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A Large-scale Regional Assessment of Suitable Habitat for Pygmy Rabbits in Southwestern Idaho

Abstract

We tested a GIS-model developed to predict habitat suitability for the pygmy rabbit in a regional-scale analysis in southwestern Idaho. Habitat was predicted to be suitable if big sagebrush was the dominant shrub type, the soil was < 12.5% clay, slope was < 15%, and aspect was between 0-120° or 300-360°. To assess the accuracy of the GIS-model, 137 sites (72 within predicted suitable habitat and 65 within predicted unsuitable habitat) were groundtruthed for presence of predicted soil and vegetation types. The GIS-model predicted suitable habitat with 80.5% accuracy and unsuitable habitat with 76.9% accuracy. The main factor limiting GIS-model performance was the accuracy of the vegetation layer. We also checked the 137 sites for pygmy rabbit activity to determine how well the GIS-model predicted use and non-use areas. The model predicted areas unused by pygmy rabbits (74%) better than areas used (42%). We concluded that the model is robust in predicting non-use areas and works adequately for predicting suitable and unsuitable habitat, but stress the need for accurate vegetation maps. Application of this model over the whole range of the pygmy rabbit would provide managers with a valuable tool in conserving this species.

Introduction

The pygmy rabbit (*Brachylagus idahoensis*), the smallest of the North American leporids, historically has had a limited distribution within the Great Basin and adjacent intermountain areas. It is thought that the pygmy rabbit's distribution has been largely determined by the distribution of big sagebrush (*Artemisia tridentata*) (Orr 1940, Hall 1946, Green and Flinders 1980a, Campbell et al. 1982), which provides the pygmy rabbit with its primary source of food, as well as protection from predators such as badgers (*Taxidea taxus*) and weasels (*Mustela frenata*) (Orr 1940, Wilde 1978, Green and Flinders 1980a; 1980b, White et al. 1982). Within the sagebrush community, several investigators have identified the presence of taller, denser stands of big sagebrush as an essential feature of pygmy rabbit habitat (Grinnell et al. 1930, Davis 1939, Orr 1940, Hall 1946, Severaid 1950, Wilde 1978, Green and Flinders 1980a, Campbell et al. 1982, Weiss and Verts 1984, Katzner and Parker 1997, Gabler 1997, Heady 1998).

In addition to its reliance on big sagebrush, the pygmy rabbit is unique among North American leporids in that it excavates its own burrows

(Walker et al. 1964). Burrow entrances are typically located at the base of a large sagebrush and extend 50-100 cm below the surface (Grinnell et al. 1930, Davis 1939, Orr 1940). Recent work has demonstrated that pygmy rabbits are strongly tied to their burrows and the habitat characteristics (e.g., shrub height) at the burrow sites (Heady 1998). Consequently, soil characteristics that affect where a pygmy rabbit can burrow (e.g., soil texture and soil depth), likely also play an important role in determining where pygmy rabbits are found (Davis 1939, Orr 1940, Wilde 1978, Campbell et al. 1982, Weiss and Verts 1984, Kehne 1991, Gabler 1997, Katzner and Parker 1997).

In the last few decades, the availability of big sagebrush habitat has been greatly reduced due to range fires and the conversion of sagebrush-steppe for grazing and farming (Gabler et al. 2000). This reduction in big sagebrush habitat is thought to have led to a concurrent reduction in the distribution of pygmy rabbits in the state of Washington (Dobler and Dixon 1990, Washington Department of Wildlife 1995) and Idaho (Weiss and Verts 1984, Gabler et al. 2000). In Idaho, which encompasses a significant area of potential pygmy rabbit habitat, the extent of habitat loss and the distribution of remaining suitable habitat for pygmy rabbits is largely unknown. Little, too, is known about the current distribution of the pygmy rabbit.

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Gabler et al. (2000) conducted the first GIS-based assessment of current pygmy rabbit habitat on the Department of Energy, Idaho National Engineering and Environmental Laboratory (INEEL), a 2315 km² site located on the upper

Snake River Plain in southeastern Idaho (Figure 1). Gabler et al. (2000) located burrows on the INEEL and then spatially correlated the digitized locations to digital data sets of vegetation type, surface geology, slope, and aspect. The vegetation

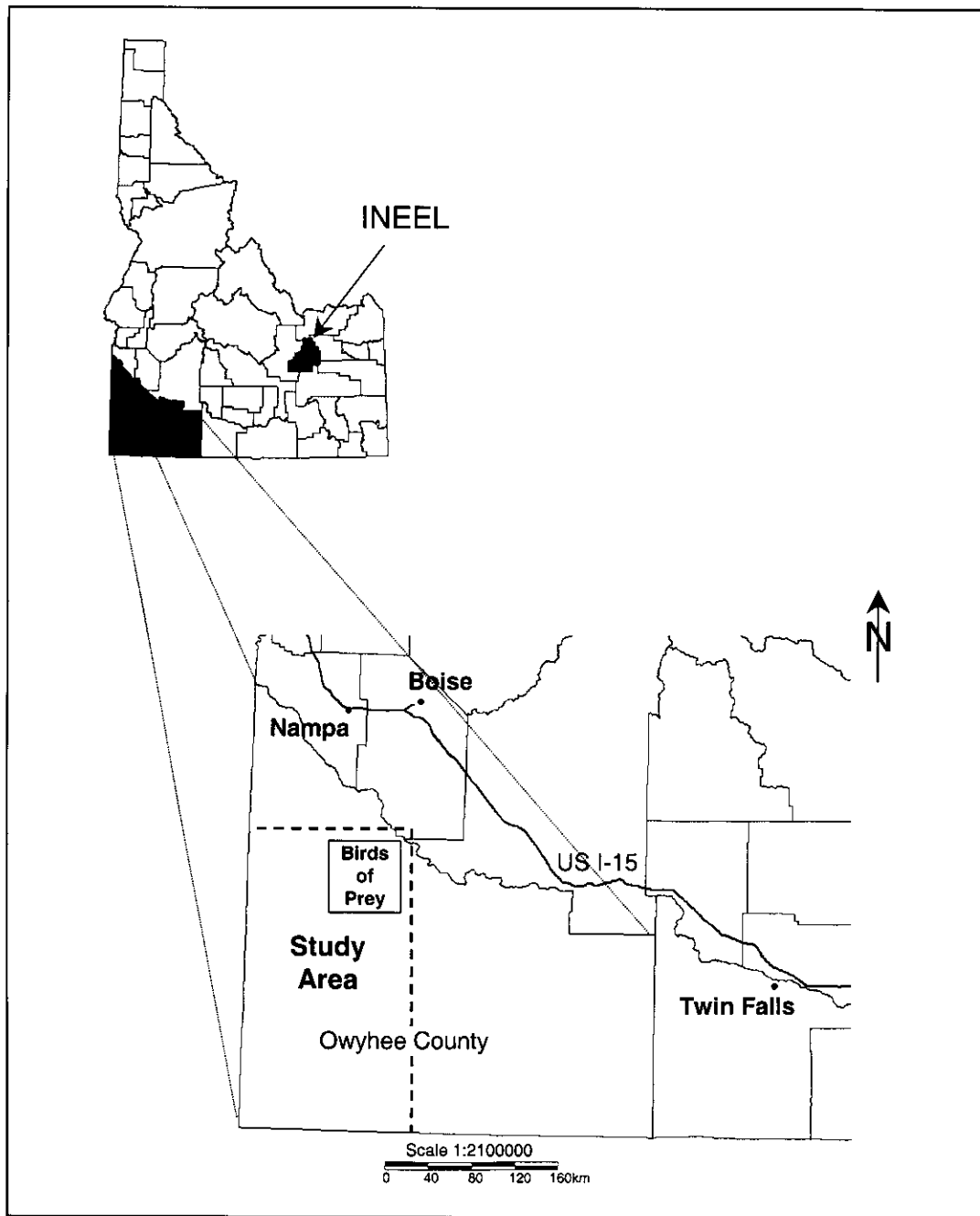


Figure 1. Locations of study area of Gabler et al. (2000) on the INEEL and current study area in Owyhee County, Idaho.

data set Gabler et al. (2000) used was developed from 2 Landsat satellite images and comprised 11 vegetation classes (Kramer et al. 1992). The surface geology data set was constructed from field and lab studies and comprised 54 deposit and rock classes (Kuntz et al. 1990). Gabler et al. (2000) used the data set of surface geology as a surrogate for a soil type data set, which was not available for INEEL. The slope and aspect data sets were developed from a USGS Digital Elevation Model (DEM) of INEEL and were included because topography can also influence soil features (e.g., soil depth) (Wilde 1978, Kehne 1991, Gabler 1997, Gabler et al. 2000).

From their analysis, Gabler et al. (2000) identified the range of each of the four variables associated with pygmy rabbit presence (Table 1). These ranges were then used to create a map of suitable habitat distinguishing predicted use from non-use areas. Groundtruthing found their model to be 100% accurate at predicting non-use areas and 57% accurate at predicting use sites.

TABLE 1. Habitat variables associated with pygmy rabbit burrow locations and used in the GIS-model of the INEEL (Gabler 1997, Gabler et al. 2000).

Habitat Variable	Range
Vegetation	Three vegetation classes with sagebrush as dominant species
Slope	0–15% (mean 8.9%)
Aspect	0–120° or 300–360°
Geology	Seven geologic classes

The objective of our study was to test this GIS-model under different conditions to see if it could be used to predict habitat suitability at a regional scale. We specifically tested the accuracy of the GIS-model in predicting habitat suitability and use and non-use areas for the pygmy rabbit within a study area that was both larger than the INEEL study area (2,315 km² vs. 15,000 km²) and in a different part of the pygmy rabbit's theoretical range in Idaho (south-west vs. central-east; Figure 1)

Study Area

Our study area covered approximately 15,000 km² of southwestern Idaho, including the majority of Owyhee County and the southeastern corner of

Ada County (Figure 1). The majority of the area is within the Boise District of the Bureau of Land Management (BLM) and included portions of the Snake River Birds of Prey National Conservation Area. The topography is highly variable, with plateaus, rises, and depressions of varying extent and degree of slope. The elevations range from ~670 to 2570 m above sea level, with the highest elevations occurring in the Owyhee Mountains in western Owyhee County. The lowest elevations are primarily in the northern half of the study area. The entire region is semiarid rangeland consisting of mixed shrublands, grasslands, and agriculture. Big sagebrush is the dominant shrub throughout the area, with bitterbrush (*Purshia tridentata*) and rabbitbrush (*Chrysothamnus* spp.) also commonly occurring. Areas dominated by cheatgrass (*Bromus tectorum*) are also present throughout the area.

Methods

We adapted the Gabler et al. (2000) GIS-model to the local data that was available for our Owyhee County study area. For the vegetation data set, we used the GAP1 cover type map (30 m pixels) created for the Idaho Gap Analysis Project (www.wildlife.uidaho.edu), which allowed us to select for areas classified as *Artemisia tridentata* (Code 75). We constructed our soil data set from the State Soil Geographic Database (STATSGO) for Idaho (U.S. Department of Agriculture 1994). The STATSGO data set (80 m pixels) is based on soil type and allowed us to incorporate Gabler's (1997) findings that the clay percent of areas used by pygmy rabbits on the INEEL was significantly lower (i.e., < 12.5%) than in non-use areas. Finally, the slope and aspect data sets were generated using Arc/Info 7.1.2 (Environmental Systems Research Institute, Redlands, CA) and four 1:250000 USGS DEMs (30 m pixels). The pixel size of the final suitable habitat map was determined by the 80 m pixel of the soil data set, which we could not resample at 30 m.

We reclassified each data set into a boolean layer based on the GIS-model developed by Gabler et al. (2000). For the vegetation layer, only those pixels classified as *Artemisia tridentata* (Code 75) in the GAP1 cover type map were considered suitable and assigned a value of 1. A 0 was assigned to all remaining cover-type codes. Pixels within a soil polygon were considered suitable and assigned a value of 1 if their clay percent

was less than 12.5%. Suitable slope values were any less than 15% and suitable aspects were all bearings ranging between 0-120 and 300-360. We overlaid the four layers: vegetation type, soil type, slope, and aspect, using Arc/Info to create a suitable habitat map for pygmy rabbits in the Owyhee County study area. This final map was then the result of a multi-criteria analysis where each 80 m pixel was only considered suitable if it was within the suitable range for each of the four variables.

In any GIS-model, there are two primary sources of error: inaccuracies in the data sets used in the GIS and inaccurate or incomplete inclusion of factors in the model. To address inaccuracies in the data sets, we groundtruthed the vegetation and soil layers at 137 random sample sites (72 predicted suitable sites and 65 predicted unsuitable sites). Because of the large geographic area and limited accessibility, we constrained our selection of random sample sites to within 1000 m of a primary or secondary road. To do this, we created a 1000 m buffer around each road and then used the coordinates of the buffer as the range of values from which x and y coordinates defining potential sample sites were randomly generated. Because site coordinates did not necessarily fall in the center of a pixel, the first sites per habitat class that were >80 m from the edge between predicted suitable and unsuitable habitat made up the final 137 sample sites.

We located the 137 random sample sites on the ground with the use of a Garmin XL 12 GPS (error \pm ~ 20m) and 1:24000 USGS quadrangle maps. At each site, we verified the vegetation layer by noting whether big sagebrush was both present and the predominant shrub type (i.e., visually covered >50% of area) at predicted suitable sites and was absent or very sparse at predicted unsuitable sites. To assess the accuracy of the soil layer, we collected a soil sample at each site for laboratory analysis of percent clay with the soil fractionation method outlined in Brower and Zar (1998). Individual layer accuracy and the overall accuracy of the GIS were expressed in confusion matrices (Verbyla 1995). A confusion matrix compares predicted to groundtruth data to determine the accuracy of the model output. The overall accuracy of a GIS-model is determined by both commission errors (pixels incorrectly included in a class) and omission errors (pixels incorrectly excluded from a class). In our analysis, commis-

sion errors were made when pixels that were predicted to be suitable were observed to be unsuitable, and omission errors were made when pixels that were predicted to be unsuitable were observed to be suitable.

To address the second source of error in our GIS-model, we determined how accurately the GIS-model predicted use and non-use areas of pygmy rabbits. At each of the 72 predicted use and 65 predicted non-use sample sites, we set up a 360 m x 360 m grid centered on the site coordinates as described by Gabler et al. (2000). A grid size of 360 m x 360 m reflects the average pygmy rabbit home range size during spring and summer, which is approximately 13 hectares (Gahr 1993). We then systematically checked each 360 m x 360 m grid for sign of pygmy rabbit activity (i.e., pellets and burrows) by walking 30 m north-south transects (Gabler et al. 2000). Because the pygmy rabbit is a sagebrush-habitat specialist (Katzner and Parker 1997, Gahr 1993, Kehne 1991, Weiss and Verts 1984, Green and Flinders 1980a, 1980b, Severaid 1950, Orr 1940, Grinnell et al. 1930), we did not search sites at which tall shrubs were entirely absent (e.g., farmland, cattle feed lots, and areas at which recent range fires had occurred). From these data, we determined the percent of the predicted suitable sites that were used and the percent of the predicted unsuitable sites that were unused.

Results

Predicted suitable habitat covered ~ 21% of the study area, with a greater proportion falling in the southern half (Figure 2). Based on groundtruthing 137 randomly selected points (Figure 2), the overall accuracy of the GIS-model at predicting suitable habitat was 79% (Table 2). Of the 72 sites, 58 (80.5%) were correctly classified as suitable and 50 of the 65 sites (76.9%) were correctly classified as unsuitable. The accuracy of our vegetation layer was 77% (Table 3). Of the 78 sites classified as *Artemisia tridentata*, 62 (79.5%) were classified correctly. At the other 16 sites, however, big sagebrush was absent or sparse. Cheatgrass was the predominant vegetation type at 8 of these 16 sites, which indicates either inaccurate mapping or where fires may have recently occurred. Of the 59 sites classified as some cover type other than *Artemisia tridentata*, 44 (74.6%) were classified correctly. The accuracy of the soil layer was 100%; all 58 sites from which soil

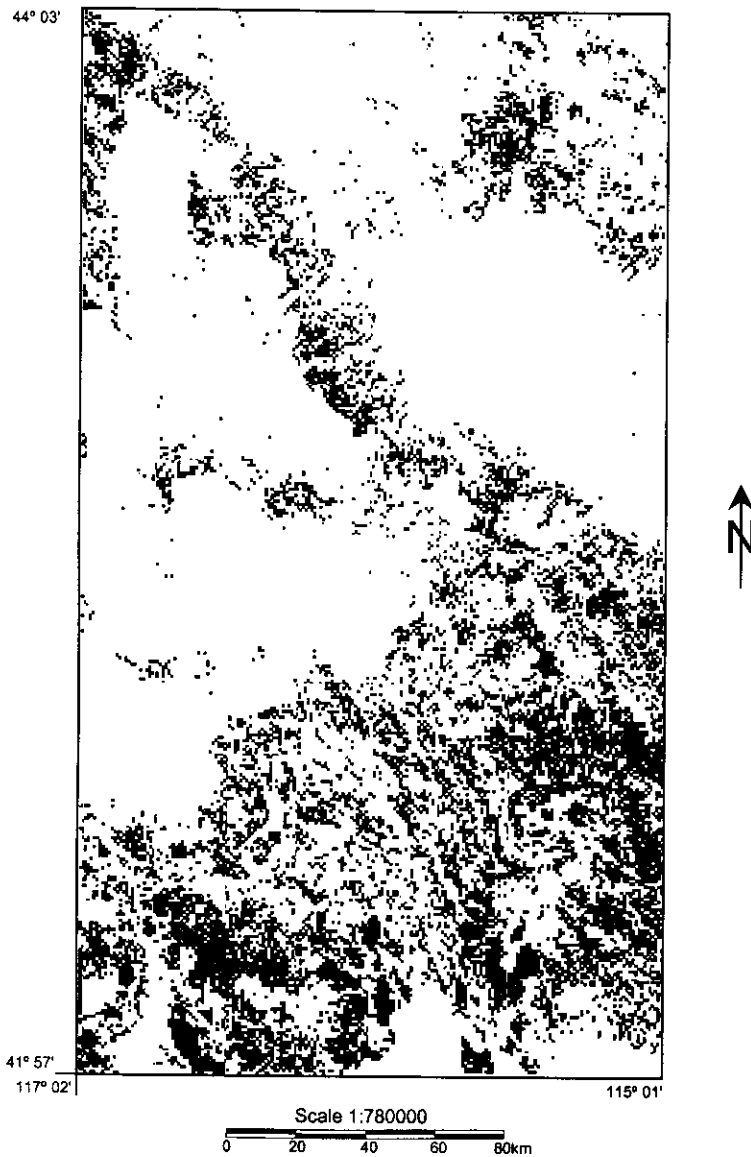


Figure 2. Final map of suitable habitat for the Owyhee County study area. Suitable habitat is shown in black.

TABLE 2. Confusion matrix comparing the predicted number of suitable and unsuitable sites to the observed number of suitable and unsuitable sites. Accuracy was determined by dividing the number of sites predicted correctly by the total number of sites $((58+50)/137 = .79)$

		Observed			Accuracy
		Suitable	Unsuitable	Totals	
Predicted	Suitable	58 (81%)	14 (19%)	72	81%
	Unsuitable	15 (23%)	50 (77%)	65	77%
Totals		75	62	137	79%

map, which was extensively groundtruthed (Anderson et al. 1996).

The second source of potential error in the vegetation layer was changes in vegetation physiognomy and floristics that have occurred in some areas as a result of range fires that have occurred since the GAP1 cover-type map was created in 1995 (Caicco et al. 1995). Range fires kill big sagebrush and native grasses and forbs, which allows fast growing, non-native species such as cheatgrass to invade (Radosevich and Holt 1984). Thus, the dominance of cheatgrass at 8 out of the 16 sites where big sagebrush was predicted to be the dominant vegetation type but was absent likely indicates where range fires have occurred. Recently, Rachlow and Svancara (2003) used fire history in their statewide GIS-analysis as 1 of 5 habitat variables to prioritize potential habitat as high priority (not burned after 1990) or low priority (burned during or after 1990) for future survey efforts. Because their GIS-model evaluation was based on the same data as were used to construct the GIS-model, it is not clear as to whether or not the addition of fire history improved predictability.

In both our study (21% of our study area) and the Gabler et al. (2000) study (23% of the INEEL), a relatively small percentage of the study area was potentially suitable for pygmy rabbits. These small percentages indicate that much of what has been considered potential pygmy rabbit habitat may actually not be suitable (Gabler et al. 2000). Based on the observed presence of big sagebrush, there were 77 sites with big sagebrush and 60 without big sagebrush. Comparing the observed activity to observed vegetation type results in a 57% accuracy at predicting use areas (44 out of 77 sites) and a 97% accuracy at predicting non-use areas (58 out of 60). These percentages are almost identical to those of Gabler et al. (2000) at the INEEL (57% and 97%) and could imply that ~ 60% of what is predicted by the GIS-model to be suitable is actually usable by pygmy rabbits.

In our study, the GIS-model's better performance when predicting non-use sites (74%) was not attributable to unsuitable sites being predicted with higher accuracy than suitable sites (42%); the number of commission errors (14) (19%) was nearly the same as the number of omission errors (15) (23%) (Table 2). Several factors may have contributed to the difficulty of predicting use areas.

First, the relatively low probability of predicting use areas could simply be because the pygmy rabbit population in our study area is at a low density. There is evidence that pygmy rabbit numbers have been on the decline throughout their range (Weiss and Verts 1984, Washington Department of Fish and Wildlife 1995). Another possibility is that the GIS-model does not include all the important environmental variables that are necessary for accurately predicting pygmy rabbit distribution. A number of variables have been suggested in the literature (e.g., density of grasses and forbs) (Heady 1998) that may be important in finer-scale pygmy rabbit habitat selection that cannot at present, be captured in a regional GIS-analysis.

The GIS-model may also perform better at predicting non-use areas because the degree of patchiness is lower in unsuitable areas. Predicted unsuitable sites were often located in large patches of clearly unsuitable territory (i.e., farmland). A higher degree of small-scale variation was seen in the vegetation structure of predicted suitable sites that was not reflected in the final suitable habitat map. Specifically, the vegetation data set did not distinguish between sparse big sagebrush cover and the greater big sagebrush cover that pygmy rabbits require (Gabler 1997, Green and Flinders 1980a, Weiss and Verts 1984, Katzner and Parker 1997).

Finally, the GIS-model accuracy may have been limited because species interactions are playing a greater role in pygmy rabbit habitat selection than has previously been considered. For instance, we saw extensive badger activity throughout the study area, and badgers prey on pygmy rabbits (Green and Flinders 1980b). We also observed signs of recent livestock activity at the majority our sample sites. Grazing is the dominant use of sagebrush-steppe lands (West 1983) and overgrazing can break down shrub cover and lead to loss of native grasses and forbs (Washington Department of Fish and Wildlife 1995). Overgrazing, like range fires, can lead to invasions of non-native species like cheatgrass (Washington Department of Fish and Wildlife 1995); and, because pygmy rabbits are big sagebrush obligates, these types of changes to vegetative physiognomy and floristics would cause areas to become unsuitable.

That we found pellets localized around rock outcroppings at many of the active sites suggests that pygmy rabbits may be taking refuge in lava

rock outcroppings. The only mention of this type of behavior in the primary literature that we found was by Green and Flinders (1980b), who observed pygmy rabbits using areas of volcanic rock, holes in stone walls, and abandoned buildings. Green and Flinders (1980b) did not speculate on why a pygmy rabbit might use those areas, and we did not collect data specific to addressing that issue. However, we did notice that livestock activity appeared, qualitatively, to be limited around the outcroppings. One potential area for future research would be to compare grazed and ungrazed areas that pygmy rabbits occupy to look for differences in habitat use.

In summary, a GIS-model can be used to investigate the spatial relationships between species presence and habitat features. Uncovering these species-habitat relationships in the spatial framework provided by a GIS-model can be especially useful when identifying suitable or critical habitat for area-sensitive species whose available habitat is in danger of being reduced and/or degraded. We have shown that a GIS-model like that of Gabler et al. (2000), based on vegetation type, soil type, slope, and aspect, can be used effectively

to identify areas that pygmy rabbits are not using in Idaho. Within areas our GIS-model predicted to be suitable, the level of use we found may actually reflect the proportion of big sagebrush habitat that is really suitable for pygmy rabbits. Because pygmy rabbits are such habitat specialists, efforts to predict use areas would be improved upon by finer-scale analyses within predicted suitable habitat. We suggest that application of the Gabler et al. (2000) GIS-model, using statewide data sets as we have, over the total range of the pygmy rabbit would be a valuable first step in assessing the actual amount of suitable habitat available for this species.

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