Habitat Associations of Preble's Meadow Jumping Mice in Wyoming:

A GIS Model and Descriptive Analysis

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Summary

The purpose of this study was two fold: to develop a generalized, predictive habitat model for Preble's meadow jumping mice (*Zapus hudsonius preblei*) in southeastern Wyoming and to provide an initial, descriptive analysis of the habitats in which *Z. h. preblei* have been found in this area. The model applied classification-tree analysis of known present and absent locations in a GIS setting to identify what site-specific environmental criteria are useful in predicting Preble's distribution and used those predictors to produce a potential habitat map (e.g., Fertig and Reiners, In press). The limited location data for *Z. h. preblei* and a lack of relevant riparian data at a sufficiently large scale hampered the development of such a model, but several interesting issues where still raised by the modeling effort. The model showed much potential *Z. h. preblei* habitat in southeastern Wyoming, with much heretofore over-looked land in the Laramie Basin and very little in far eastern Wyoming. Both of these results are supported by anecdotal data collected by jumping mouse researchers.

To quantitatively describe the characteristics of *Z. h. preblei* habitat, we returned to 17 locations where they have been captured and where location data where sufficiently accurate to precisely locate the point of capture. Given that very few specific and significant habitat associations have been identified for *Z. h. preblei* and studies attempting to do so have been based largely on data from Colorado, we have herein attempted to describe the range of habitats in which mice likely occur in Wyoming for use as a rough comparison to those in Colorado. Based on this effort, it appears that *Z. h. preblei* use a wide variety of riparian habitat in this portion of their range, and although dense shrubs seemed to be preferred, there was little evidence of clear habitat requirements. Since this is not a formal habitat preference analysis, as we have no quantified availability data, investigation of use versus the available habitat in Wyoming is a logical direction for future study.

Introduction

There are four species of jumping mice that are distributed through much of temperate North America (Figure 1) and two of these species are found in Wyoming: the western jumping mouse (*Zapus princeps*) and the meadow jumping mouse (*Z. hudsonius*; Figure 2). The Preble's meadow jumping mouse is a subspecies found in Wyoming and Colorado that was listed as threatened under the Endangered Species Act in May of 1998 (USFWS, 1998). Its range extends roughly from Colorado Srpings, Colorado along the foothills of the Rocky Mountains to the northern limits of the Laramie Range Mountains south of Douglas, Wyoming (Schorr, 2001).

Until recently, distinction between *Zapus* in the central Rocky Mountains has been based largely on assumed geographic and elevation differences. *Z. h. campestris* occurs in the Black Hills of northern Wyoming, whereas jumping mice found in the eastern foothills of the Front Range at elevations less than roughly 7,400 ft were assumed *Z. h. preblei* and those found at higher elevations were assumed *Z. princeps* (Schorr, 2001). Analysis shows that occurrences of *Zapus* species within the suspected range of Preble's seem to be less than roughly 7,800 ft (Pague, 2000), but they have also been documented at over 8,000 feet in the Laramie Mountains of Wyoming (WYNDD, Unpublished data). The geographic and elevation boundaries separating these taxa are becoming less certain. There is likely distributional overlap with potentially extensive hybrid zones, particularly between *Z. h. preblei* and *Z. princeps* (Figure 2). Attempts to genetically differentiate Preble's meadow jumping mice from western jumping mice have been largely unsuccessful and extensive morphological comparisons are now underway to help clarify the issue (Mary Jennings, USFWS, personal communication). The morphological analysis, although still in progress, seems effective in differentiating between adult *Z. princeps* and adult *Z. h. preblei* from the Colorado Front Range, but an insufficient sample size from Wyoming makes the application of this method to Wyoming populations uncertain (Mary Jennings, USFWS, personal communication). In any case, since this method is based on detailed skull measurements, it is not applicable to identification of live jumping mice in the field, and its primary value will be to more precisely estimate the geographic extent of species and sub-species based on collections of specimens. Some further method of range delineation may therefore be necessary.

As with taxonomic investigations, nearly all studies investigating the habitat associations of *Z. h. preblei* have been conducted in the Colorado Front Range. It is not clear whether these data can be reliably applied to jumping mice occurring in Wyoming. The mountains of southeast Wyoming are the northern-most extent of *Z. h. preblei* range and they have a more gradual foothills transition zone and a lower peak elevation than typical habitats investigated in Colorado. In fact jumping mice occur throughout the Laramie Range and into the Laramie Basin (WYNDD, Uunpublished data) with no clear break that suggests habitat limitations. Among other things, this results in a potentially large zone of sympatry between *Z. h. preblei* and *Z. princeps*, the extent of which is largely unknown. Further, the human demography of Wyoming is much different than in Colorado, so the associated threats are also different. There is less urban pressure and perhaps more grazing pressure on riparian corridors in Wyoming.

Past studies and recent experiences in Colorado suggest that *Z. h. preblei* occur in dense, brushy riparian ecosystems along foothills and prairies (Schorr, 2001; Tonya Shenk, Colorado Division of Wildlife, personal communication), although habitat of the species as a whole may be more varied (e.g., Whitaker, 1972; Quimby, 1951).

The running hypothesis of what constitutes good *Z. h. preblei* habitat includes an extensive canopy of shrubs combined with a dense herbaceous under story. However, several recent studies found no clear habitat associations when investigating miocrosite and larger scale vegetation parameters at *Z. h. preblei* capture versus non-capture localities (Armstrong et al., 1997; Bakeman and Deans, 1997; Meaney et al., 1997; Shenk and Eussen, 1998). In some cases, seems to be a weak positive correlation with density of shrubs (Schorr, 2001; Ryon, 1997), and perhaps a negative correlation with tree cover (Schorr, 2001). The shrub layer is often comprised of willows (*Salix* spp.). Neither the species composition of the shrub nor the herbaceous layers appears to be critical to *Z. h. preblei* habitation, although there is some evidence that the mice favor sites with a high diversity of plant species (Meaney et al., 1997; Norm Clippenger, University of Colorado, personal communication).

A detailed understanding of an animals range and habitat use is critical to designing proper management strategies. However, like many other rare species, we do not have adequate knowledge of *Z. h. preblei* distribution on either a fine (e.g., individual stream) or large (e.g., watershed or county) scale. What knowledge has been gained from localized studies (USFWS and CDOW, 1997; Keinath, 2001; Taylor, 1999), regulatory surveys (e.g., Grant, 1999), and anecdotal information is confounded by the fact that rare species might be absent from otherwise suitable sites do limited stochastic events resulting in chance mortality or non-uniform dispersal and colonization (Wiser et al., 1998). It is therefore valuable to know as accurately as possible where a species of concern might occur based on existing knowledge of the species' natural history, presence-absence data, and the spatial distribution of available habitat. These pieces of information can be combined to from a model of the species realized niche, or where it is likely to occur given optimal environmental conditions (Fertig and Reiners, In press). To this end, we characterized the habitat at known present locations in southeast Wyoming and investigated the utility of applying classification-tree analysis to develop a predictive model of *Z. h. preblei* distribution in the same area (Fertig and Reinger, in press; Breiman et al., 1984).

Methods

Statewide Habitat Modeling

First, we collected known present and absent points for *Z. h. preblei* from the Biological and Conservation Data System (BCD) maintained by WYNDD. Present points were defined as locations where jumping mice have been documented in the last 10 years, either by small mammal trapping efforts, cataloged voucher specimens, and/or positive sightings identified by biologists trained in small mammal identification. Absent points were defined as those stream segments where official surveys for jumping mice were conducted in the last 10 years as per established guidelines (latest guidelines presented in USFWS, 1999), but where those survey efforts resulted in no evidence of jumping mice. Further, to be classified as an absent point, a stream segment needed to be more than 1 mile from a known present point and on a different stream, otherwise it was discarded. This resulted in 32 known present points and 15 known absent points.

Second, we compiled a suite off habitat variables that, alone or in combination with other variables, might serve as predictors of jumping mouse presence (Table 1). Since our motive was a predictive model and we did not have the resources to generate habitat classification maps over an area as large as southeast Wyoming, we were limited to those variables that were currently available in a statewide GIS format. These were largely obtained through the Wyoming Geographic Information Science Center (WGIC) of the University of Wyoming.

Third, each present and absent point was assigned a value for each of the habitat variables by intersecting its location with the geographically referenced variable coverages. Once values were assigned to each point, a classification-tree analysis was performed with the presence/absence of jumping mice at each point as the dependent (predicted) variable and the habitat values as the independent (predictor) variables (S-plus, version 1.1). This classification-tree analysis begins by splitting the data points into two groups using the predictor variable that explains the largest portion of the overall sample variability. It then splits each of the two resultant groups using the variable that explains the largest portion of the variability within that group and continues in this fashion until certain minimum splitting criteria are reached (see Breiman et al., 1984), resulting in a hierarchical classification tree with the most important predictor variables represented by early branches and increasingly less significant variables accounting for lower-level branches (e.g., Figure 4). From this tree and its associated quantitative values, we can predict weather we would expect jumping mice to be present or absent from any stream for which we have estimates of the habitat variables used in the model. We determined the accuracy of the model by calculating errors of omission (i.e., known present points that were predicted to be absent points) and commission (i.e., known absent points that were predicted to be present points).

Vegetation Surveys

Our vegetation surveys were designed to get a quick snapshot of the habitat along streams where *Z. h. preblei* have been captured with a minimal expenditure of time. We were mainly interested in differences in vegetative structure in the vicinity of each capture point, rather than a detailed account of fine-scale variation and plant species present.

To determine the relative composition of habitat along the stream and the average width of the riparian corridor we recorded vegetation characteristics along two 400 m transects; one on either side if the stream centered on the point of capture. The transects were approximately 10 meters from the stream at all times. Stops were made every 10 meters along each transect, at which points we recorded the vegetation structure and taxonomic type and estimated the width of the riparian corridor on the near side of the stream. The vegetation structure and taxonomic classification were estimated within a two-meter diameter circle centered on each point (see Table 2 for a list of types). The dominant type was the tallest type that comprised the largest portion of the area as viewed from above. For example, a plot that consisted of 40% cover of cottonwoods, 40% cover of willows, and 20% cover of herbaceous vegertation would be recorded as Forest/Cottonwood, where forest is the structural type and cottonwood is the taxonomic type within that structure. Since it was possible for structural types to overlap, the tallest vegetation component was recorded as the dominant type. For instance, a plot might be 100% covered by cottonwoods and still have a nearly complete under story canopy cover of willows. In such cases, the tallest vegetation component was recorded as the dominant type.

We estimated the width of the riparian corridor to the nearest meter. This was initially done using a 100 m tape measure. Once field technicians became proficient at visually estimating distances, we discontinued regular use of the tape measure and relied solely on visual approximation. The riparian corridor was generally defined as the distance from the stream's edge to the point where vegetation shifts from predominantly moist-soil plants (e.g., cottonwoods, willows, rushes, cattails, tall-grasses) to the more xeric upland types (e.g., conifer, aspen, sagebrush, short-grass prairie).

To gain an idea of the nature of upland vegetation in the vicinity of streams with known *Z. h. preblei* captures, we mapped the habitat by using digital ortho quads to define polygons of relatively homogeneous vegetation and then labeled these polygons with their dominant structural and taxonomic vegetation types based on field reconnaissance. Polygons were delineated such that greater than 60% of the area of the polygon contained one structural/taxonomic type that was distributed roughly evenly across the entire polygon. Where this criterion was not met, polygons were subdivided until each resulting polygon was dominated by one cover type. When there was a clear secondary cover type, this was also noted. The minimum polygon size was about 1 ha.

Habitat mapping was done within a "capture zone" for each site that extended roughly 200 m upstream and 200 m down stream of the capture point, and 200 m from the stream's edge on both sides of the stream. Depending on the tortuosity of the stream, this represented about 12 - 16 ha centered on the point of capture. This range was chosen to capture the variety of habitats a jumping mouse might encounter during normal movement periods. Jumping mice have been documented in a wide variety of streams, but research results have not been clear on how the width and vegetative structure of the riparian corridor affects the distance that *Z. h. preblei* will travel from the stream or the amount of time spent in upland habitats. *Z. h. preblei* movement distances can be great (e.g., over 1,600 m; Schenk and Sivert, 1998), but long distance movements generally occur along riparian corridors and are not necessarily typical. Home ranges based on radio telemetry have been reported from about 0.5 ha to over 2 ha (Schorr, 2001; Harrington et al., 1996). Average distances radio collared jumping mice moved from streams have been reported as approximately 35 ± 27.3 meters with a maximum distance on the order of 150 meters (Schorr, 2001; Schenk and Sivert, 1998). Distances from stream not withstanding, it is not clear how extensively or for what purposes jumping mice use upland habitat, so a conservatively large area was selected. An example of a completed habitat map is given in Appendix 1.

Results

Habitat Modeling

The classification tree and its associated predicted available habitat map are presented in Figures 4 and 5 respectively. The shaded portions of the map represent areas that have been deemed to have suitable environmental variables for *Z. h. preblei* occurrence. They include upland habitats, even though the actual areas suitable for jumping mice are likely those portions of the shaded polygons within about 200 meters of streams. Entire polygons were presented in order to better see the extent of distribution of potential habitat. Two important points to draw from the map are: 1) there is much suitable land predicted in the Laramie Basin and the Snowy Range Mountains, and 2) there is very little suitable habitat predicted in Goshen, Niobrara, and eastern Laramie counties.

As can be seen from the tree, the most important predictor variable was elevation, with most positive paths (85% of the known present points) being more than 1872 meters above sea level. Further, most positive paths (79.4% of the known present points) had upland landcover of forest or shrub-dominated riparian vegetation, lodgepole pine, and/or mixed grass prairie combined with a mean January precipitation of more than 11 milimeters (i.e., moderate snow cover). A small number of present locations above 1872 meters (5.6% of the known present points) where grouped based on the presence of human disturbances, ponderosa pine and/or xeric upland shrubs and had a mean April precipitation of less than 4.5 centimeters. Finally, a relatively small number of positive paths (8.2% of all present points) had elevations less than 1872 meters, and in these cases two other conditions were also present: a mean April temperature of greater than

43^{o}F (i.e., a warm spring) combined with an upland landcover of shrub-dominated riparian vegetation, ponderosa pine, and/or Wyoming big sagebrush.

Vegetation Surveys

The width of riparian corridors on which *Z. h. preblei* have been captured was quite variable. The average width of the riparian corridors sampled, excluding the actual stream width, was 19.2 meters with a 95% confidence interval of 10.4 meters – 30.0 meters. However, the distribution was heavily skewed, with a large number of narrow riparian areas offset by a few larger ones (Figure 3). Thus the median value was somewhat narrower (13.38 meters) and the values ranged from 5.2 meters to 96.7 meters.

The near stream habitat was also fairly variable, but still showed some marked trends (Table 2). As expected based on previous studies, on average, shrubs represented the largest component of this vegetation, comprising 42% ± 10% (95% confidence interval) of the vegetation along the near stream-transects. Where shrubs were dominant, they were often fairly tall, since 88% was over one meter. 77% of shrubs were willows and the remaining 23% was a mix of other groups including junipers, sage, and bitterbrush, none of which comprised more than 10% of the transects. Herbaceous and forested areas represented slightly smaller proportions of the transects (32% and 22% respectively), and there was very little unvegetated area (~4%). The range of these values was fairly broad, and there were sites at which there was no forest, shrub or open cover. Only herbaceous vegetation was represented on all transects, with a minimum recorded value of 6%.

The upland vegetation types at each capture location are summarized in Table 3. There was no clearly dominant structural type, since on average all types were represented at comparable levels. However, when compared to each other, the composition of individual streams varied quite a bit, as shown by the broad ranges of values. In addition to being variable, the inter-site distribution of forest and open habitats was somewhat skewed, as demonstrated by the difference between the mean and median values. This occurred because, although forest and open habitats did not usually constitute a disproportionately large fraction of the upland vegetation, there were a few sites that where predominantly forested or open. When considering each upland structural type separately, some trends emerged. Much of the forest along *Z. h. preblei* streams was ponderosa pine, which accounted for 41% of all forested area surveyed. The rest of the forested area was a mixture of cottonwoods (21%), other conifers (17%; e.g., limber pine, lodgepole, Engelmann spruce, subalpine fir), and mixed deciduous conifer (19%; usually cottonwood and aspen with lodgepole pine). Shrubs were predominantly willow (43%) and big sagebrush (43%), with all other types combined comprising only 14% of the shrub-dominated area. Most sites had substantial tracts of herbaceous vegetation, all of which were dominated by grasses or grasses mixed with other, less abundant forbs.

Discussion

Habitat Modeling

The large areas of potential jumping mouse habitat in southeast Wyoming challenges the notion that most Preble's meadow jumping mouse habitat lies in Colorado. Moreover, it is important to note that, based on this model: 1) there is much suitable land predicted in the Laramie Basin and the Snowy Range Mountains; and 2) there is little or no suitable habitat predicted in Goshen, Niobrara, and eastern Laramie counties.

it is intriguing that such a broad extent of suitable habitat was predicted within the Laramie Basin and Snowy Range Mountains. This prediction is supported by anecdotal evidence suggesting that jumping mice occur in the Laramie Basin and in the Laramie Range Mountains (WYNDD, Unpublished data). The Laramie Basin has, in the past, served to operationally separate populations of western jumping mice (*Z. princeps*) in higher elevation areas of the Rocky Mountains from Preble's meadow jumping mice (*Z. h. preblei*) in the foothills regions of the Front Range, so the occurrence of jumping mice throughout this area would pose challenging taxonomic and regulatory questions. Such a situation would suggest potentially large areas of sympatry (and potential hybridization) between *Z. princeps* and *Z. h. preblei* and may greatly complicate management of the Preble's subspecies.

Second, little or no suitable habitat was predicted to occur in the eastern-most Wyoming counties, suggesting that the eastern edge of the *Z. h. preblei* range in Wyoming is better defined than is the western edge. In fact, areas such as F. E. Warren AFB in Cheyenne, Wyoming seem to fall outside the predicted range, suggesting that such areas may be more distributionally marginal that previously thought. This pattern indicates a relatively distinct break between the ranges of *Z. h. preblei* and *Z. h.pallidus,* which occurs in the Great Plains states. However, the possibility of suitable *Z. h. preblei* habitat north of Douglas suggests another potential intergrade zone, this time between *Z. h. preblei* in the south and *Z. h. campestris* in the Black Hills (see Figure 2).

Given such interesting results, it must be stressed that there are strong caveats to the application and interpretation of this habitat model. Given the lace of good riparian corridor information in the state, riparian obligate species are notoriously difficult to model at a scale much beyond small watersheds. Accurate, statewide (or even watershed wide) data on riparian corridor hydrology and vegetation characteristics does not exist for Wyoming, so we were limited to only those variables for which such broad data was available. In most cases these variables (Table 1) are fairly coarse scale (e.g., precipitation and temperature) or have only indirect relevance to riparian characteristics (e.g., upland vegetation). Also the model is based on relatively few known present points and even fewer known absent points. Although all the results discussed in this report held true for all model runs, with so few points there is evidence of many small-scale changes in the predicted range when points are added to or removed from the model set.

Therefore, any given location within the range of suitable habitat predicted by the model may or may not contain jumping mice, but broad-scale patterns that hold true over several replicated model runs can be more confidently discussed. The model can be a useful tool to identify potential large-scale patterns in jumping mouse distribution and help guide future survey efforts, but should not be used to set management actions or conclude presence/absence in any given area.

Vegetation Surveys

Streams investigated in this study were often rather small, with riparian corridor widths typically less than 20 m, and often less than 10 m. In descriptively analyzing our preliminary vegetation structure data, we have found nothing to cast doubt on the current definition of high quality *Z. h. preblei* habitat. As previously thought, vegetation near the stream is likely more important than upland vegetation in the vicinity of the stream, as evidenced by the relatively low variability in near stream vegetation. Abundant shrub cover, especially willows, and an absence of sparsely vegetated stream-sides were typical, although not definitive, of the stream segments that we surveyed. In other words, *Z. h. preblei* preferred dense, shrubby riparian corridors, but wide variation in the data suggested that, at least with respect to Wyoming sites, *Z. h. preblei* habitat use was highly variable and there was little evidence of a "required" habitat component when one considers coarse metrics of vegetation structure, as we have done.

There may also be an environmental or temporal component that we did not accurately capture. Nearly all captures studied in this report were from recent captures in 1998 and 1999, both of which were seemingly high abundance years. Trapping also occurred in 2000, but virtually no jumping mice where captured, giving us a fair number of the absent points used for the above habitat model. Based on such limited information, it seems that in years with high *Z. h. preblei* abundance, the mice prefer the classic dense shrubby habitat, but they can also be found in habitats with little or no shrub cover. It is possible that in years with low jumping mouse abundance (e.g., draught years like 2000 and 2001), their distribution could be restricted to those sites that are closer to our current idea of optimal. Regardless, habitat structure alone cannot be used to include or exclude sites from *Z. h. preblei* range. Rather, given the high variability in habitat use, it seems prudent that decisions on any give stream not be made without trapping efforts designed to confirm presence of jumping mice, which is largely similar to the policy now practiced by the U.S. Fish and Wildlife Service.

As with the habitat model, interpretation of data collected for this report should be viewed with caution. There are relatively few confirmed locations of Preble's meadow jumping mice in the state and much of our information comes from only two sources (the U.S. Forest Service, Medicine Bow National Forest, Laramie Ranger District and True Ranches). Much of the other potentially suitable habitat in the state is located on private lands where landowners are not willing to support data collection efforts. Thus, due to time constraints, budget, and landowner access issues, our sampling was limited to points on public land or where large landowners gave permission, which makes our sample size relatively small and not randomly selected across the suspected range of *Z. h. preble*i habitat in Wyoming. If a wider variety of streams were sampled, new patterns might emerge or those evidenced herein might be mitigated. Useful comparisons for future efforts might include comparisons to streams on which *Z. h. preblei* were collected only in low abundance years and/or comparisons to available habitat data collected on a random set of sites throughout southeast Wyoming.

Recommendations for Future Study

A survey effort directed toward the Laramie Basin and foothill streams on the western slopes of the Laramie Range Mountains and the eastern slopes of the Snowy Range Mountains would help clarify the western limit of *Z. h. preblei* range in Wyoming and the extent to which overlap may occur with the range of *Z. princeps*. The limited collection of voucher specimens in this area for inclusion in ongoing genetic and morphological analyses will determine if tests applied to differentiate these two species in Colorado can realistically be applied to populations of jumping mice in Wyoming, where the potential range of sympatry is quite broad, as suggested by our habitat model and anecdotal evidence collected by WYNDD biologists.

The greatest opportunity for improving the *Z. h. preblei* habitat model discussed in this report is by refining information on riparian corridors in southeast Wyoming. The best vegetation information we have is from the Wyoming Gap Analysis Program (WYGAP), which was used to develop this model. WYGAP includes riparian vegetation classifications, but the scale of this information is so coarse that most moderate to small riparian zones are completely overlooked. Geographic information specialists at the University of Wyoming, including WYNDD staff, are investigating the potential for refinement of WYGAP's vegetation classification, but results from such an effort will likely not be realized for several years.

A useful supplement to our initial vegetation surveys of Wyoming *Z. h. preblei* capture points would include comparison of values at known present locations to streams on which *Z. h. preblei* were collected only in low abundance years and/or comparisons to available habitat data collected on a random set of sites throughout southeast Wyoming. Such analyses will shed light on the extent to which the mice switch their habitat use based on prevailing environmental conditions and determine if they are actually selecting in favor of certain types of streams in excess of what we would expect based on the availability of those streams.

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Tables and Figures

Table 1: Structural and Taxonomic Vegetation Types

<table>
<tr><th>Structural Type*</th><th>Taxonomic Type</th></tr>
<tr><td>Forest Dominated (F)
Vegetation consists of single-stemmed woody plants over 3 m (10 ft) tall.</td><td>Cottonwood (CW)
Aspen (ASP)
Russian Olive (RO)
Juniper (Jun)
Ponderosa Pine (PP)
Limber Pine (Lim)
Lodgepole Pine (LPP)
Other Conifer (Con)
Other Deciduous (Dec)</td></tr>
<tr><td>Tall Shrub (TS)
Vegetation consists of woody plants less than 3 m (10 ft) tall but greater than 1 m (3 ft) tall, often with multiple stems.</td><td rowspan="2">Willows (Wil)
Sagebrush (Sage)
Juniper (Jun)
Alder (Ald)
Greasewood (GW)
Mountain Mahogany (MM)
Bitter Brush (BB)
Skunk Bush (SB)
Other Evergreen (Ev)
Other Deceduous (Dec)</td></tr>
<tr><td>Short Shrub (SS)
Vegetation consists of woody plants less than 1 m (3 ft) tall, usually having multiple stems.</td></tr>
<tr><td>Tall Herbaceous (TH)
Vegetation consists of non-woody plants less than 1 m (3 ft) tall, but taller than ½ m (1½ ft) tall.</td><td rowspan="2">Graminoid (Gr)
Forb (Forb)
Sedge (Sed)
Rush (Ru)
Mixed grass-forb (Mix)</td></tr>
<tr><td>Short Herbaceous (SH)
Vegetation consists of non-woody plants less than ½ m (1½ ft) tall.</td></tr>
<tr><td>Open (O)
There is no vegetation suitable for concealing a jumping mouse.</td><td>Bare ground (BG)
Rock (R)
Woody Debris (WD)
Human modified landscape (e.g., roads, concrete lots; H)
Other (0)</td></tr>
</table>

* For a patch to be defined as a given structural type, that type must account for a canopy cover roughly equal to or greater than 60% of the area of the patch as viewed from above, with no large breaks in canopy cover that could be clearly delineated as another patch.

Table 2: Summary of Near-stream Transects

Vegetation Structure	Mean portion of transect	95% CI of the Mean	Maximum	Median	Minimum	Number of Sites	Portion of Sites
Forest [a]	22%	±10%	67%	19%	0%	15	88%
Shrub [b]	42%	±12%	75%	45%	0%	16	94%
Herbaceous [c]	32%	±12%	88%	23%	6%	17	100%
Open [d]	4%	±3%	17%	2%	0%	11	65%

This table presents the mean proportion of the near-stream transect at each capture point that was dominated by each structural vegetation category, along with: the 95% confidence interval about the mean; the maximum, median, and minimum recorded proportions; the number of capture sites that contained the vegetation category (out of 17); and the proportion of the total capture sites that contained each vegetation category. The vegetation categories can be further subdivided as follows:

a Forest consisted of cottonwood (39%), limber pine (24%), ponderosa pine (19%), aspen (9%), other deciduous (5%), and other conifer (4%)

b Shrub consisted of willow spp. (77%), other deciduous spp. (13%), big sagebrush (8%), juniper (2%)

c Herbaceous vegetation consisted almost entirely of mixed grasses and broad-leaved forbs which were not identified to species.

d Open habitat consisted of bare ground (52%), woody debris (27%), rock outcrops (12%), and human structures (10%).

Table 3: Summery of Upland Vegetation Mapping

Vegetation Structure	Mean portion of upland area	95% CI of the Mean	Maximum	Median	Minimum	Number of Sites	Portion of Sites
Forest [a]	20%	±14%	100%	5%	0%	11	65%
Shrub [b]	28%	±9%	46%	35%	0%	14	82%
Herbaceous [c]	33%	±13%	80%	38%	0%	14	82%
Open [d]	19%	±12%	78%	6%	0%	12	71%

This table presents the mean proportion of the upland area within 200 m of the capture points that was dominated by each structural vegetation category, along with: the 95% confidence interval about the mean; the maximum, median, and minimum recorded proportions; the number of capture sites that contained the vegetation category (out of 17); and the proportion of the total capture sites that contained each vegetation category. The vegetation categories can be further subdivided as follows:

a. Forest consisted of ponderosa pine (41%); cottonwood (21%); other conifer including limber pine, spruce, and fir (17%); mixed deciduous - conifer (19%); aspen (2%).

b. Shrub consisted of willow spp. (43%); big sagebrush (42%); other shrub including greasewood, bitterbrush, and juniper (14%).

c. Herbaceous vegetation consisted of stands of grass (32%) and mixed grasses and broad-leaved forbs (68%), which were not identified to species.

d. Open habitat consisted of rock outcrops (50%), bare ground (35%), and human structures (15%).

Figure 1: Distribution of jumping mice in North America (Based on data from Hall, 1981; Hafner et al., 1981; and the Wyoming Natural Diversity Database)

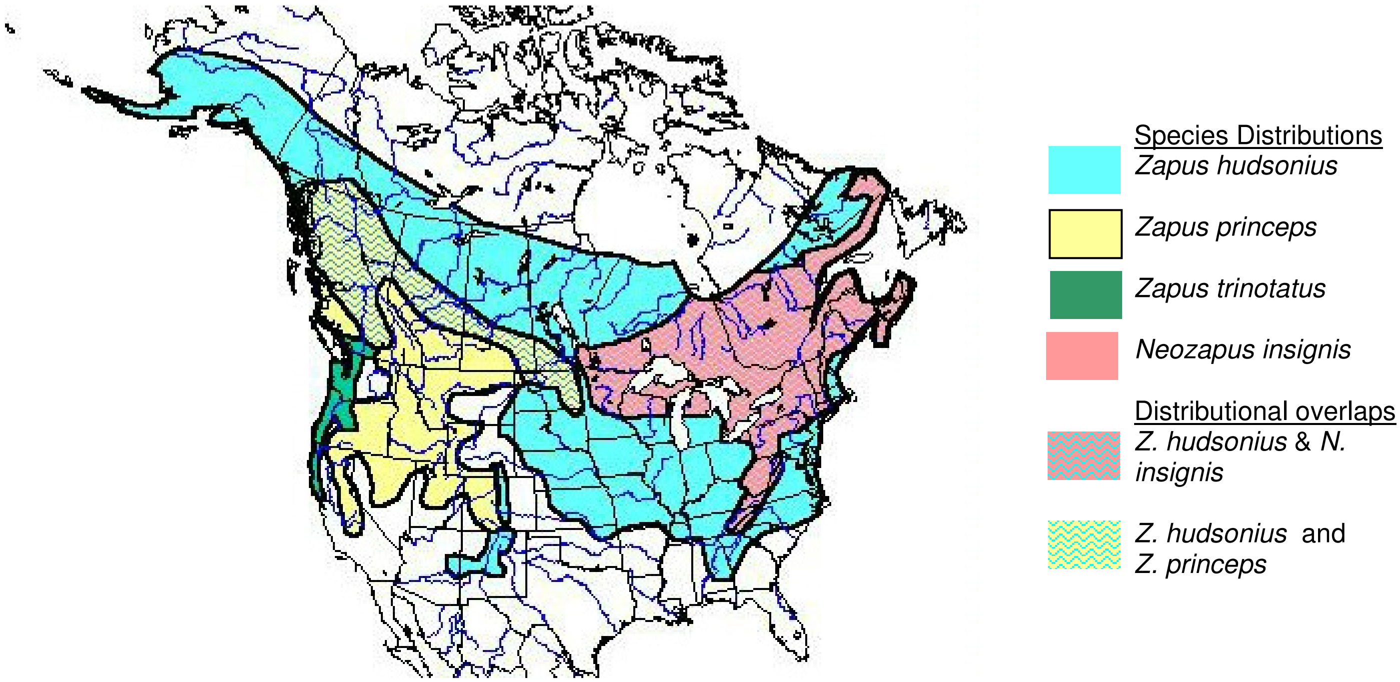


Figure 2: Wyoming distribution of jumping mice (Based on data from Hall, 1981; Hafner et al., 1981; and the Wyoming Natural Diversity Database)

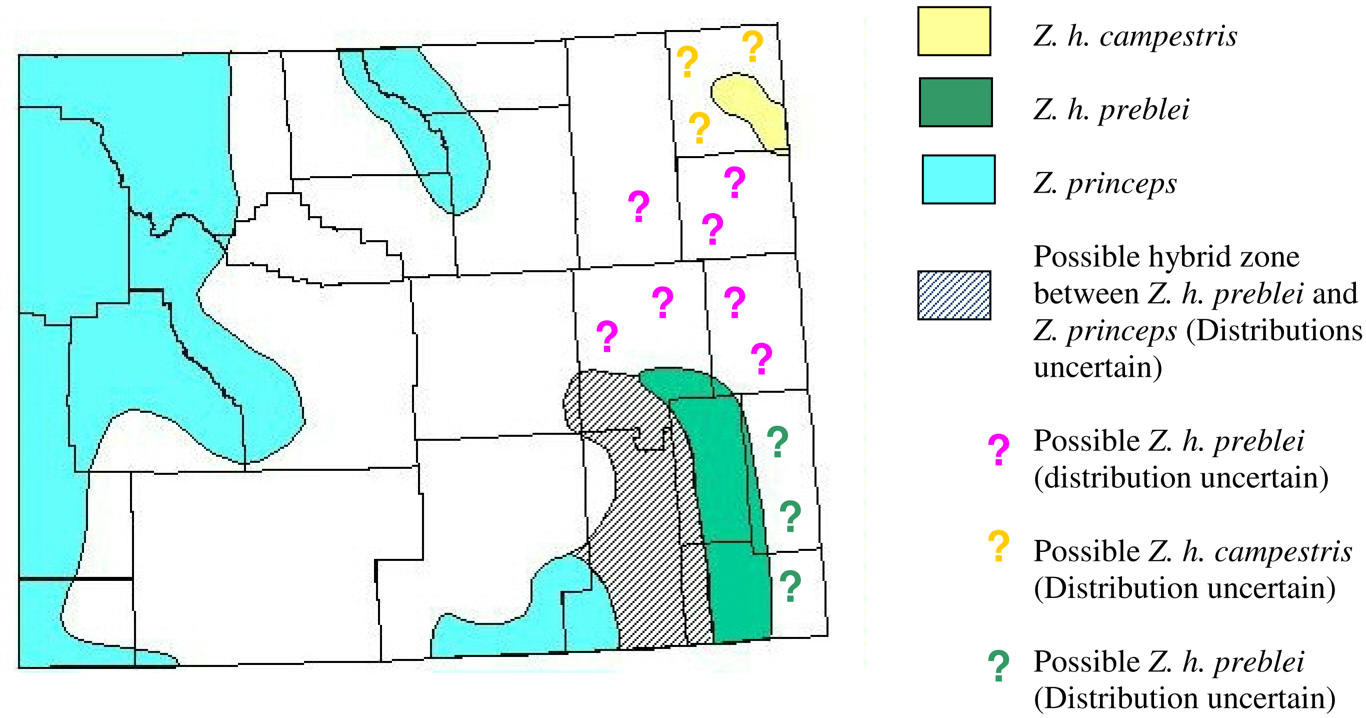


Figure 3: Distribution of riparian corridor widths for selected *Z. h. preblei* capture sites in southeastern Wyoming

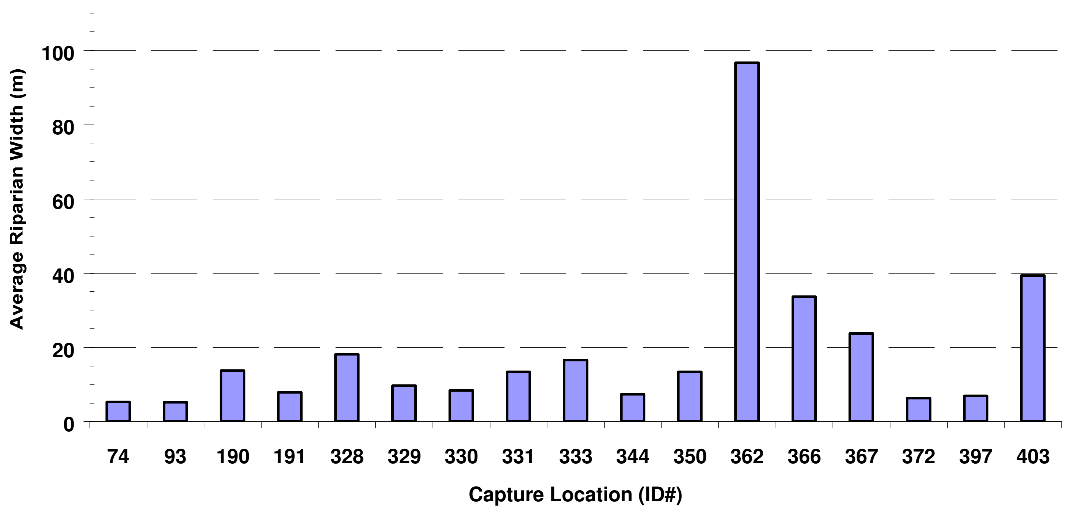
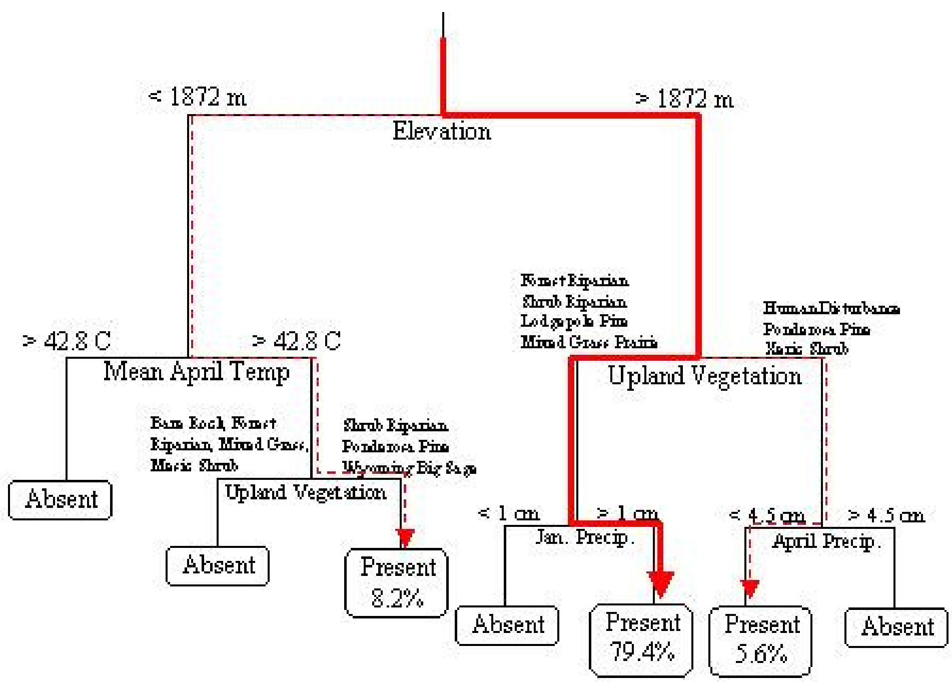


Figure 4: Classification tree of *Z. h. preblei* capture sites in southeastern Wyoming



Note: Percentages on the tree diagram refer to the proportion of known present points accounted for by the given path. All the correctly classified points total 93.2% of all known present points, with the remaining 6.8% being incorrectly classified as absent based on the regression tree model.

Figure 5: Predicted suitable habitat for *Z. h. preblei* in southeastern Wyoming