*Pica hudsonia*)	1
18	Common Nighthawk (*Chordeiles minor*)	1
19	Turkey Vulture (*Cathartes aura*)	1
20	Broad-tailed Hummingbird (*Selasphorus platycercus*)	1

APPENDIX III. All plants encountered in habitat measurements at burrow locations are listed below.

A list of plant species encountered at each burrow site and comparable random, unoccupied site when habitat data were collected.

		Burrow Sites	**Random Sites**
1	SHRUBS	Big Sagebrush (*Artemisia tridentata*)	Big Sagebrush (*Artemisia tridentata*)
2		Big Rabbitbrush (*Chrysothamnus nauseous*)	Big Rabbitbrush (*Chrysothamnus nauseous*)
3		Little Rabbitbrush (*Chrysothamnus viscidiflorus*)	Little Rabbitbrush (*Chrysothamnus viscidiflorus*)
4			Black Sagebrush (*Artemisia nova*)
5			Four-wing Saltbush (*Atriplex canescens*)
6			Prostrate Kochia (*Kochia scoparia*)
7	GRASSES	Bluebunch Wheatgrass (*Elymus spicatus*)	Bluebunch Wheatgrass (*Elymus spicatus*)
8		Indian Ricegrass (*Stipa hymenoides*)	Indian Ricegrass (*Stipa hymenoides*)
9		Cheatgrass/Downy Brome (*Bromus tectorum*)	Cheatgrass/Downy Brome (*Bromus tectorum*)

10		Squirreltail (*Elymus elymoides*)	Squirreltail (*Elymus elymoides*)
11		Ripgut Brome (*Bromus diandrus*)	Ripgut Brome (*Bromus diandrus*)
12		Crested Wheatgrass (*Agropyron cristatum*)	Crested Wheatgrass (*Agropyron cristatum*)
13		Intermediate Wheatgrass (*Elymus hispidus*)	Needle and Thread Grass (*Hesperostipa comata*)
14		Blue Grama Grass (*Bouteloua gracilis*)	Timber Oatgrass (*Danthonia intermedia*)
15			Bluestem Wheatgrass (*Elymus smithii*)
16			Smooth Brome (*Bromus inermis*)
16			Blue bunchgrass (*Festuca idahoensis*)
17			Black Grama (*Bouteloua eripoda*)
18			Tanglehead (*Heteropogon contortus*)
19	FORBS	Common Lambsquarter (*Chenopodium album*)	Common Lambsquarter (*Chenopodium album*)
20		Russian Thistle (*Salsola iberica*)	Russian Thistle (*Salsola iberica*)
21		Common Peppergrass (*Lepidium densiflorum*)	Common Peppergrass (*Lepidium densiflorum*)
22		Tansy Mustard (*Descurania pinnata*)	Musk Thistle (*Carduus nutans*)
23		Desert Princesplume (*Stanleya pinnata*)	Buckwheat (*Eriogonum umbellatum*)
24		Rock Jasmine (*Androsace septentrionalis*)	Cushion Buckwheat (*Eriogonum ovalifolium*)
25		Alfalfa (*Medicago sativa*)	Scarlet Globe Mallow (*Sphaeralcea coccinea*)

26		Sweet Yellow Clover (*Medicago officionalis*)	Dandelion (*Taraxacum officionale*)
27		Scarlet Gila/Skyrocket (*Ipomopsis aggregate*)	Blue Penstemon (*Penstemon glaber*)
28		Princely Daisy (*Erigeron formosissimus*)	Milk-vetch (*Astragulus* spp.)
29		Purple Loco (*Oxytropis lambertii*)	Tailcup Lupine (*Lupinus caudatus*)
30		Giant Ragweed (*Ambrosia trifida*)	Silverstem Lupine (*Lupinus argenteus*)
31		Alfalfa (*Medicago sativa*)	Cobu
32		Rocky Mountain Bee Plant (*Cleome serrulata*)	1 Unidentified Forb (same as burrow species)
33		Western Blue Flax (Linium lewisii)	
34		Stickseed (*Hackelia* spp.)	
35		Stickweed (*Verbesina occidentalis*)	
36		Rate	
37		Halogeton (*Halogeton glomeratus*)	
38		Plains Prickly Pear (*Opuntia polycantha*)	
		1 Unidentified Forb	

APPENDIX IV. Wildlife species to species comparisons using two sample t-tests are reported here. Data on the right-hand side of the matrix indicate the actual data and significant values are highlighted. Cells to the left reflect the same analyses, but are only marked significant so as to illustrate the species to species comparisons without being encumbered by the actual values.

	Pygmy Rabbit (*PYRA*)	Desert Cottontail (DECO)	Black-tailed Jackrabbit (*BTJR*)	Greater Sage-grouse (*SAGR*)	Sage Thrasher (*SATH*)	Brewer's Sparrow (*BRSP*)	Horned Lark (*HOLA*)
PYRA Shrub Decadence		T = 3.64 P = 0.001 DF = 51	T = -1.32 P = 0.19 DF = 282	T = -0.41 P = 0.68 DF = 76	T = 1.74 P = 0.088 DF = 47	T = -2.16 P = 0.032 DF = 280	T = -1.25 P = 0.21 DF = 273
DECO Shrub Decadence	SIGNIFICANT		T = -4.88 P = 0.0000 DF = 38	T = -2.99 P = 0.004 DF = 77	T = -1.11 P = 0.27 DF = 56	T = -5.48 P = 0.000 DF = 37	T = -4.48 P = 0.000 DF = 58
BTJR Shrub Decadence		SIGNIFICANT		T = -0.31 P = 0.76 DF = 63	T = -2.59 P = 0.013 DF = 38	T = 1.04 P = 0.30 DF = 599	T = -0.21 P = 0.83 DF = 239
SAGR Shrub Decadence		SIGNIFICANT			T = 1.70 P = 0.094 DF = 77	T = -0.77 P = 0.44 DF = 62	T = -0.40 P = 0.69 DF = 83
SATH Shrub Decadence			SIGNIFICANT			T = -3.07 P = 0.004 DF = 38	T = -2.51 P = 0.015 DF = 52
BRSP Shrub Decadence	SIGNIFICANT	SIGNIFICANT			SIGNIFICANT		T = 0.55 P = 0.58 DF = 236
HOLA Shrub Decadence		SIGNIFICANT			SIGNIFICANT		
PYRA Shrub Height		T = -1.50 P = 0.14 DF = 36	T = -3.69 P = 0.000 DF = 311	T = -0.70 P = 0.48 DF = 92	T = -1.55 P = 0.13 DF = 48	T = -2.70 P = 0.007 DF = 302	T = -2.62 P = 0.009 DF = 278
DECO Shrub Height			T = 0.30 P = 0.77 DF = 32	T = -0.88 P = 0.38 DF = 51	T = -0.16 P = 0.87 DF = 53	T = -0.22 P = 0.83 DF = 32	T = -0.05 P = 0.96 DF = 37
BTJR Shrub Height	SIGNIFICANT			T = 1.85 P = 0.068 DF = 75	T = 0.60 P = 0.55 DF = 41	T = 1.22 P = 0.22 DF = 598	T = 0.70 P = 0.49 DF = 285
SAGR Shrub Height					T = 0.81 P = 0.42 DF = 68	T = -1.13 P = 0.26 DF = 73	T = -1.26 P = 0.21 DF = 94
SATH Shrub Height						T = 0.02 P = 0.98 DF = 40	T = -0.16 P = 0.87 DF = 49
BRSP Shrub	SIGNIFICANT						T = -0.32 P =

Height							0.75 DF = 277
HOLA Shrub Height	SIGNIFICANT						
PYRA Shrub Canopy Cover		T = -0.35 P = 0.73 DF = 35	T = -0.95 P = 0.34 DF = 299	T = 0.38 P = 0.71 DF = 74	T = -0.08 P = 0.94 DF = 43	T = -0.38 P = 0.70 DF = 280	T = 1.14 P = 0.25 DF = 263
DECO Shrub Canopy Cover			T = -0.08 P = 0.94 DF = 31	T = 0.56 P = 0.58 DF = 61	T = 0.23 P = 0.82 DF = 56	T = 0.19 P = 0.85 DF = 30	T = 0.90 P = 0.38 DF = 31
BTJR Shrub Canopy Cover				T = 0.91 P = 0.37 DF = 63	T = 0.41 P = 0.68 DF = 37	T = 0.71 P = 0.48 DF = 594	T = 2.48 P = 0.013 DF = 364
SAGR Shrub Canopy Cover					T = 0.35 P = 0.73 DF = 74	T = 0.60 P = 0.55 DF = 61	T = -0.24 P = 0.81 DF = 63
SATH Shrub Canopy Cover						T = -0.11 P = 0.91 DF = 36	T = -0.68 P = 0.50 DF = 37
BRSP Shrub Canopy Cover							T = -1.87 P = 0.062 DF = 345
HOLA Shrub Canopy Cover			SIGNIFICANT				
PYRA SPI		T = 0.20 P = 0.85 DF = 15	T = -0.71 P = 0.48 DF = 313	T = 3.02 P = 0.005 DF = 33	T = -0.69 P = 0.50 DF = 17	T = 1.51 P = 0.13 DF = 428	T = -0.13 P = 0.90 DF = 108
DECO SPI			T = 0.52 P = 0.61 DF = 16	T = -1.81 P = 0.082 DF = 27	T = 0.67 P = 0.51 DF = 27	T = -0.45 P = 0.66 DF = 16	T = 0.25 P = 0.80 DF = 21
BTJR SPI				T = 3.31 P = 0.002 DF = 38	T = 0.39 P = 0.70 DF = 18	T = -2.01 P = 0.045 DF = 325	T = -0.39 P = 0.70 DF = 131
SAGR SPI	SIGNIFICANT		SIGNIFICANT		T = 2.40 P = 0.023 DF = 28	T = -2.15 P = 0.039 DF = 35	T = 2.71 P = 0.009 DF = 52
SATH SPI				SIGNIFICANT		T = -1.26 P = 0.23 DF = 17	T = -0.58 P = 0.57 DF = 22
BRSP SPI			SIGNIFICANT	SIGNIFICANT			T = 1.17 P = 0.24 DF = 121
HOLA SPI				SIGNIFICANT			
PYRA Shrub Density		T = 2.19 P = 0.031 DF = 88	T = 2.58 P = 0.010 DF = 312	T = 3.56 P = 0.000 DF = 273	T = 2.16 P = 0.034 DF = 76	T = 2.90 P = 0.004 DF = 294	T = 0.95 P = 0.34 DF = 298
DECO Shrub Density	SIGNIFICANT		T = -0.04 P = 0.97 DF = 20	T = 1.27 P = 0.22 DF = 18	T = 0.10 P = 0.92 DF = 27	T = 0.40 P = 0.70 DF = 17	T = -1.58 P = 0.12 DF = 38
BTJR Shrub Density	SIGNIFICANT			T = 2.02 P = 0.046 DF = 104	T = 0.09 P = 0.93 DF = 2	T = 0.60 P = 0.55 DF = 311	T = -2.10 P = 0.038 DF = 109
SAGR Shrub	SIGNIFICANT		SIGNIFICANT		T = -1.00 P =	T = -1.58 P =	T = -3.50 P =

Density					0.33 DF = 19	0.12 DF = 82	0.001 DF = 88
SATH Shrub Density	SIGNIFICANT					T = -0.23 P = 0.82 DF = 19	T = 1.56 P = 0.13 DF = 36
BRSP Shrub Density	SIGNIFICANT						T = 2.57 P = 0.012 DF = 96
HOLA Shrub Density			SIGNIFICANT	SIGNIFICANT		SIGNIFICANT	

A review of pygmy rabbit (*Brachylagus idahoensis*) research and conservation efforts in Utah.

Report period: July 2005 – April 2006

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Table of Contents

Background and Historic Information

Notable exceptions to the lack of historical information available on pygmy rabbits in Utah are two works by Reuel Janson. Conducted almost 60 years ago at Utah State University, Reuel's Bachelor's thesis (Janson 1940) and Master's thesis (Janson 1946) represent the vast majority of what is known about pygmy rabbits and their distribution in the 1900s. By observing and collecting pygmy rabbits throughout the state, Janson was able to derive and publish a coarse distribution map delineating the likely extent of pygmy rabbits during the time of his studies (Figure 1). Janson also authored two follow-up publications (Janson 2002, 2003), which were based largely on his earlier works (1938-1946), but were supplemented with more contemporary observations and literature reviews. Janson's half century of experience lends an invaluable insight to the debate over trend data. In addition to these published information resources, many of Janson's specimens remain available for study at the University of Utah's and Brigham Young University's vertebrate collections, and Janson himself (to our knowledge) is still alive and well in Missoula, Montana.

Several other notable collections of historic distribution data (Durrant 1952, Holt 1975, Toone 1994) were researched and compiled by the Utah Natural Heritage Program (UNHP). Location data from these three documents and Janson's work comprise the bulk of the 61 pygmy rabbit records documented prior to 2001 (Figure 1). A timely and relatively exhaustive look at Utah's pygmy rabbits and UNHP data was also recently completed by UNHP zoologist, George Oliver (2004). This work represents a thorough literature review on the classification of the species and its general life history traits, as well as Utah specific information on the rabbit's geographic distribution, abundance, and threats.

Current Information and Survey Work

In December 2003 the Utah Division of Wildlife Resources revised its *Utah Sensitive Species List*. Among the changes made to the previous list (1998) was the inclusion of the pygmy rabbit. Designed to be locally reactive to species for which conservation actions are needed, Utah sensitive species designations prompt early actions to help preclude the need to list a species under the provisions of the ESA. The 2003 listing of the pygmy rabbit on Utah's list also facilitated the allocation of hundreds of thousands of dollars to support actions directly related to the conservation of the species (see Ongoing Projects). The pygmy rabbit's current legal status also prohibits collection and controls the importation and possession of the species or its parts.

Beginning in the spring of 2003, field surveys were implemented to help assess the current distribution of pygmy rabbits in Utah. Janson's historical distribution map was digitized and overlaid with all known pygmy rabbit observations or specimen collection sites to aid in survey site selection. Surveys to determine the distribution of pygmy rabbits currently occur at two scales: landscape level and site level. Landscape level surveys are used to recognize and delineate areas containing potential habitat suitable for pygmy rabbit occupation. Fine scale surveys are conducted to determine the actual presence of rabbits on a site, and rely heavily on observation of rabbit sign. Rabbit occurrence is defined by presence of tracks during snow surveys, concurrent presence of pellets and burrows during surveys conducted without snow cover, or the direct observation of a rabbit. Absence of rabbits and their sign is interpreted carefully, especially when investigating sites considered to have had pygmy rabbits historically. Many of the historical descriptions are extremely vague, making it difficult to determine when the area has been surveyed to its full extent. Due largely to this lack of specificity, historical sites are considered to extend 5 miles from the center of the location provided by the UNHP.

A significant amount of public input has been solicited to facilitate finding the rabbits and accessing private lands to conduct surveys. Training observers, handling information requests from individuals and special interest groups, and educating landowners has been handled through statewide training seminars, working groups, and a downloadable flyer. The presentations and flyers emphasize the identification of pygmy rabbits, their habitat, and their sign. Standardized data forms are handed out and participants are strongly encouraged to contribute to local survey efforts. Biologists' participation within local working groups emphasize the value of open dialog with respect to species of concern and the important role of the private landowner in maintaining healthy ecosystems.

As of January 1, 2006: Of the 61 UNHP sites, 28 are still known to be occupied by pygmy rabbits, 23 have been surveyed at least once without finding pygmy rabbits, and 10 remain unverified (Figure 2). Additional surveys, not limited to areas that were known to historically support pygmy rabbits, have been conducted throughout the state to expand our knowledge of the rabbit's current distribution. The statewide database currently holds data on over 2200 survey sites (Figure 3). Rabbits are currently known to occur in the following 7 counties: Box Elder, Rich, Morgan, Sevier, Wayne, Piute, and Iron. Only in Rich county have rabbits been found outside (> 16 miles) the range predicted by Janson. The counties where pygmy rabbits have not currently been detected, but were identified by Janson as historically having potential habitat are: Cache, Salt Lake, Utah, Tooele, Sanpete, Millard, Beaver, Garfield, and Washington. On a regional scale, the sympatry between pygmy rabbits and healthy greater sage-grouse populations seems high.

Although our knowledge of pygmy rabbit distribution and behavior has advanced significantly over the last 2 years, attempts to estimate population sizes are still proving problematic. Direct enumeration, density estimation, and indices, although often successful with other rabbit species, have been found to be largely ineffective because of the high brush densities commonly inhabited by pygmy rabbits. Capture of the rabbits for use in mark-resight or mark-recapture studies has also been found to be difficult. Experiments with live-traps, pitfalls, mist-nets, noose-poles, and enclosure traps have not demonstrated great returns. The feasibility of using pellet plots is currently under investigation as a method of determining relative population size. Although the capture of rabbits has limited Utah's participation in the range-wide genetic surveys being conducted in Washington State, several contemporary samples have been submitted and proposals are being drafted to sample from Utah's museum specimens. Researchers working throughout the state have been instructed on how to preserve genetic samples.

On March 30th 2006 it was announced that a group of conservation organizations had filed a federal lawsuit against the U.S. Fish and Wildlife Service and the Secretary of the Interior to dispute the agencies recommendation not to list the pygmy rabbit as threatened or endangered. The lawsuit, filed by Western Watersheds Project, Biodiversity Conservation Alliance, Center for Native Ecosystems, Oregon Natural Desert Association, and the Sagebrush Sea Campaign, will likely result in another review of available range wide datasets. The projects listed below are designed to help improve our understanding of the rabbits and their conservation.

Ongoing Projects

Believing that habitat loss and degradation are the most threatening issue facing wildlife in Utah, the UDWR launched its Habitat Initiative in 2003 to implement restoration projects designed to prevent and reverse loss of habitat. Special emphasis has been placed on the protection and restoration of shrub-steppe and riparian habitats due to their importance in supporting a diversity of wildlife species. Key to the Initiative's success has been the UDWR's ability to develop cooperative working relationships with key political decision makers, federal and state land managers, local governments, tribes, private landowners, and conservation groups. Implementation and planning of Habitat Initiative projects occurs in coordination with game and non-game species biologists to maximize the biotic return of each project. The UDWR and its partners are currently designing and implementing treatments for close to 75,000 acres of degraded sagebrush steppe annually.

Monitoring the effects of Habitat Initiative projects is an important component to assessing our progress, but as implementation of sage-grouse, mule deer, and pronghorn treatments occur, it is well understood that pygmy rabbits operate neither in an ecological nor political vacuum. It is equally apparent that successful management of pygmy rabbits is not likely to come from the design of new single species prescriptions, but rather from the design and implementation of habitat treatments that benefit many species. As such, successful pygmy rabbit conservation will depend on the speed and efficiency with which land managers are armed with the knowledge to properly manage for the rabbits and their habitat. Anticipating these and other information needs, the UDWR, in conjunction with its partners, is funding several academic programs to address the impacts of treatments on pygmy rabbit populations. Currently both Brigham Young University and Utah State University have graduate students focusing on topics ranging from the development of a reliable population enumeration technique to assessing movement within various scales of vegetation treatments. Although Brigham Young University's program is described more fully under within their own annual report (Contact: Dr. Jerran Flinders; 801-422-2322), a brief description of Utah State University's project status follows below.

Pygmy rabbit research addressing occurrence, abundance, and movement are being investigated within the context of treatment effects by a PhD student at Utah State University (Tammy Wilson, tlw@leupold.gis.usu.edu). To investigate obtain these objectives, Tammy's work centers on the development of transferable, cost-effective monitoring techniques that will provide inferences at multiple scales and provide insight into the effectiveness of methodologies that, so far, have provided major challenges for pygmy rabbit researchers range-wide (trapping, marking, detection rates, determination of density). Tammy also plans to develop a habitat model to help predict rabbit occurrence and act as a baseline for future management scenarios. Tammy's study area focuses on the sagebrush-steppe of Rich County. Summer 2006 will be Tammy's first field season. UDWR personnel are on Tammy's graduate committee to help insure that the study's objectives address the needs of Rich County's CRM group and the Division.

With the higher intensity research objectives being addressed by the USU team in Rich County, the DWR has been concentrating mostly on increasing our knowledge of PYRA distribution and assessment and modification of shrub-steppe treatments to be as beneficial as possible for pygmy rabbits. Especially in the light of the lawsuit filed against the Department of the Interior in late March, it is imperative that we implement a protocol to track pygmy rabbit populations across the entire state as soon as possible. It is believed that current data sets, collected through the efforts of multiple DWR regions and agencies statewide, are adequate to implement such a protocol. The survey effort would be designed to 1) be conducted long-term, 2) detect trends in distribution, 3) provide response to treatment data, 4) provide ancillary data on historical treatment effects, and 5) provide separate trend data for pygmy rabbits based on land ownership. The UDWR is currently developing such a large-scale survey effort to employ occupancy modeling theory to refine current presence and absence data. Efforts will dovetail with current efforts in Rich County and be improved with data arising from USU and BYU's research. The protocol will be finalized by end of June 2006 and implementation will begin immediately. Efforts will continue to identify and work around occupied pygmy rabbit habitat that is scheduled to be treated.

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Figure 1: Historical distribution of pygmy rabbits digitized from Janson (1946) and overlaid with Utah Natural Heritage Program point location data (pre 2001).

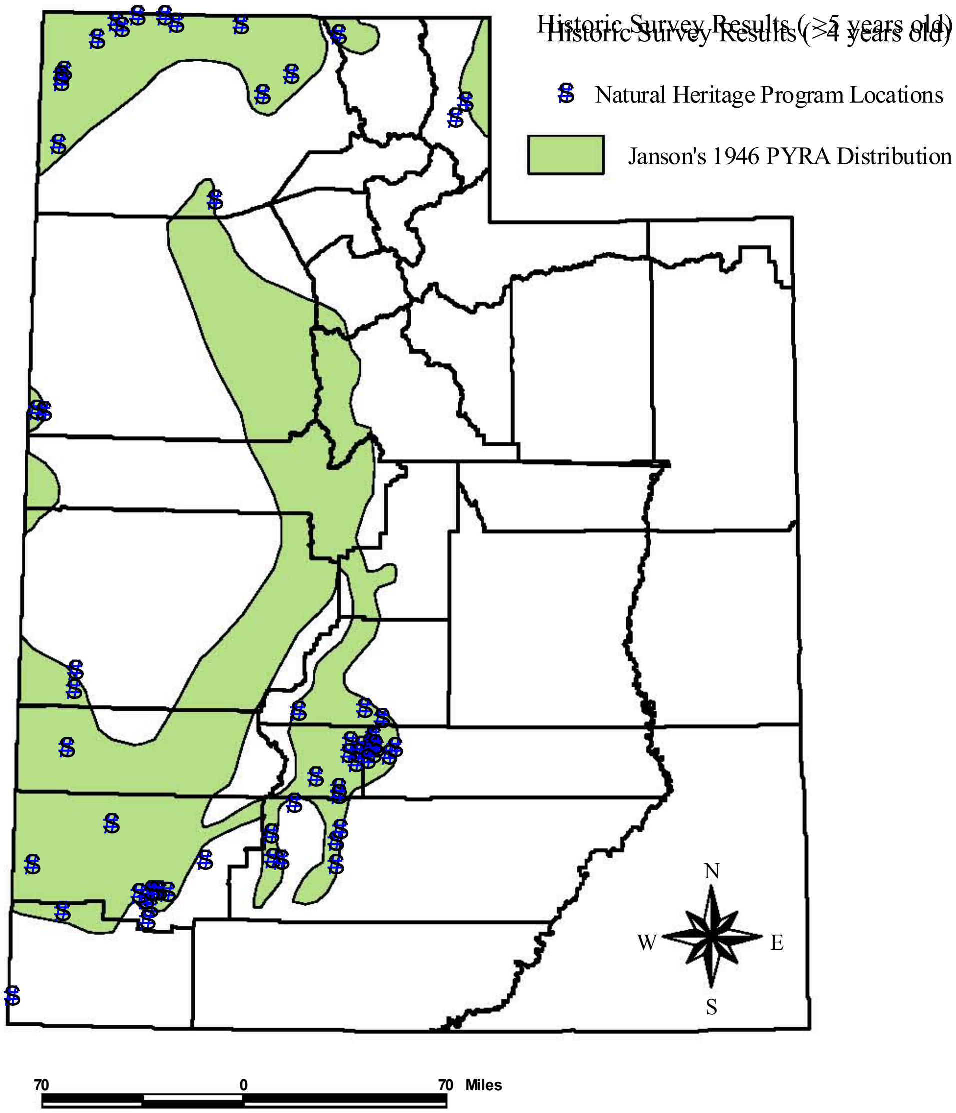


Figure 2: Current presence (green) or absence (red) of pygmy rabbits at locations listed as historical in the Natural Heritage Database. Sites where rabbits currently are marked absent only indicate the status of the site given its current survey effort. To date, increased effort has resulted in increased detections.

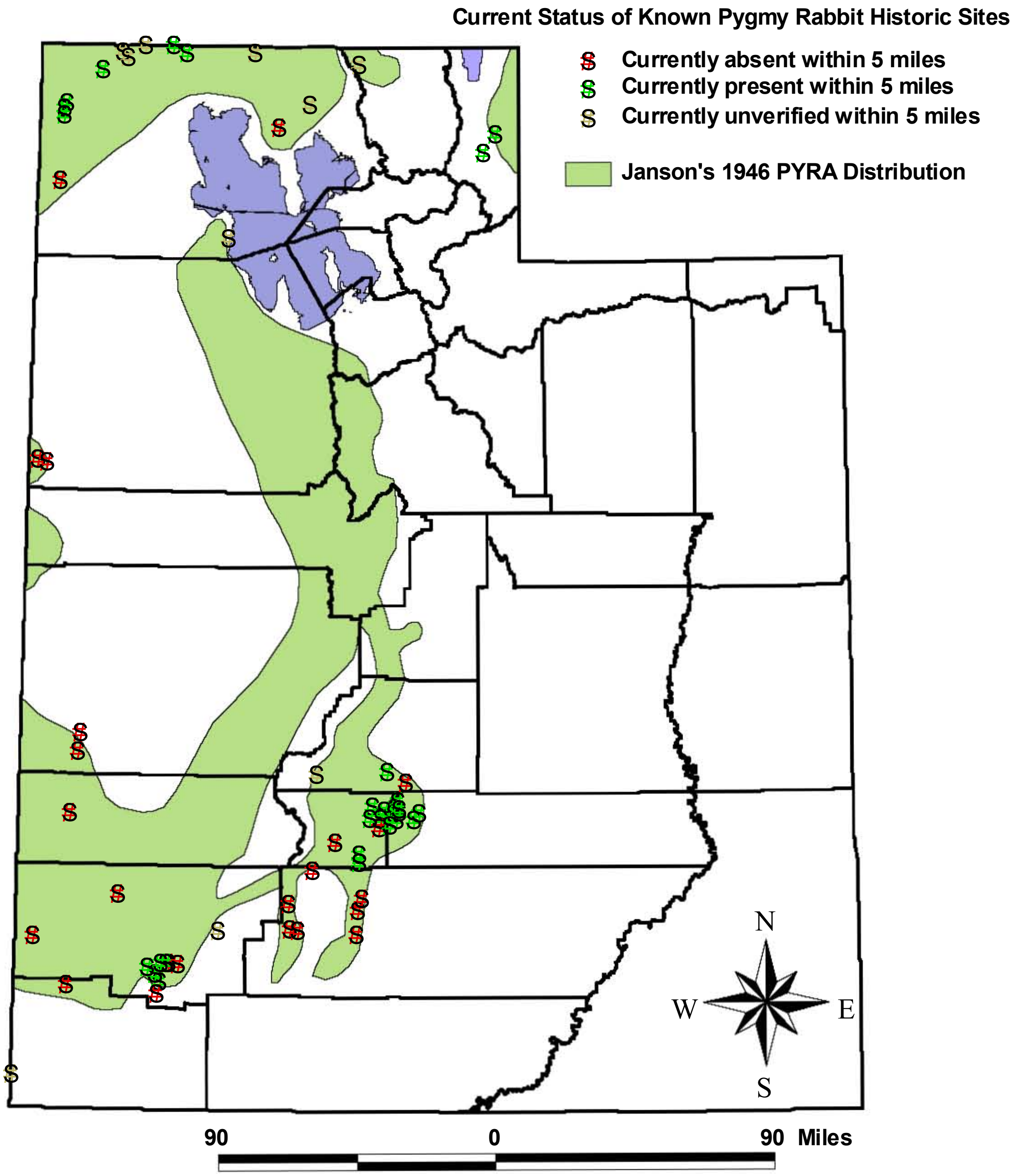
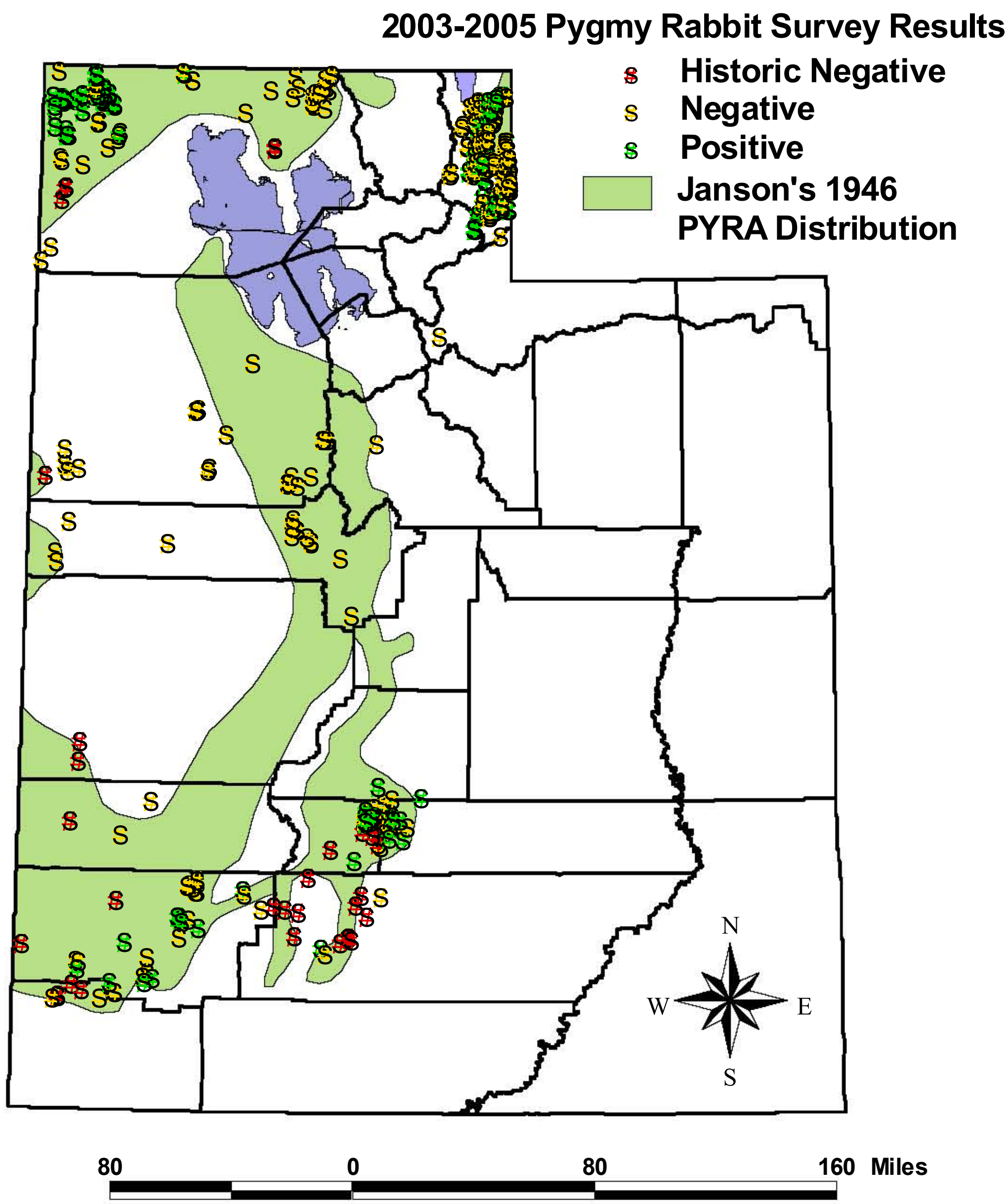


Figure 3: Current distribution map for pygmy rabbits derived from April 2003- January 2005 survey data. Survey sites labeled 'Positive' denote current detection of pygmy rabbits, 'Negative' denotes lack of historical or current evidence to support rabbits presence, and 'Historical Negative" denotes that although pygmy rabbits are currently absent, this site historically had rabbits within 5 miles of it.



Appendix A: Ecological Integrity Table for the pygmy rabbit (Brachylagus idahoensis)

Authored by: George Oliver, Natural Heritage Program Zoologist, Utah Division of Wildlife Resources, September 2005.

Funded by: Utah Division of Wildlife Resources (75%) and The Nature Conservancy (25%)

Category	Key Ecological Attribute	Indicator	Indicator Rating				Basis for Indicator Rating	Comments
			Poor	Fair	Good	Very Good		
size	population	density (individuals per ha)	<2	2–8	9–44	≥45	Janson (1946, 2002), Green (1978)	
condition	habitat	big sagebrush* (frequency)	<50% of woody plants	50–75% of woody plants	75–90% of woody plants	>90% of woody plants	Green (1978), Gahr (1993), Gabler (1997)	Ratings are estimates based on qualitative reports.
condition	habitat	mean shrub height*	<25 cm	25–56 cm	56–82 cm	>82 cm	Green (1978), Weiss and Verts (1984), Gahr (1993)	
condition	habitat	shrub cover*	<21%	21–36%	36–46%	>46%	Green and Flinders (1980), Gahr (1993), Gabler (1997)	
condition	habitat	mean sagebrush height*	<68 cm	68–91 cm	91–127 cm	>127 cm	Weiss and Verts (1984)	
condition	habitat	sagebrush cover*	<16%	16–25%	25–33%	>33%	Green and Flinders (1980), Weiss and Verts (1984)	
landscape	habitat	soil depth*	<36 cm	36–51 cm	51–60 cm	>60 cm	Weiss and Verts (1984)	
size	habitat	size of suitable habitat patches	<25 ha	25–50 ha	50–100 ha	>100 ha		Ratings are estimates based on home range sizes and population densities.

[1]Several authors have reported differences in soil composition (% sand versus % clay) between inhabited and uninhabited sites, but the research of others has either not strongly supported this observed difference (Weiss and Verts 1984) or contradicted it (Gabler 1997). Because soil composition (sand/clay) is a debatable and unreliable indicator, it is not included in this table.

*Most important indicators.

Literature Cited for Integrity Table

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UTAH ENDANGERED SPECIES MITIGATION FUND: 2006-2007 ANNUAL REPORT

ESMF PROJECT TRACKING NUMBER: 3205

PROJECT TITLE

OCCURRENCE, HABITAT USE, BEHAVIOR, AND POTENTIAL LIMITING FACTORS AFFECTING THE PYGMY RABBIT (*Brachylagus idahoensis*) IN UTAH

PROJECT CONTACT

Jerran T. Flinders, Professor, Wildlife and Wildlands Conservation, Brigham Young University, 275 WIDB, Provo, UT 84602, (801) 422-2322, jerran_flinders@byu.edu

PROJECT SUMMARY

Throughout the Great Basin and adjacent intermountain areas, the pygmy rabbit (*Brachylagus idahoensis*) has seen severe population declines (Janson 2002; Flinders 1999). These declines have primarily occurred due to anthropogenic disturbances (e.g. habitat fragmentation, increased fire frequency, overgrazing) currently impacting the sagebrush-steppe habitat type and the limited knowledge available to properly manage this specialized lagomorph (Heady and Laundre 2005). Although the status of pygmy rabbits varies throughout its range from locally common in parts of Idaho to Endangered in Washington, its overall distribution is much reduced from historic levels. Indeed, evidence from our surveys in Utah over the past three years supports the idea of severely reduced habitat and distribution of the pygmy rabbit.

Our work involves identification and then measurement of potential limiting factors that are, or could, impact pygmy rabbits. Much work remains to be done in this regard before we can help prescribe treatment patterns in big sagebrush that will also benefit pygmy rabbits. Important data are summarized in this report, but should still be considered preliminary since this report covers the third year of a projected four to eight year project.

PROJECT ACCOMPLISHMENTS

Field surveys were completed between July 1, 2006 and June 30, 2007 in historic areas as well as new locations in Sevier, Piute, Wayne, Tooele, Juab, Garfield, Iron, Millard, and Beaver counties. To guide search efforts, our approach has involved completion of a predictive map depicting suitable pygmy rabbit habitat within Utah. The predictive map (Appendix I) is based on two primary layers depicting vegetation and soils. We have used slope as a surrogate for soils to complete the larger scale map given vagaries associated with the Natural Resource Conservation Services' (NRCS) electronic soils data. Slope has been used by others with some success in similar mapping efforts (e.g. Gabler et al. 2000, 2001). Vegetation data were obtained from the 2004 Southwestern Regional Gap Analysis Project—a recently completed remote sensing of several southwestern states that categorizes vegetation type into one of more than 120 detailed categories (Lowry et al. 2005).

Previous efforts in other states fault inaccuracies in the vegetation layer as a big reason that large-scale GIS mapping has only had marginal success. Our preliminary results suggest that the 2004 Southwestern Regional Gap analysis may be more accurate than other available layers as few burrows have been found outside of classified sagebrush habitat (Table 1.).

Table 1. Pygmy rabbit burrows in association with 2004 SWregional GAP habitat type

GAP ID #	GAP Habitat Type Description	No. Burrows	Percentage
36	Colorado Plateau Pinyon Juniper Woodland	4	0.01
37	Great Basin Pinyon Juniper Woodland	9	0.02
41	Rocky Mountain Gambel Oak Mixed Montane Shrubland	1	0.00
48	Inter Mountain Basins Big Sagebrush Shrubland	319	0.60
50	Colorado Plateau Mixed Low Sagebrush Shrubland	20	0.04
62	Inter Mountain Basins Montane Sagebrush Steppe	174	0.33
111	Developed, Open Space Low-Intensity	1	0.00
114	Agriculture	3	0.01

During the reporting period, we have spent hundreds of hours actively searching 37 new and historic areas for evidence of pygmy rabbit presence. Eleven (29.7%) of these areas show evidence of current pygmy rabbit activity while four (10.8%) had signs of dated activity (Table 2 and Table 3). A total of 456 burrow complexes were found, 193 (42.3%) of which had current or recent pygmy rabbit activity.

Table 2. Newly discovered areas found during reporting period with evidence of current pygmy rabbit activity.

Location	County	NAD	Zone	UTM	
Off Highway 24, Parker Mountain	Wayne	83	12	433616	4254849
Road to Silas Springs, North Mountain	Wayne	83	12	445373	4263293
Cedarless Flat, North Mountain	Wayne	83	12	449334	4261383
Southeast of Greenwich	Piute	83	12	419617	4247486
Hillside east of Greenwich	Piute	83	12	422566	4252993
Northwest of Angle	Piute	83	12	413111	4236403
Peterson Loop (ATV trail) 7.5km E of Panguitch	Garfield	83	12	381033	4188568
Peterson's Wash, 9.2 km from Panguitch	Garfield	83	12	382396	4188691
Hamlin Valley Road, Southeast of the Nevada State Line	Beaver	83	11	760883	4244593
Highway 130, South of Minersville	Iron	83	12	325013	4212256
Southeast of Modena, off Highway 56 (Mile 11)	Iron	83	12	244822	4184830

Table 3. Areas found during reporting period with sign of dated pygmy rabbit activity.

Location	County	NAD	Zone	UTM	
Gold Gulch, near Junction	Piute	83	12	392715	4247631
Dry Creek Road, Northeast of Piute Reservoir	Piute	83	12	402582	4246715
Elkwell, off Pine Valley Road	Iron	83	12	269257	4225922
Northwest of Enterprise	Washington	83	12	259733	4168202

Of particular interest this reporting period is discovery of fairly extensive populations of pygmy rabbits in the Hamlin Valley located on the Utah-Nevada border in Iron and Beaver County. This area was identified as a potentially large area of sagebrush from the predictive map. Numerous burrow complexes with current or recent activity have been found in this area. This area may provide a critical habitat corridor between Utah and Nevada populations as evidence of use has been found for several miles on both sides of the border. Further research will be carried out in these areas to examine the extent of connectivity between this population and other identified pygmy rabbit populations.

We have also completed extensive walk transects in the Grass Valley area (Piute, Sevier, and Wayne Counties). In this area alone, we found 197 pygmy rabbit burrow complexes this past fiscal year. To date, this population is the most robust we have studied in Utah. We anticipate use of this population as a source for translocation efforts to begin early in fiscal year 2007-2008.

Additional accomplishments include collection and analysis of habitat data from a use compared to non-use framework, thousands of hours of photographic sampling designed to evaluate burrow activity ranking schemes, and estimates of habitat use in relation to mechanical treatment/manipulation. Occupied habitat, for example, was found to have taller shrubs, a greater composition of sagebrush, higher shrub density, and shrubs exhibiting lower levels of decadence than unoccupied areas. Horizontal obscurity values (a measure of thickness and cover) were higher for occupied sites compared to unoccupied habitat for all readings. Values diverged and the distance between values for occupied versus unoccupied habitat increased from low to high readings indicative of a more developed shrub structure at occupied sites compared to unoccupied sites.

Most recently, we have begun the process of establishing baseline information relative to pygmy rabbits for Snake Valley. The approach here has been the same and involves detailed searching of areas highlighted by the predictive map.

RECOMMENDATIONS

Big sagebrush is critical to pygmy rabbits for both cover and food. Pygmy rabbits consume up to 51% sagebrush during spring and summer months and up to 99% during winter (Green & Flinders 1980). Perturbations in these areas that reduce the height, density, or cover of sagebrush are likely to negatively affect pygmy rabbits. We caution against traditional habitat treatment aimed at reduction of sagebrush cover (e.g. dixie harrow, burning, application of herbicide, etc.) in areas where pygmy rabbit burrows are found.

Results from Grass Valley show the potential for reduction of suitable habitat due to treatment. Fecal pellet plots were placed inside mature stands of big sagebrush and adjacent areas where stands had been removed via treatment with a Dixie harrow. The results (Table 4) show pygmy rabbit activity restricted to a narrow band adjacent to mature stands of big sagebrush and significantly decreased use within the treated areas. In addition, we have noted burrow abandonment following treatment and suggest at least a 40 meter buffer between active burrows and habitat treatment.

Table 4. Shown here is a comparison of average (n=89) fecal pellet counts in relation to distance from treatment edge.

	Mature Big Sagebrush	10m within treatment	20m within treatment
Pygmy Rabbit	13.7	5.7	2.2
Black-tailed Jackrabbit	3.4	10.8	11.9
Cottontail	3.1	11.7	9.8

*Pygmy rabbit fecal pellet counts were significantly higher ($P < 0.001$) in untreated areas.

We further suggest walking proposed treatment areas prior to habitat manipulation and planning treatments with pygmy rabbits in mind. Habitat treatments should be designed in a mosaic fashion. Future mosaic treatments within pygmy rabbit habitat should include preservation of long and wide swaths of undisturbed mature big sagebrush with corridors of connectivity between all residual stands.

We stress continued efforts to understand pygmy rabbit natural history and ecology within Utah. Little is known about population connectivity as well as complete pygmy rabbit distribution. Further evaluation of population trends, movement patterns, and survivorship would also aid in the management of this sensitive species.

BUDGET STATUS

Funds Provided: $60,000.00
Funds Expended: $60,000.00
Remaining Balance: $0.00

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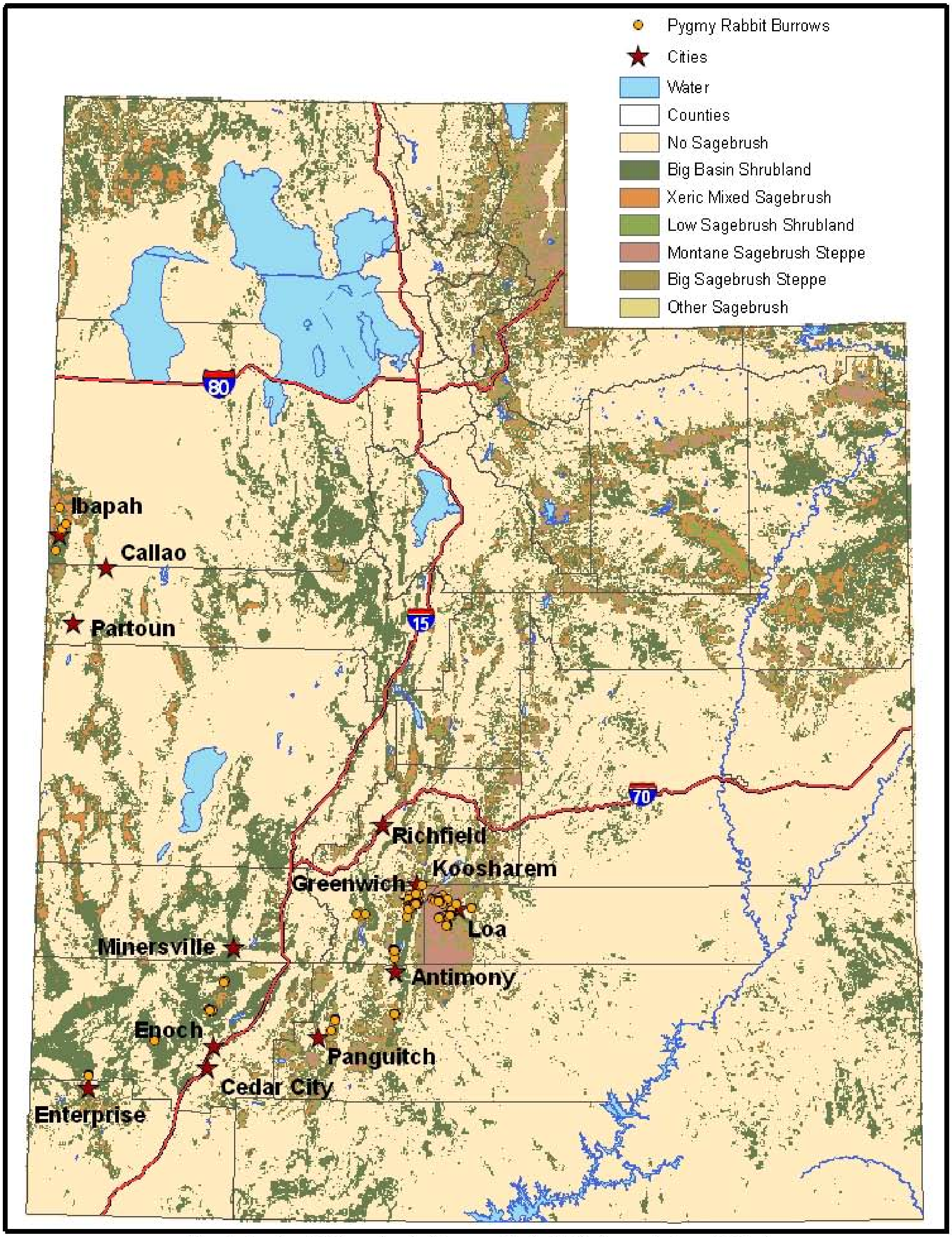
APPENDIX I.

Our documentation of pygmy rabbit (Brachylagus idahoensis) distribution in Utah



Created by Janet E. Lee, Randy T. Larsen, Daniel F. Bentley and Jerran T. Flinders

Note: This map does not include pygmy rabbit locations in northern Utah or recent discoveries from earlier this summer such as the population in Hamlin Valley.